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THE GLORY OF GOD IS INTELLIGENCE

Cover: Aerial photo of Utah Valley and surrounding area.

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Studies for Students No. 10, Geologic Guide to Provo Canyon and Weber Canyon, Central Wasatch Mountains, Utah

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INTRODUCTION

Few field trips offer the variety and quality of geologic features as does one through Provo Canyon and Weber Canyon.

All rock systems except the Ordovician, Silurian, and possibly the Devonian are exposed. Igneous, sedimentary, and metamorphic rocks are available for field examination, with a wide variety of sedimentary rocks dominating the exposures. Igneous rocks, both intrusive and extrusive, are found in the Park City complex. An excellent, high-grade, metamorphic sequence dominates the core of the Wasatch Mountains through Weber Canyon.

Several structural features are also evident. The area is on the eastern edge of the Basin and Range Province, with the Wasatch Fault zone delineating the eastern margin. High-angle faults of similar character are also found farther to the east, but they have less displacement. Thrust faults are also present but are much less evident. Features associated with these thrusts can be seen particularly well along Provo Canyon and the eastern part of Weber Canyon. The dynamic movements of thrusting have also folded Paleozoic and Mesozoic rocks into several small folds along the thrust belt. Rocks in one such fold produce oil in the Pineview field. Prominent angular unconformities are easily seen in several places along the field-trip route. In each case flat to slightly tilted Tertiary rocks overlie folded Mesozoic and Paleozoic rocks.

Physiographically the field-trip area is principally a dissected upland topography. Mountain ranges are separated by relatively narrow, north-south-trending valleys, such as Heber and Rhodes Valleys. East-west topography is dominated by the Uinta structural trend. Faults bound most of the valleys. Several terrace levels are evident along the Provo and Weber River drainages.

Glacial features are evident in the upper mountain peaks. Alpine glacial erosional and depositional features are found on Mount Timpanogos and other high parts of the Wasatch Mountains and in the Uinta Mountains. Lake Bonneville, a glacial lake, has many depositional features well displayed at the mouth of Weber Canyon.

GEOLOGIC HISTORY

Major geologic events that have affected the area occurred in the following sequence, as outlined by L. F. Hintze (1973).

Precambrian–Thick sequences of sedimentary rocks, mostly sandstones, dominate the Uinta area; Precambrian metamorphic rocks exposed along the front of the Wasatch Range are more than 1 billion years old. It is thought all the exposed metamorphic rocks along the field-trip route are on thrust plates and were originally several miles to the west.

Early Paleozoic–Miogeosynclinal sediments dominate the Cambrian through Devonian periods. Great thicknesses of limestone, shale, and sandstone accumulated in the area west of the Wasatch Mountains, but thinner sections accumulated in eastern parts of the state during these times. A Late Devonian-Early Mississippian uplift in the area allowed much of the Devonian, Silurian, and Ordovician rock to be stripped away.

Late Paleozoic–Rocks of late Paleozoic age are largely marine, miogeosynclinal rocks that have been subsequently thrust eastward to their present positions. Great thicknesses of carbonates and sandstones with some phosphorites are found in this sequence. Rocks of late Permian age have been eroded from much of the area. This uplift and erosion at the end of the Paleozoic is evident not only in this area, but worldwide. Rocks of the late Paleozoic are generally very fossiliferous. The structural influence of the Uinta Mountains began in the Late Devonian and continues through the present.

Early Mesozoic–Triassic and Jurassic rocks are marginal marine sedimentary rocks, with deposits representing shallow-water environments dominating. Broad tidal flats and marginal marine marshes with sand dunes and deltas are evident in the Triassic section. Jurassic rocks were largely marine, with the Twin Creek Limestone and associated evaporites developing in an isolated basin. These basins were filled gradually by deltaic sediments. A major orogenic event began in the Jurassic. This event, called the Nevadan orogeny, most likely the result of plate interaction to the west, caused a mountain chain to develop in Nevada, California, Idaho, and other states and provinces. The orogenic belt as expressed by thrusting, moved gradually eastward. This faulting continued at least through the late Mesozoic and probably into the early Cenozoic. Several major plutons developed in western North America during the early phase of this later orogeny, which we call the Sevier orogeny.

Late Mesozoic–Rocks of late Mesozoic age indicate a subtropical environment, with deltas building out

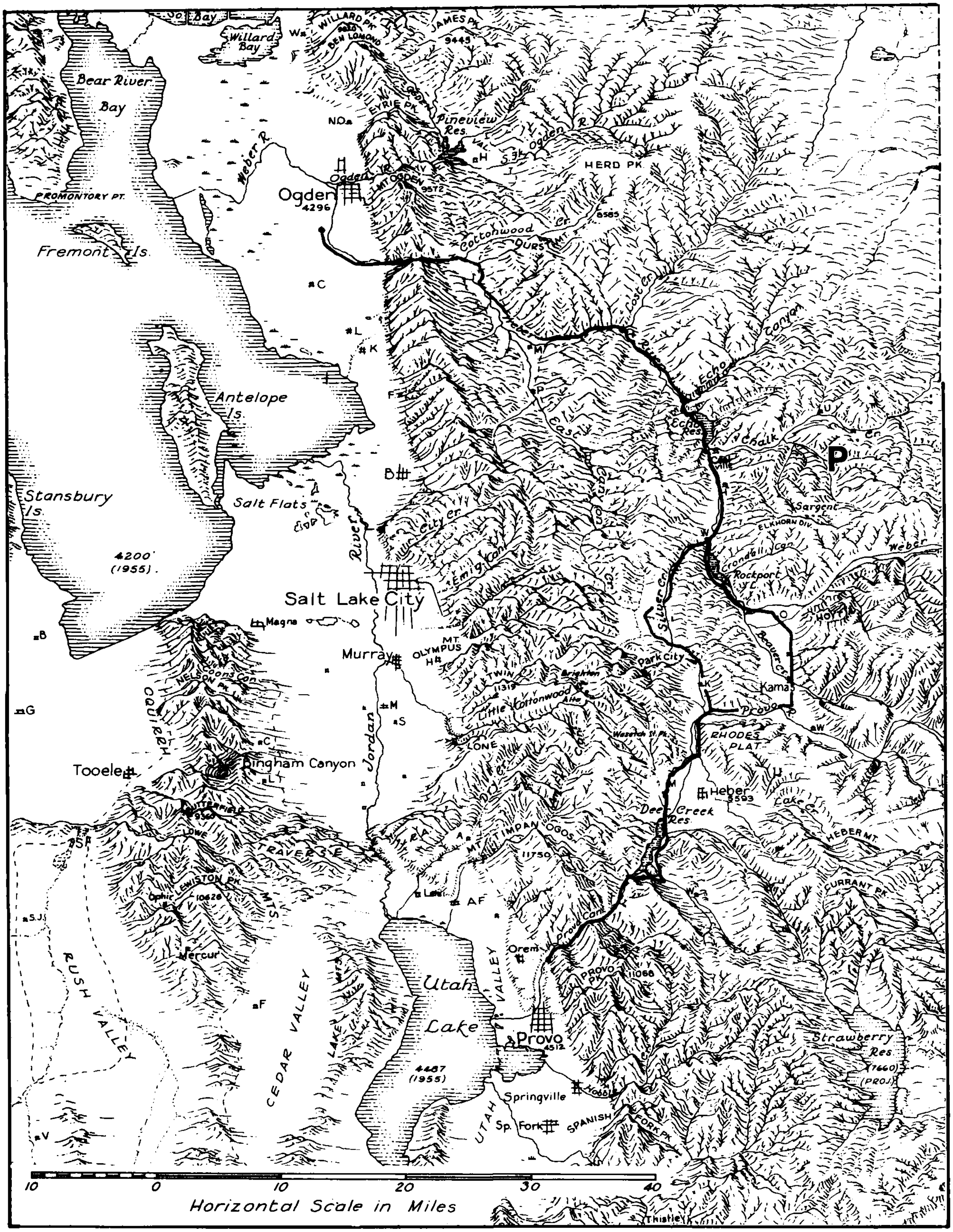


FIGURE 1.–Index map. Letter "P" marks location of Pineview oil field.

onto a shallow sea to the east. Great thicknesses of sandstone and shale make up most of the rocks in the area, which is thought to have been much like the present-day Gulf Coast region. Rocks of Cretaceous age have abundant coal, oil, and gas reserves.

Cretaceous rocks were thrust eastward throughout much of the field-trip area. This late pulse of thrusting coincided with the beginning of a major uplift in the area. The rocks indicate a gradual shift from marine to nonmarine environments. The uplifts and folding were not uniform, with some areas rising higher and faster than others. Nevertheless, the whole region experienced general and periodic uplift. This uplift episode is called the Laramide disturbance.

Cenozoic–Lacustrine and fluvial deposits represent the principal environments found in the Tertiary section. Mountainous areas to the west were broken up by normal faults into a valley-and-mountain pattern. Igneous activity became more intense as intrusive and extrusive rocks were emplaced along the Bingham-Cottonwood trend. Uplift continued throughout the Cenozoic and is still going on. It caused the area to be reelevated several thousand feet.

Quaternary–Uplift, glaciation, and fluvial events are the principal geologic processes that formed and are forming the present topography.

WEBER LOOP

0.0 INTERSECTION OF UTAH 52, WEST INTO OREM, WITH U.S. 189 at the mouth of Provo Canyon (figs. 1, 2). Go northeast on U.S. 189.

0.2 Outcrops of Great Blue Limestone occur on either side of the canyon (fig. 3). Broad talus fans flank both sides of the canyon. The well-bedded unit in the escarpment on the north is the uppermost part of the gray, shaly Great Blue Limestone. The aqueduct for electric power generation has been tunneled through the bluff. Notice the small faults in the bedded material (fig. 4).

0.5 Local landslide on the south side of the canyon (fig. 5). The hummocky topography is typical of that produced by slow creep of the Manning Canyon Shale down into the valley. Manning Canyon Shale here has a moderate overgrowth of selenium-indicator plants. Selenium has been found to be a contributor to neuromuscular difficulties in cattle and human beings. The drinking fountain on the north of the road feeds out of this selenium-rich shale-slumped area. A steady consumption of selenium could cause trouble.

0.6 Flow-folded outcrops of the upper part of the Great Blue Limestone on the south side of the road. Notice that bedding of the limestone has been badly contorted (fig. 6). Low exposures of the uppermost resistant beds of Great Blue Limestone can be seen in canyon walls to the north. Directly ahead are gravel quarries in sediments related to the filling of this part of the Provo River Canyon by deltas developed out into Lake Bonneville at the Provo level and at older, higher levels.

FIGURE 2.–Mile 0. View of mouth of Provo Canyon toward the northeast. Wasatch Fault runs roughly parallel to road on right. Rock outcrops near powerplant outlet are Mississippian Great Blue Limestone. Mount Timpanogos in background is made up of Pennsylvanian-Permian Oquirrh Formation.

1.1 Cross canal. Some Pleistocene mammals have been found in the sediments to the south as a result of the quarry operation. Across the canyon to the north, hummocky topography is formed on slumping Manning Canyon shales in the city park area. The movement may not be as active now as in the recent geologic past, but with heavy rainfall or an unusually wet, rainy season, this area could be mobilized, causing trouble. Should a highway be constructed on the north side of the canyon, the effect of that hazard would be increased. The aqueduct would also be jeopardized if the substrate starts to move downslope.

1.3 Major bend. Ahead, on the north side, the aqueduct is about at the plane of a major thrust fault, the Charleston Deer Creek–Nebo Thrust, which has eastward apparent movement of the overlying block. Around the bend, major slump blocks in the mouth of the small tributary canyons on the north are mostly of Manning Canyon Shale.

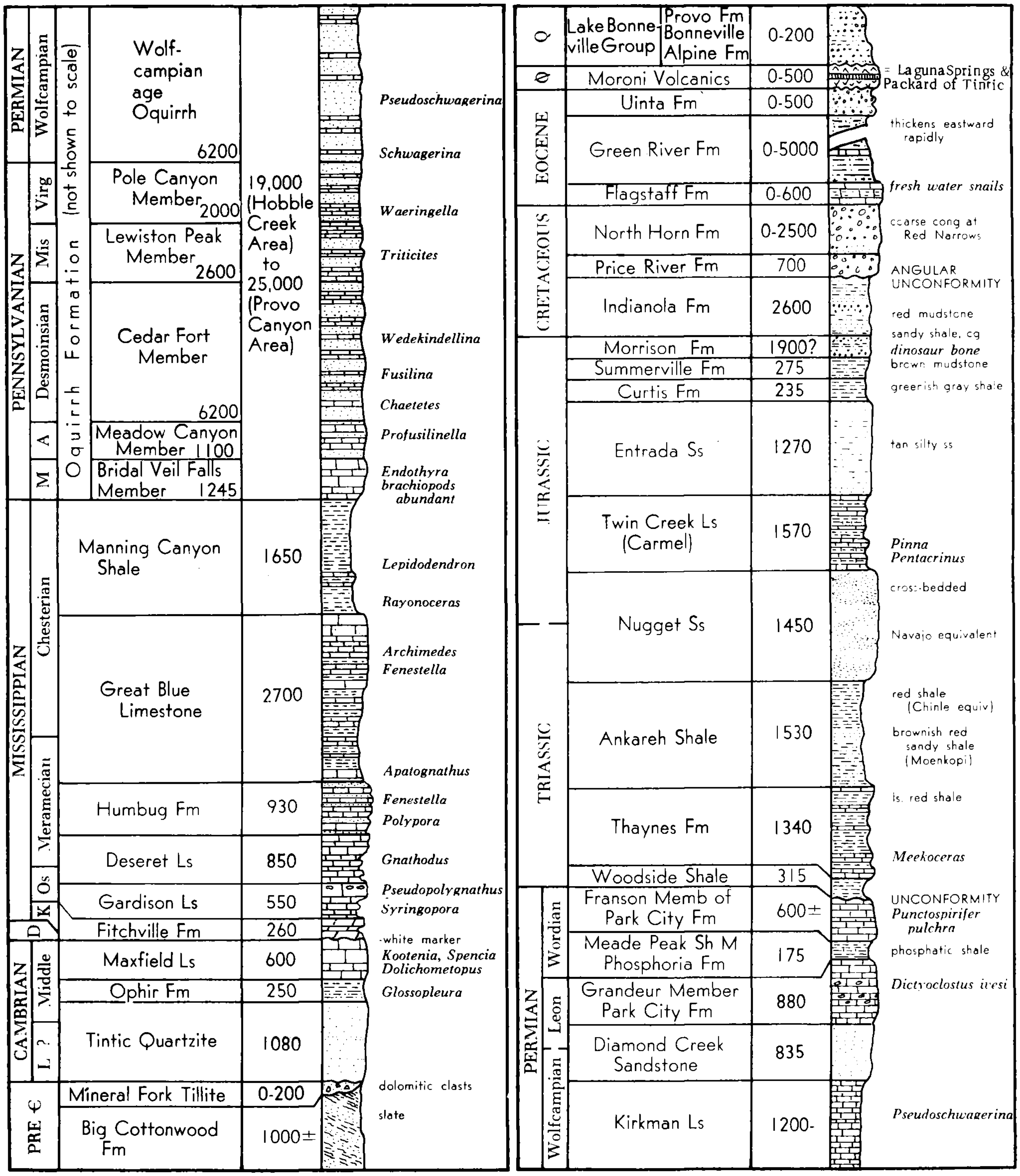
1.6 Pass Wicks. A resistant fin of Great Blue Limestone (fig. 7) rises above the valley on the north side of the road. Uppermost Great Blue Limestone is exposed in roadside cliffs on the south side. Notice how the river here has impinged upon the roadside exposures as a result of meandering.

2.0 Side road to Squaw Peak Road, leading southward up a subsequent valley carved in Manning Canyon Shale. This is the same shale that is creeping down into the canyon, forming the hummocky topography in the valley on the north side.

2.2 Landslide debris of Manning Canyon Shale and overlying loose rocks exposed in roadcuts on the south side.

2.5 ENTRANCE INTO SPRING DELL. Spring Dell obtains its culinary water from the Manning Canyon Shale in the slump blocks above the development to the south.

PROVO AREA - SPANISH FORK CANYON



After: Baker (1947),(1964); Hunt and others (1953); Bissell (1962a),(1963); Hardy (1962)
Mississippian: Woodland (1958); Pinney (1965); Permian: McKee and others (1967); Jurassic: Wright and Dickey (1963a); Imlay (1967); Pinnell (1972); Green River Fm: Baer (1969); Flagstaff Fm: Weiss (1969)

FIGURE 3.–Stratigraphy in Provo Canyon-Heber area (chart 23, Hintze 1973).

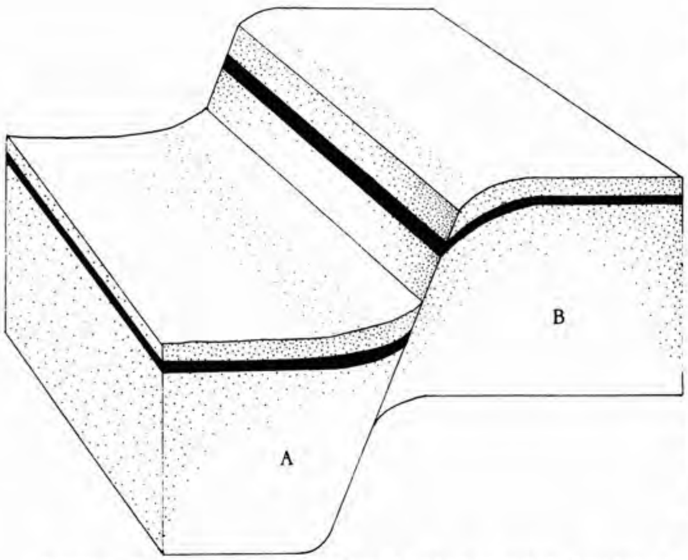


FIGURE 4.–Diagram of normal fault. Most of the high-angle faults found along the field-trip route are of similar character. Note the drag or bending of beds near the fault trace.

FIGURE 5.–Groundwater seeps northward through the Manning Canyon Shale and eventually comes out at the roadside fountain.

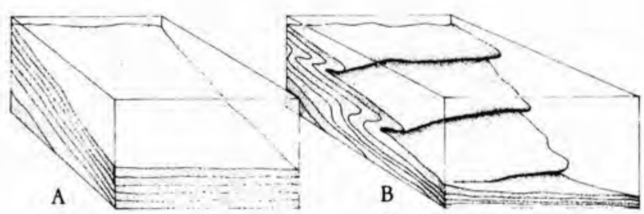


FIGURE 6.–Mile 0.3. Diagram of soft-sediment deformation. In the Great Blue Limestone are found several small folds whose origin is suspected to be soft-sediment deformation.

FIGURE 7.–Mile 1.6. Rib of Great Blue Limestone with Manning Canyon Shale in upper part of photo near the aqueduct.

2.7 A picnic area on the north. Manning Canyon Shale is well exposed in the stream bank, beyond the picnic area on the north side of the canyon (fig. 8). The resistant ledges near the aqueduct are the Medial Limestone Member of the Manning Canyon Shale (fig. 3). Some fossils have been obtained from road-cuts and from canyon cuts in the upper part of the park.

3.1 Spectacular fold in basal Oquirrh Formation (fig. 9) exposed in the high canyon wall south of the road, near a small side road heading up the canyon. A minor cave has developed in the crest of the anticline in the massive, bedded limestone.

3.4 Road drops off from the landslide block on the south side. Across the canyon to the north, from the west end of Rotary Park, rather characteristic hummocky, maple- and oak-covered topography is on landslide debris.

FIGURE 8.–Mile 2.7. Medial Limestone of the Manning Canyon Shale exposed along the aqueduct.

FIGURE 9.–Mile 3.1. Small, but prominent, asymmetrical anticlinal fold found in the Oquirrh Formation. This fold is thought to be associated with the forces that caused the thrusting in the area.

3.6 Cross Provo River at Rotary Park. Upper part of the Manning Canyon Shale is exposed in cuts on the south side.

3.9 BRIDAL VEIL FALLS (SCENIC STOP)–DEPOT OF THE WASATCH MOUNTAIN RAILROAD (HEBER CREEPER). Bridal Veil Falls (fig. 10) flow over the Lower Pennsylvanian West Canyon Member of the Oquirrh Formation. The stream issues from springs in the cavernous upper part of the limestone, well over 305 m above the valley floor.

Periodically, the ornamental retaining wall in the parking lot area is broken by avalanches and ice falls that come from the south side during heavy winter and spring snowstorms. A couple of times, in past years, cars have been buried in the parking lot area during these avalanches. Small lakes were ponded upstream from the avalanche until the Provo River excavated a channel through the avalanche debris.

Exposures on the north side of the canyon are part of the Oquirrh Formation. The lower Oquirrh beds are of Morrowan age (fig. 3). Atokan and Desmoinesian rocks are exposed higher on the bluffs as the tan- and buff-colored slopes and cliffs. The lower part of the Oquirrh Formation is cyclic (fig. 11), with massive fossiliferous limestone interbedded with thin, shaly-bedded, crinoidal-bryozoan limestone. The formations on the north and south sides are abundantly fossiliferous.

4.7 Upper Falls Resort area. Just beyond the Upper Falls Resort area is the screening and processing plant for the Salt Lake aqueduct.

4.9 The highway swings out around the toe of the Slide Canyon alluvial fan. Slide Canyon also has a history of repeated avalanches and snowfall debris slides. Slides in 1978 produced a debris fan 15 m deep and more than 0.8 km wide across the highway (fig. 12). Vegetation is sheared off by the snow and rock debris.

5.1 Intake of the aqueduct on Provo River.

5.2 Cross the major West Aspen Grove fault which downdrops the upper part of the Oquirrh Formation, on the east, against the lower part of the Oquirrh Formation, on the west (fig. 13). The brownish quartzitic talus fans here are typical of the upper part of the unit. The West Aspen Grove fault is traceable for several miles to the north, along the east side of Mount Timpanogos, through the Aspen Grove development. Talus fans are spectacular here just east of the fault system. The canyon assumes a steep, V-shaped profile in areas where the lower part of the Oquirrh Formation is exposed. To the east the

FIGURE 10.–Mile 3.9. Bridal Veil Falls–Water cascades from a shallow surface drainage and groundwater to the south. The relative erosion from this small amount of discharge has not been able to keep pace with the erosive power of the Provo River.

FIGURE 11.–Mile 4.1. Excellently displayed sedimentary cycles typical of the Oquirrh Formation.

geologic structure rises so that we look beneath Deer Creek thrust slices to the underlying rocks through windows in the fault, at road level. In these window areas, the canyon widens out.

6.1 ROAD JUNCTION TO VIVIAN PARK. The wide area in the Vivian Park region is in a small window beneath the thrust fault. Just east of Vivian Park, the road crosses the East Aspen Grove fault

FIGURE 12.–Mile 4.9. View looking north into Slide Canyon, which derives its name from the periodic snow avalanches that come out of its upper reaches onto the highway below.

FIGURE 13.–Mile 6.1. West Aspen Grove fault. The fault cuts through just this side of the outcrop and continues northward. This fault bounds the principal graben found in Provo Canyon (see figure 16).

(fig. 14) into the lower part of the Oquirrh Formation, again on the upper part of the Deer Creek thrust. The area between the aqueduct intake and Vivian Park is a small graben (figs. 15–16), with displacement of 305–610 m. The steep, V-shaped profile of the canyon east of Vivian Park is characteristic of limestone bedrock exposures of the lower part of the formation.

7.2 Cross small fault within the Oquirrh Formation. The wide part of the canyon ahead is produced by the more easily eroded, younger material.

7.3 JUNCTION SIDE ROAD NORTH TO ASPEN GROVE, ALPINE OR TIMPANOGOS LOOP, AND SUNDANCE SKI RESORT. The gravel-washed alluvial material east of the junction is related, in part, to glaciation of the east side of Timpanogos to the north and, in part, to damming along

FIGURE 14.—East Aspen Grove fault. The fault cuts across the road at just about the position of the house trailers in the center part of the photo.

Provo River by landslides farther down. This is a terrace-filling, which has been preserved in various locations along the canyon from here to Heber Valley.

7.5 Utah County–Wasatch County line. Exposures beyond are in fractured limestone of the Oquirrh Formation, here situated immediately above the Deer Creek thrust fault, which is just below canyon level. The fault rises to the west and east.

7.9 Badly brecciated Oquirrh Limestone. Notice rehealing of some limestone by white crystalline calcite.

8.1 Heber Creeper (Wasatch Mountain Railroad) bridge across the Provo River to the right. Notice the undulations and slides in the road, which is constructed on brecciated Oquirrh Formation and Manning Canyon Shale, almost at the thrust surface. Manning Canyon Shale has slumped in roadcuts (fig. 17).

8.3 Deer Creek thrust exposed here in the Sulphur Springs window (fig. 16), Manning Canyon Shale is exposed beneath the Oquirrh Rocks in the upper plate. This is the reason for the broad, open valley ahead. Hummocky landslide topography in areas to the south is characteristic of shale exposures.

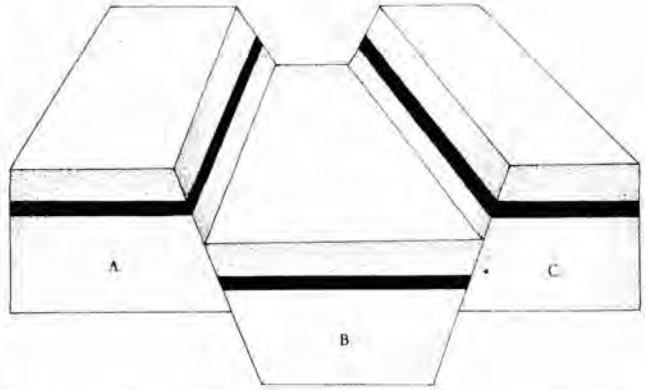


FIGURE 15.—The Aspen Grove faults create a graben, as seen in this diagram. Many of the valleys, such as Heber Valley, downdropped along faults and are therefore grabens.

8.8 Slide area (fig. 17). The road here usually is in disrepair because of slow movement of the Manning Canyon Shale in roadcuts.

8.9 Exposures of Manning Canyon Shale in roadcuts.

9.1 Gravelly appearing, brecciated thrust fault zone high on the north side. Hummocky topography in a proposed housing development on the south is on landslide material.

9.4 Canyon widens markedly at housing development. The development obtains its water from springs associated with Manning Canyon Shale. The high terrace area to the north marks a high-level filling of Provo River behind dams produced by landslides of Manning Canyon Shale. Note for the next 3.2 km, the almost nausea-producing undulations in the highway related to movement of the Manning Canyon Shale downslope. Both north and south sides of the canyon are actively "underway," and the roadbed is also being modified, particularly during wet years (fig. 18). On the south, highly contorted Manning Canyon Shale crops out in the railroad cuts along the Heber Creeper route. Such distortion could have been produced by the thrust fault, as well as by movement of landslide blocks downslope.

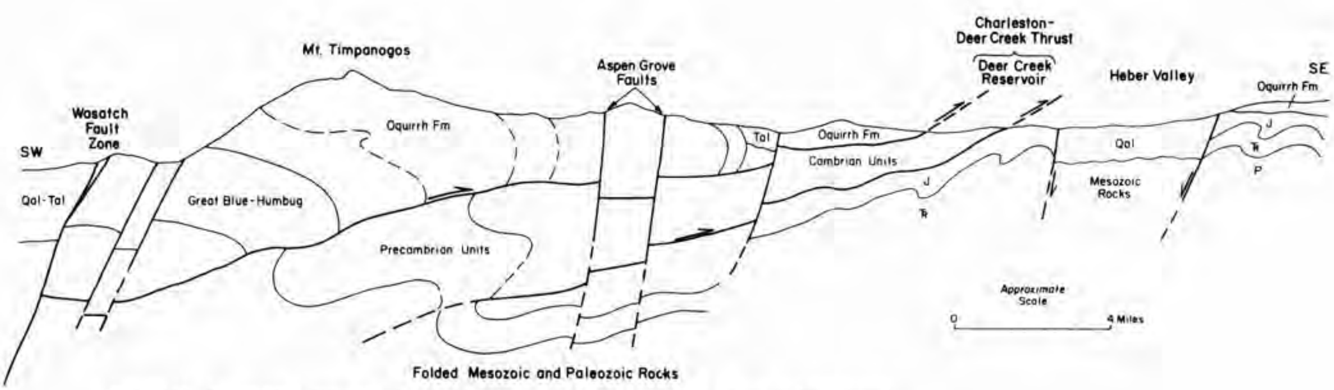


FIGURE 16.—Generalized cross section, Provo Canyon to Heber Valley. Cross section is diagrammatic.

FIGURE 17.–Mile 8.8. Downcanyon view of slumps in the Manning Canyon Shale at the Sulphur Springs location. The canyon widens noticeably wherever it intersects the lower plate and the easily eroded Manning Canyon Shale.

FIGURE 18.–Mile 9.4. Road failure is common as the Manning Canyon slumps into the Provo River.

10.1 Exposures of the Medial Limestone in the Manning Canyon Shale.

10.6 Cross beneath overpass of the Heber Creeper tracks. The earthfill dam of Deer Creek Reservoir is visible directly ahead. Deer Creek is the major tributary from the north and has helped produce major terraces on the northwest (fig. 19). Notice how some of the sandstone ledges terminate as they are traced from the east, behind the powerhouse at the west end of the dam. Termination and offset of these rock units are related to the complex fault zone situated right at the dam site. This may be a good dam site, but it looks as if the reservoir is ponded on a "sieve."

11.1 CROSS OVER THE SPILLWAY ONTO THE NORTH APPROACH TO THE DAM. As you head south across the dam, notice the intense fracturing of the upper Oquirrh quartzitic units. Each of these fractures could function as a leakage point for water out of the reservoir and down into the lower canyon.

11.4 Off the dam on the south side, intensely brecciated Oquirrh rocks are visible in outcrops in an area of periodic rock falls. Notice the accumulations in the borrow pits if the highway has not been cleared off this week. Rock falls are particularly active during spring thaws.

11.9 Mylonite zone in the Oquirrh Formation (fig. 20) near a broad turnout and parking area on the north side. Mylonite is rock ground to "flour" by movement along faults. Notice that bedding can be seen in the western outcrop, but it disappears near the eastern edge where the rocks have been thoroughly crushed. From here, the view back toward the west includes the high peaks of Mount Timpanogos. The bowl-shaped areas on the east face of Mount Timpanogos on the skyline are a series of cirques produced during Pleistocene glaciation. To some degree they are still active, for they experience some frost-wedging during the winter and spring.

12.2 The road now swings away from the Deer Creek Reservoir onto alluvial fans veneered by clayey soil. The large alluvial cone over which it rises came from Sunday Canyon to the southwest. Directly ahead is broad Wallsburg or Round Valley. The road continues parallel to a small arm of Deer Creek Reservoir, which extends up into Wallsburg Valley. Barren sagebrush slopes here are the result of frequent range fires which have now destroyed the forest cover.

14.2 Cross Round Valley Creek to junction with road heading south to Wallsburg. You may notice the Heritage Hills development proposed in areas to the south. This development is on the clayey soil of the alluvial fan and west flank of Wallsburg Valley. Soil

FIGURE 19.–Terraces in upper Provo Canyon attest to the periodic uplift of the region.

FIGURE 20.–Mile 11.9. Badly brecciated Oquirrh Formation. Brecciation is thought to be caused by movement along the thrust plane.

engineers with the Bureau of Land Management and the Soil Conservation Service have indicated that it is a very poor area for a housing development from the standpoint of drainage. The developers propose to use septic tanks and drainage systems to dispose of human sewage. The clayey soil will keep such a system from being effective, however; so each family's sewage will water the lawn below theirs. Before developments like this are allowed, they should be required to connect with sewage treatment plants. There is a proposed (1978) hookup of this development and some others in the canyon with the Provo City or the Orem City sewage treatment plant.

15.1 High point as the road swings from Wallsburg Valley across the ridge, through deeply weathered and fractured Oquirrh Formation, along Deer Creek Reservoir, and into Heber Valley. Far to the north the prominent peak has been terraced artificially in some of the high-runoff avalanche-prone regions.

16.1 The Twin Creek Limestone is exposed beneath the thrust in a variety of places to the north. For example, the limestone is exposed on the small, rounded hill just west of the wide pullout.

16.5 Brecciated limestone and quartzite of the lower Oquirrh Formation in roadcuts on the south side. The road leading into Cascade Springs and Wasatch Mountain State Park is visible between hills across the reservoir to the north (fig. 21). That road is on Triassic rocks beneath the Deer Creek thrust.

17.0 Mylonite zones in brecciated Oquirrh rocks. During the spring, the roadside is littered with small, angular blocks that have weathered out of the exposures.

17.6 Entrance to small fishing camp. The island in the reservoir to the north is composed of Twin Creek Limestone beneath the thrust fault (fig. 16). The hills to the east and south are carved in Mississippian and Pennsylvanian rocks in the thrust block above the fault. Note the brecciation of rocks on top of the island.

18.1 Pass between the island and the "mainland." Brecciated Cambrian limestone is exposed on the east side.

18.3 Angular, fragmental Tintic Quartzite (fig. 22), a Cambrian unit, exposed in roadcuts on the south.

18.5 Olive drab Cambrian Ophir Shale (fig. 3) in roadcuts on the south side of the road west of the junction.

FIGURE 21.–Mile 16.5. Cascade Springs road from across the reservoir. Overthrust Oquirrh and Cambrian rocks make up the majority of the outcrops in this photo.

FIGURE 22.–Mile 18.3. Brecciated Tintic Quartzite (Cambrian). It is suspected that the Cambrian is thrust over the Mesozoic rocks here. See figure 14.

18.6 UTAH 113 JUNCTION WITH U.S. 189. Turn north toward Midway along the east edge of Deer Creek Reservoir, into Charleston, on Utah 113. The flat floor of Heber Valley has been produced by fill related to damming of Provo River by landslides downstream in Provo Canyon. The fill is mainly coarse, boulder debris swept from the Uinta Mountains and volcanic hills to the east.

Heber City has a water-producing sewage system. Because of inseepage of groundwater, almost twice as much water is treated at the plant as goes through people's meters. Proposals have been made to sink wells and pump them to lower the groundwater table in order to lessen the water produced by the sewage system.

19.5 Pass old schoolhouse and new church house. The school is made of red Triassic sandstone. Directly across the lake, to the west, light colored Twin Creek Limestone is exposed beneath the Deer Creek thrust fault in railroad cuts. The reddish exposures farther south, along the west side, are brecciated Precambrian quartzite which has been thrust over the Jurassic rocks. The major fault trace crosses through the notch between the high railroad embankments west of Charleston.

20.3 Cross Provo River.

20.9 Cross tracks of Wasatch Mountain Railroad (Heber Creeper). Junction of Utah 220 with Utah 113. Utah 220, the wandering road to the west, leads into Cascade Springs and Wasatch Mountain State Park. Cascade Springs issue out of broken upper Paleozoic limestone at the Deer Creek thrust.

21.2 To the west the low terrace is one of the southernmost tufa cones in the Midway tufa complex.

21.5 The road rises from one of the low terraces of Provo River onto an intermediate terrace.

21.7 MIDWAY FISH HATCHERY. A federal hatchery is east of the road.

21.8 Rise on intermediate terraces onto one of the upper terraces of Provo River at the general level of the community of Midway. This terrace is underlain by sheeted tufas associated with springs to the north.

22.5 Enter Midway.

22.8 Turn east along MAIN STREET IN MIDWAY on Utah 113. Alternate Route 1 leads west to near The Homestead through tufa cone fields and rejoins the major route at mile 24.6 (see p. 27-30).

23.3 Turn north off Main Street on River Road at the east end of Midway.

23.6 WEST ENTRANCE TO MEMORIAL HILL, an outlier of Thaynes Formation (fig. 23). Continue north on Utah 113. The marshy area near the road marks a former position of Provo River.

24.0 Remnants of small "hot pot" tufa cones are visible 30 m west of the road.

24.1 Mountain Spa access road to the west. The Mountain Spa sign, to the west, is on top of a small tufa cone. The spa is developed around a warm spring and is situated on the flanks of a broad cone, visible

FIGURE 23.–Mile 23.6. Memorial Hill, which is made up of Triassic Thaynes Limestone and probably represents rocks below the Deer Creek thrust.

northwest of the sign. Many of these small conical mounds of calcium carbonate tufa occur in the northwestern part of Midway. Hills directly ahead are held up by Thaynes Limestone.

24.6 Right-angle bend toward the east. Hills immediately north of the junction are in Thaynes Limestone. A series of springs at the terrace edge east of the ranch buildings issues at the edge of a tufa apron, upon which the road is built. Tufa has cemented river gravel. The road continues on an upper terrace of Provo River. Provo River has reexcavated part of the fill of Heber Valley, leaving a series of low terraces, each one 1.5 to 5.0 m above the river plain. Hills east of Heber are in gray Keetley volcanic rocks. The weathered debris of volcanic rocks produces a particularly tight soil, as far as disposal of sewage is concerned.

25.6 Exposures of Thaynes Limestone in roadside cuts.

26.1 Borrow pit to the south. Notice the extremely gravelly nature of the fill and the river terraces. The road continues past somewhat fossiliferous Thaynes Limestone, on the north side.

26.6 Road drops onto the Provo River floodplain. Massive, angular, jointed Pine Creek stock shows well on the skyline to the northwest.

27.2 Cross Provo River. The marshy floodplain is typical. Gravel fill of the valley is probably carrying much more water than is evident in the river.

27.5 Cross irrigation canal.

27.7 ROAD JUNCTION OF UTAH 113 WITH U.S. 189. The Coyote Canyon Member of the Keetley volcanic series forms all the low country to the east. Turn north toward Park City and Silver Zone Junction on U.S. 189. Toward the west, the resistant igneous intrusions or stocks stand as high, barren, jointed exposures (fig. 24). The bedded limestone and other units into which the stocks have intruded are poorly exposed in scrub-oak-covered hills lower on the valley flanks.

FIGURE 24.–Mile 22.7. Tertiary stocks of the Park City complex make up the hills in the background. In the foreground are volcanic flows.

FIGURE 25.–Mile 29.4. Fractured Tertiary volcanic flow. Fractures develop perpendicular to the cooling surface and take on an outline similar to mudcracks.

28.3 Old power plant of Heber City to the east.

28.8 Broad bend in the highway. Jointed Keetley Volcanics are exposed in road quarries ahead on the west side of the canyon. Beyond that, on the skyline, the rounded hill, with the road around it, is on the Flagstaff Peak stock, one of a series of small stocks exposed from here west into Little Cottonwood Canyon.

29.4 Minor access road leading west to quarry in jointed, rhyodactie porphyry in the Keetley Volcanics (fig. 25). Notice the springs coming out of the jointed volcanic rock. The highway continues northward on the Provo River floodplain, surrounded east and west by Keetley volcanic rocks.

30.5 Cross Provo River at Jordanelle. Bluffs to the north are in massive tuffaceous rocks of the Keetley Volcanics.

31.7 HAILSTONE, ROAD JUNCTION OF ALTERNATE UTAH 189, east to Kamas, with U.S. 40 and 189. Turn east along the Provo River on Alternate U.S. 189. For an alternate route through Silver Zone Flats and along Interstate 80 to Wanship see Alternate Route 2 (p. 30). Toward the northwest, occasional glimpses can be seen of dumps associated with mines in the Park City district. The hills on either side of the Provo Valley, east of the junction, are in Keetley Volcanics with occasional, nearly buried, low exposures of Thaynes Limestone near the valley floor.

32.2 To the northeast, up the small gully, the rounded hill on the skyline is an inlier of Thaynes Limestone, surrounded by Keetley Volcanics. The volcanic rocks form castles and hoodoos where they become massive and, in part, have been rewelded after being extruded. Former, high positions of the Provo River, before excavation of the present canyon into the Keetley Volcanics, are marked by high-level terraces to south and north.

33.2 Double roadcuts through Thaynes Limestone. Rounded hills beyond the roadcuts are in Keetley Volcanics. This location is about the position of the proposed Jordanelle Dam on the Provo River. The volcanic rocks are fractured and highly porous in this area, which is reminiscent of the dam site for Deer Creek Reservoir. Here, instead of being on fractured Oquirrh quartzite, the site is on highly jointed, deeply weathered, altered rocks of the Keetley volcanic series.

FIGURE 26.–Mile 35.5. Brecciated Keetley Volcanics. Their source is uncertain.

FIGURE 27.–Mile 37.0. Fractured volcanics north of the road. These fractures are more widely spaced than those in figure 25. They are thought to have a tectonic origin rather than to have been formed from cooling.

34.7 Very coarse angular laharic breccia in the Keetley series. The coarse breccias hold up the more resistant units. Much of the rounded topography here is due to ease of erosion of the hydrothermally altered rocks, where some of the minerals have changed to clay.

35.3 Breccia which forms irregular castles in the hill on the north is part of the volcanic sequence.

35.5 Excellent exposures of laharic breccias (fig. 26). The road continues east through the laharic breccia remnants well exposed in bluffs on the north side.

36.1 Breccia exposed in bold bluff right at the roadside. Angular outcrops continue on both the north and the south sides of the canyon.

36.8 Bluffs of breccia are capped by high gravel terraces of the Provo River on the north side. The coarse, angular, fragmental nature of the breccia is well exposed here, as in outcrops immediately to the east.

37.0 Farmhouse. Angular breccia still forms the prominent exposures walling the canyon, particularly on the north side. Notice the very coarse angular jointing (fig. 27). The ledges here appear to be composed of at least two separate flow units, with a minor recessive tuff separating the massive rocks.

37.8 Well-exposed breccia.

37.9 Cross canal at the Wasatch County-Summit County line. The flat terrace ahead to the north is at the same general elevation as the high terraces downcanyon to the west. The terrace is the south edge of Kamas Prairie. The Provo River has now entrenched below the level of the Kamas Valley floor, but at one time headwaters of the Provo River drained northward from here into the Weber River. The Provo River has now been diverted again and recaptured by the lowered drainage from Heber Valley.

38.6 The road rises off the floodplain of the Provo River, beginning to cut up through volcanic rocks capped by quartzite pebbles.

38.8 Excellent exposures of coarse, high-terrace gravels, composed, in large part, of fragments of Uinta Quartzite (fig. 28).

39.3 Downtown FRANCIS, junction of Alternate U.S. 189 and Utah 35. Turn north on Alternate U.S. 189 toward Kamas, in Rhodes Valley, across the Kamas Valley floor, a gravel-veneered terrace cut on Keetley Volcanics. The western end of the Uinta Mountains is the high promontory to the northeast. High ledges to the east are held up by Paleozoic limestone and Precambrian quartzite. Those in the immediate vicinity are in large part the limestone, and the quartzite is exposed in the core of the mountains to the east. Rounded hills across the prairie to the west are held up by Keetley Volcanics. High peaks in the Park City district are on the skyline to the west, in the Wasatch Mountains.

41.3 ENTER KAMAS.

41.7 Junction of Utah 150 with Alternate U.S. 189 in downtown Kamas. Continue northward on U.S. 189.

44.2 Schoolhouse, Marion.

44.6 Alluvial fan material from canyons to the east is exposed in the borrow pit.

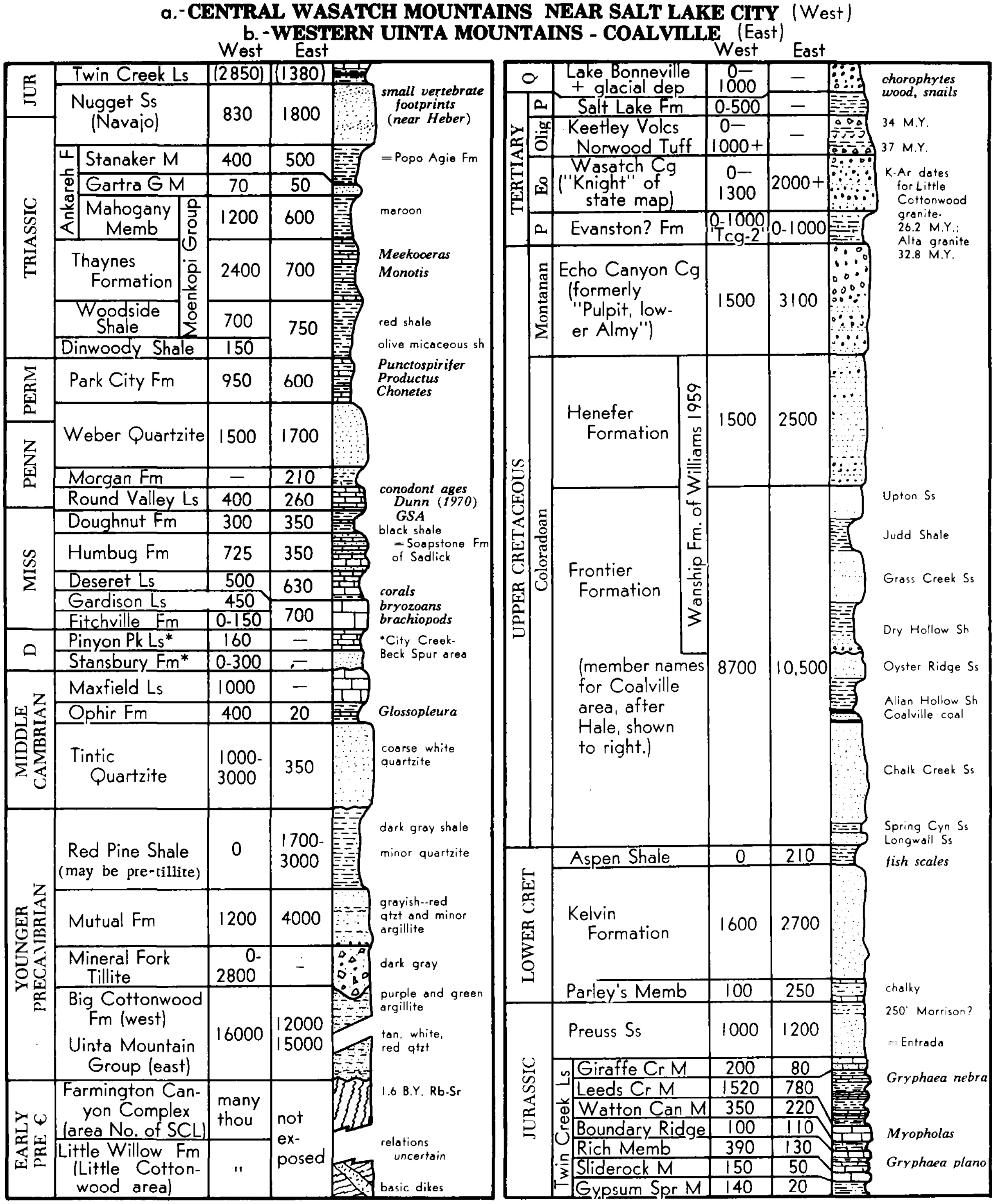
46.7 ENTER OAKLEY. The town is in the Weber River drainage which comes off the north flank of the Uinta Mountains.

46.8 Cross Weber River, with several channels of the river on the floodplain.

47.4 Drive up off the floodplain of the Weber River across several terraces. To the east, on the north flank of the Uinta Mountains, the strong dip slope south of the Weber Canyon is on the Park City Group (fig. 29). Weber Canyon is carved into Triassic rocks, with Jurassic Nugget Sandstone forming the strong cuesta (fig. 30) on the north side. The area directly north of Kamas is underlain by conglomeratic units derived from the Sevier orogeny. These conglomerates unconformably overlie the strongly tilted older rocks.

48.0 Major bend in the road toward the west. Cretaceous and Tertiary conglomerates form the

FIGURE 28.–Mile 38.8. Boulder gravels that infill Rhodes Valley. These gravels were deposited by streams, some of which were of glacial origin.



West (Wasatch Mountains): Crittenden (1963, 1964, 1973); Stokes (1969)

East (Western Uinta): Williams (1957); Sadlick (1957); Cohenour (1959a); Hale and Van De Graaff (1964); Trexler (1966); Bissell (1964b)

Mississippian: Foutz (1966); Arnold and Sadlick (1962); Permian: Williams (1969); Triassic: Smith (1969); Jurassic: Imlay (1967); Cretaceous-Eocene: Hale (1969); Mullens (1969a); Quaternary: Arnow and Mattick (1968); Radiometric dates: Armstrong (1970a); Crittenden (1968, 1973)

FIGURE 29.–Stratigraphy of Weber Canyon-Uinta Mountain area (chart 13, Hintze 1973).

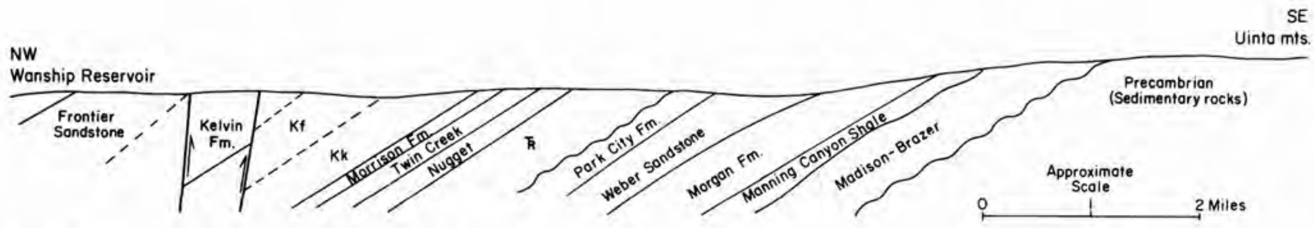


FIGURE 30.–Generalized cross section of northwest flank of Uintas.

rounded, brush-covered hills north of the valley. Keetley Volcanics are exposed in hills to the west.

48.7 The road drops beneath the Kamas Valley floor, down along Fort Creek, a small tributary canyon to the entrenched Weber River. To the southwest, across the Kamas Valley floor, high-level terraces are cut into the Keetley Volcanics. Roadcuts are in coarse, rounded, quartzite boulder debris armoring the terrace above the gully which leads down into Peoa.

49.5 ENTER PEOA.

50.1 Poor exposures of red Nugget Sandstone on the north side of the road. This formation contains the oil in the Pineview oil field north and east of Coalville.

50.4 Main road intersection in Peoa. Turn north and continue on U.S. 189. Wooden Shoe Canyon is the flat along the Weber River to the south.

50.9 Peoa Cemetery. Thin-bedded, steeply dipping Nugget Sandstone is exposed immediately north of the cemetery (fig. 31).

51.1 Contact of the Nugget Sandstone with the Twin Creek Limestone. The Twin Creek Limestone has been intensely jointed (fig. 32). The lower part of the formation is a very fine-grained, argillaceous limestone. The upper part, however, becomes slightly gypsiferous and contains interbedded sandtone in minor red beds.

51.3 Used car dealer on the hill. Road coming in from the west.

51.7 Red beds of the Kelvin Formation (fig. 29) angularly overlie the more strongly folded beds below. Low, resistant units in the Kelvin Formation are conglomerate and sandstone beds.

51.9 Excellent exposures of conglomeratic Morrison Formation in double roadcuts (fig. 33).

52.4 Gentle bend in the road. Frontier Sandstone forms the tan, steeply dipping beds to west and east. On the west side, steeply dipping Cretaceous beds have been cut across by high-level terraces.

FIGURE 31.–Mile 50.9. Outcrop of Jurassic Nugget Sandstone. Thin bedding permits the sandstone to be used as a decorative stone. This sandstone contains oil in Pineview field.

FIGURE 32.–Mile 51.1. Outcrop of Twin Creek Limestone. This limestone is a reservoir for oil and gas in Pineview field.

52.9 Cross Weber River. Excellent exposures of Frontier Sandstone, with alternating shale slopes, form the wall on the west side of the canyon (fig. 34).

53.3 ENTRANCE TO ROCKPORT LAKE STATE PARK AREA. Interbedded bentonitic shale and ripple-marked sandstone of the Frontier Formation (fig. 29) are well exposed on bluffs west of the road. This same formation has caused considerable slumping along the freeway between Coalville and Echo Junction, to the north.

53.7 Cross a small fault which drops the Kelvin Formation down against the Frontier Formation. Kelvin beds look much like Frontier beds, but have considerably more interbedded shale and light reddish beds (fig. 35). The Kelvin Formation forms broad, low passes.

FIGURE 33.–Mile 51.9. Outcrop of the Morrison Formation, famous for its dinosaur fossils.

54.1 Along the road there is a small slump of the Kelvin Formation. This formation has been eroded to form the low valleys to the southwest, as well as the rounded valley to the northeast.

54.3 Cross a minor fault.

54.4 Conglomeratic sandstone in the Kelvin Formation. Side road to the Utelite Quarry to the southwest. The highway continues through tan shale and siltstone of the Frontier Formation. Kelvin reddish shale and siltstone are exposed in roadside cuts to the north.

55.0 Excellent exposures of the Kelvin Formation. Reddish shale and siltstone, with interbedded white sandstone, are exposed in double roadcuts (fig. 36).

55.3 Excellent bentonitic, popcorn-weathering shales.

55.6 Lake Rockport development on the west, in Kelvin Formation. Bedded sandstone on the skyline to the northwest and prominent white sandstone across Rockport Lake to the east are in the Frontier Formation.

56.3 Fault separating the Kelvin Formation from Frontier beds at the northwest edge of a graben. Excellent exposures of Frontier Formation continue along the road from here to the dam. Massive sandstone at the northeastern bridge abutment is Frontier Sandstone.

56.8 Wanship Dam on Rockport Lake (fig. 37). Character and attitude of the bedrock makes this a good dam site. Frontier beds to the east dip at almost the same angle as the slope of the spillway at the east end of the dam.

57.7 South edge of Wanship, near the large highway maintenance shed and Wanship Cemetery. Upfaulted Morrison Formation is exposed in bluffs behind the cemetery. The Weber River has an exceptionally well-developed floodplain, with the river meandering back and forth across the partially refilled, alluviated valley

FIGURE 34.–Mile 52.9. Angular unconformity with flat Tertiary rocks deposited over nearly vertical Cretaceous rocks.

FIGURE 35.–Mile 53.7. Outcrops of Kelvin Formation. The Kelvin is a fluvial and marginal marine formation.

bottom with older terraces along the valley walls (fig. 38). Exposures immediately to the north, in the vicinity of the freeway and west of it, are Kelvin beds, north of the small fault-repeated Jurassic section. High to the west, the hills are capped by Keetley Volcanics, but to the east the Eocene Knight Formation (fig. 29) unconformably overlaps the folded Mesozoic rocks.

58.3 Junction with access road for Interstate 80. Turn right (northeast) onto Interstate 80. Alternate Route 2 joins the main route here after passing near Park City and Silver Zone Junction.

58.5 JOIN THE MAIN FREEWAY IN WANSHIP. To the northwest, just north of the town of Wanship, massive purplish gray breccia of the Keetley volcanic series forms angular cliffs, like those southwest of Kamas.

59.0 Cross the Weber River.

59.9 Cross beneath underpass. Keetley volcanic rocks are exposed in bluffs undercut along the Weber

FIGURE 36.–Outcrops of Kelvin Formation.

FIGURE 37.–Mile 56.8. Wanship Dam constructed on the Frontier Sandstone. Note that the rocks dip downstream. See figure 30.

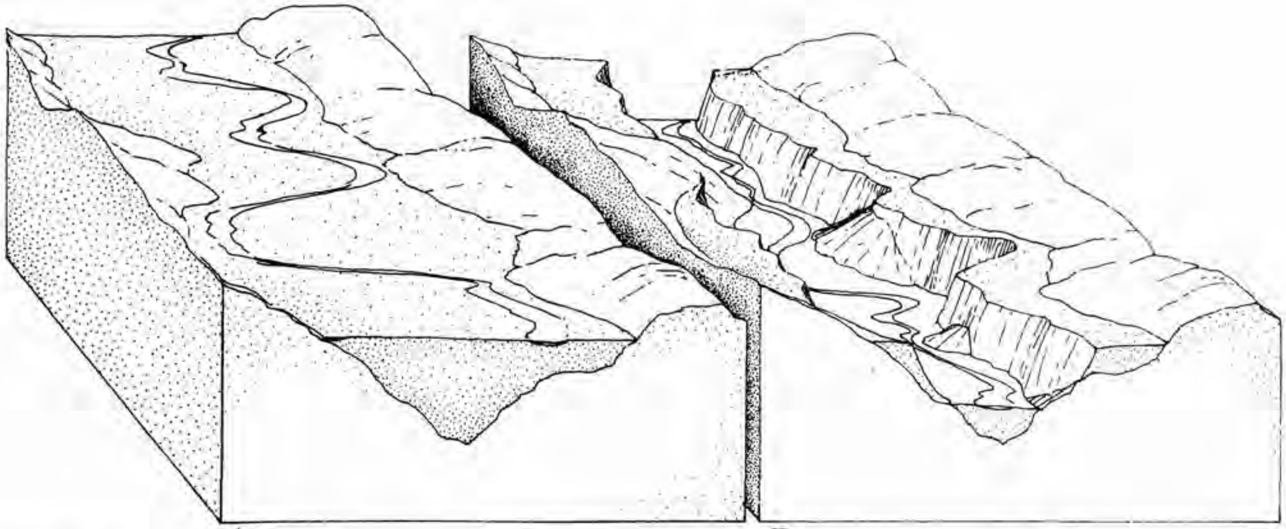


FIGURE 38.–Block diagrams that illustrate the infilling of the valleys and subsequent erosion that accompany regional uplift. Both the Weber and Provo River drainage systems show several stages of terrace development.

River, toward the west. Toward the east, major quarries utilized in construction of the freeway are in terrace gravels associated with the Knight Formation.

61.4 Railroad overpass. Pinkish beds of the Knight Formation appear ahead, on both the west and the east sides of Coalville Valley.

62.1 Underpass.

63.3 Overpass over access road. Road quarries in alluvial fan material to the east are at the south end of Hoytsville. Old Weber River terraces show along the lower valley walls.

65.8 EXIT TO COALVILLE. South-dipping Kelvin Formation exposed to the east and southeast and Frontier Sandstone to the west.

66.0 Bridge beneath the access roads at the Coalville interchange.

66.2 Junction of the entrance from Coalville to Interstate 80.

66.4 Bridge over the Weber River. Excellent exposures of the Cretaceous sandstones and coal-bearing sequence in cuts directly ahead, with the massive, light colored, resistant sandstone forming the cap and the shaly, coal-bearing beds forming exposures below in the roadcuts. All are locally slumped.

67.1 Barrier beach sandstone in the Frontier Formation, regressive over marine shales, is exposed in roadcuts on the west (fig. 39) and across the reservoir to the east.

67.3 Landslide scar in some of the shales slumped down onto the eastbound lane. Frontier shales and coaly beds are between the two resistant sandstones. This area will migrate for some time because of bentonitic shales associated with the Cretaceous coaly beds.

68.1 Excellent exposures of Cretaceous Frontier siltstones and shale, capped by massive sandstone, in both east- and westbound lanes on the west side, at the head of the reservoir.

68.4 Exit to view area.

68.6 ROADSIDE REST AREA ALONG ECHO RESERVOIR. This high vantage point provides a tremendous view of the coal-bearing sequence in the middle and lower part of the Frontier Formation toward the south. Directly west of the rest area is exposed a late angular unconformity with nearly flat-lying, probable river-terrace sediments over the upper part of the Frontier Formation (fig. 40). Toward the northwest, additional upper sandstones of the Frontier Formation (fig. 41) form cuestas between valleys carved on moderately carbonaceous shales and thin, shaly coal interbedded with tan limestones. The upper part of the sequence here appears to represent sediments deposited on an upper deltaic plain. The grayish and maroon beds in the outcrop across the road from the rest area appear to be lower delta plain sediments, perhaps even including minor brackish interdistributary shale facies and interbedded minor splay sandstone lenses.

FIGURE 39.–Mile 67.1. Frontier Sandstone makes up the capping rock in outcrops along Interstate 80.

Broad Grass Valley Canyon, across the reservoir northeast, is in uppermost Frontier Sandstone and lower Wanship Formation. The Wanship beds, to the north, appear to be overlain with moderate angularity, maybe 10° difference in dip, by the Echo Canyon Conglomerate. The latter formation forms the rounded, pinkish and gray juniper-covered exposures due north and northwest, around the dam.

Active slopes are slumping down along the roadway in many of the bentonitic shale units. In some places the roadway itself is moving, particularly where there is fill over the clay-shale soil.

Pineview Oil Field

The Pineview oil field lies approximately 18 km east of Coalville (fig. 1). It was discovered in 1972 by a group of oil companies operating together on the second well drilled in the area. The first well, drilled in late 1971 and early 1972, was declared dry and was abandoned despite the fact that a drillstem test of the upper Nugget recovered 360 feet of mud and approximately 800 feet of slightly gas-cut salt water. Recorded pressures in the hole were high. After the discovery well, No. 1 Newton Sheep Company, was drilled and declared successful, the first well was reentered and completed as a prolific oil and gas well.

The field produces primarily from the Jurassic Twin Creek Limestone and Nugget Sandstone. Source of the oil is thought to be Cretaceous shales. The producing structure is an asymmetrical anticline on the overriding sheet of a thrust (fig. 42). The thrust is part of the Absaroka Thrust Fault and can be traced northward across much of western Wyoming and into Montana.

The field is a highly successful one with the first 26 wells all producers. Wells produce 200–500 barrels

FIGURE 40.–Mile 68.6. Angular unconformity with dipping Cretaceous rocks under flat Tertiary rocks.

FIGURE 41.–Cretaceous Frontier Sandstone with minor coal beds.

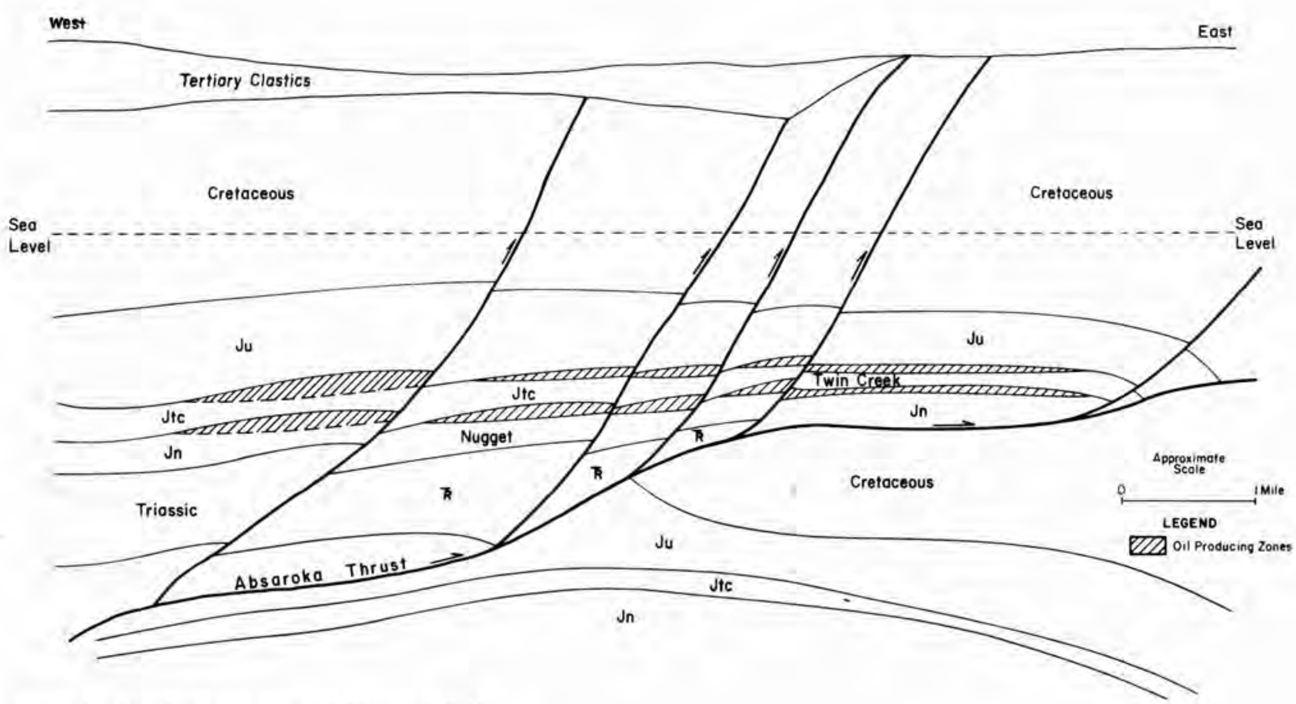


FIGURE 42.–Generalized cross sections of Pineview oil field.

of crude and 1 to 2 million cubic feet of gas daily. The limits of the field are yet to be determined (1980), but it is estimated that the recoverable reserves are from 300 to 500 million to 1 million barrels. The Pineview oil field is one of the most significant petroleum finds in the United States in recent years and points out the potential of the thrust belt in northern Utah.

A side trip to the oil field can be taken by driving north through Coalville on the old highway to the junction with Utah 133. Then, follow Utah 133 about 18 km east. There are several signs to indicate the way, and drilling rigs can usually be seen. If you choose to make this side trip, it will be necessary to return to rejoin the guidebook route at either the Coalville or the Echo Junction interchange.

68.7 Return to the freeway.

69.2 Excellent exposures of bedded sandstone and gray carbonaceous shale in the Wanship Formation, dipping toward the northwest.

69.5 Dropoff of the margin of the roadbed where the active slump is moving the rocks and road downslope.

69.6 Conglomeratic units in the lower part of the Echo Canyon Formation in exposures on the south side. This part of the road will continue to slump actively for some time because of the dip of the beds and the composition of the units.

70.2 Unstable slope slumping onto the freeway, almost opposite the south abutment of the Echo Reservoir Dam (figs. 43, 44). Attitude and composition of the bedrock make this a good reservoir site, even though there is movement of slopes along the valley wall.

70.8 Cross Weber River. Immediately after crossing, take Interstate 84 westward off Interstate 80 and cross overpass over the freeway. View back to the east shows slumps in relationship to the freeway and Echo Dam (fig. 44).

71.1 ECHO JUNCTION. Enter Interstate 84 heading west. The Echo Canyon Conglomerate is well exposed in bold bluffs along both sides of the freeway, particularly in the railroad cuts to the northwest (figs. 45, 46).

72.4 Cross synclinal axis. Rocks in the Echo Cliffs to the east dip toward the west; those that form small castles and hoodoos ahead dip toward the east.

73.0 Hoodoos in Echo Canyon Conglomerate (fig. 47), exposed on the north side of the road, now dip moderately steeply toward the east in beds above the major unconformity.

73.9 Exposures of the upper part of the eastward-dipping Frontier Formation below nearly horizontal Tertiary beds. Pipeline right-of-way shows on Wasatch Mountains to west at 11:00 o'clock (fig. 48).

74.3 Excellent exposures of eastward-dipping Frontier Sandstone in cuts north of the railroad.

74.4 Underpass beneath access road. Much of the valley floor here, near Henefer, is blanketed with Weber River gravels. These gravel deposits lap out onto the Tertiary Knight and the older Cretaceous rocks around the valley flank. Directly ahead, the massive Echo Canyon Conglomerate, uplifted along a fault,

FIGURE 43.–Mile 70.2. Slope failure in Cretaceous shales. Failures of these shales threaten the highway continually.

FIGURE 44.–Size of slope failure can be seen in this photo. Landslide is more than 183 m wide.

FIGURE 45.–Outcrops of Echo Canyon Formation, which is mostly conglomerate and is thought to be a rock unit made during orogenic movements.

FIGURE 46.–Closeup view of Echo Canyon Formation.

unconformably overlaps some of the older rocks down Weber Canyon (fig. 49).

77.3 Cross Weber River. The bold escarpment ahead (fig. 49) is a fault-line scarp of a major north-south-trending fault. The fault is mappable from here southward to east of Salt Lake City and is down-dropped on the east.

78.2 CROSS BRIDGE OVER THE WEST HENEFER INTERCHANGE near the boundary fault which separates the major conglomerates, to the west, from fill of Henefer Valley, to the east (fig. 50).

78.7 Excellent exposures of the very coarse Echo Conglomerate, both along the railroad to the north and in freeway cuts to the south.

79.3 Exposures of Twin Creek Limestone, near the river, are angularly overlain by the gently eastward-dipping Echo Canyon Conglomerate.

79.7 Cross a bridge over accessway to major quarry and cement operation in the Twin Creek Limestone on the north. Twin Creek Limestone is particularly sought after because it has about the right mixture of calcium carbonate and clay to make portland cement. Ripple-marked beds are well exposed in steeply dipping Twin Creek Limestone in cliffs south of the interchange.

80.2 VIEW AREA AT DEVIL'S SLIDE, which is eroded into vertical Twin Creek Limestone (fig. 51).

80.4 Basal contact of the Twin Creek Limestone above the Nugget Sandstone in a small quarry. Ripple-marked, siliceous, angular-weathering sandstone is standing on edge north of the railroad. The small quarry is in the basal part of the Twin Creek Limestone.

80.6 Base of the Nugget Sandstone and top of the Ankareh Formation. The Ankareh Formation is a dominantly shaly unit and forms the deep subsequent valley of Cottonwood Canyon to the north.

81.0 Upper Thaynes Limestone is excellently exposed as alternating red beds and limestones in the cuts to the north along the old highway.

81.3 Calcareous beds of the Thaynes Limestone are exposed in roadcuts and the steep cockscombs north and south.

81.5 Cross the old highway on a bridge which loops across the Weber River.

81.7 Contact of the red Woodside Shale with overlying gray Thaynes Limestone. The outcrop exposes abundant ripple marks along the old road (figs. 52, 53, 54).

81.9 White-weathering limestones of the Park City Formation are exposed particularly well on the north side. Some phosphatic black shale forms cockscombs and dark gray reentrants on the slope to the south, particularly up near the telephone poles.

82.2 Small diggings here are in phosphatic shales in the upper part of the Park City Formation. The shaly units are exposed in the cuts in the south side of the canyon.

82.4 Contact of Park City Formation and Weber Formation.

82.5 Bridge over the old highway just short of the Taggart exit. Steeply eastward-dipping Weber Formation exposed in bluffs on the north and south sides of the highway. Immediately west of the Taggart Interchange, the Weber is flat lying, and then dips toward the southwest.

82.9 BRIDGE OVER THE TAGGART INTERCHANGE. The highway heads south, along the crest of the small anticline (fig. 55) in the Weber Formation, with the Morgan Formation exposed in the core at road level.

83.3 Axis of a small syncline in the Weber Formation, almost at the major bend in the highway. Thin platy limestone in cuts on the north are in the Morgan Formation.

83.5 Cross Weber River again.

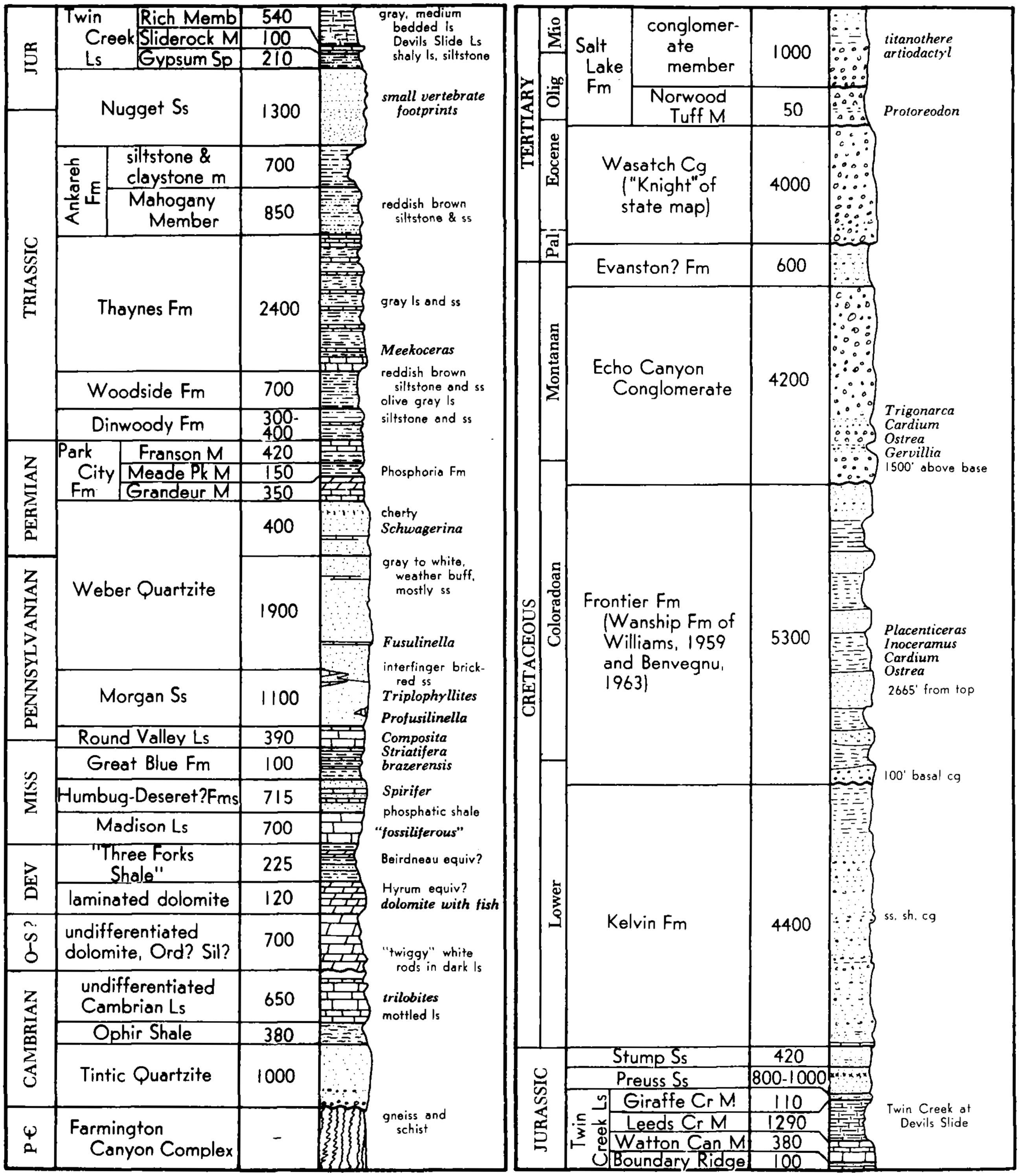
83.7 Double roadcuts and a small anticline in the faulted Morgan Formation.

84.4 The Pennsylvanian Morgan Formation is exposed in the lower part of the bluffs on the north side of the road as fossiliferous, ragged, cherty-appearing units (fig. 56). Weber Canyon spreads out here, largely because of the ease with which Morgan Limestone and shale sequences are weathered.

85.2 Bridge over ranch exit. Toward the northwest, reddish outcrops are Morgan Formation and Round Valley Limestone stained from the overlying Morgan Formation. These limestone ledges are particularly fossiliferous. The banded slope and ledge topography of the massive limestone alternating with the calcareous shales is typical. Echo Canyon Conglomerate is exposed along the skyline to the south. It is flat-lying and rests unconformably on the folded and faulted Paleozoic rocks.

86.1 Massive, resistant Round Valley Limestone ledges on both sides of the canyon. Prominent dark gray, fine-grained limestone is exposed in roadcuts on the north side.

WEBER CANYON NEAR DEVILS SLIDE



After: Mullens and Laraway (1964); Eardley (1944); Schick (1955); Benvegnu (1963); Madsen (1959), Mullens (1971); Nelson (1972)
Permian: McKee and others (1967); Jurassic: Imlay (1967); Stokes (1959); Cretaceous: Williams and Madsen (1959)

FIGURE 47.–Stratigraphy of Weber Canyon (chart 9, Hintze 1973).

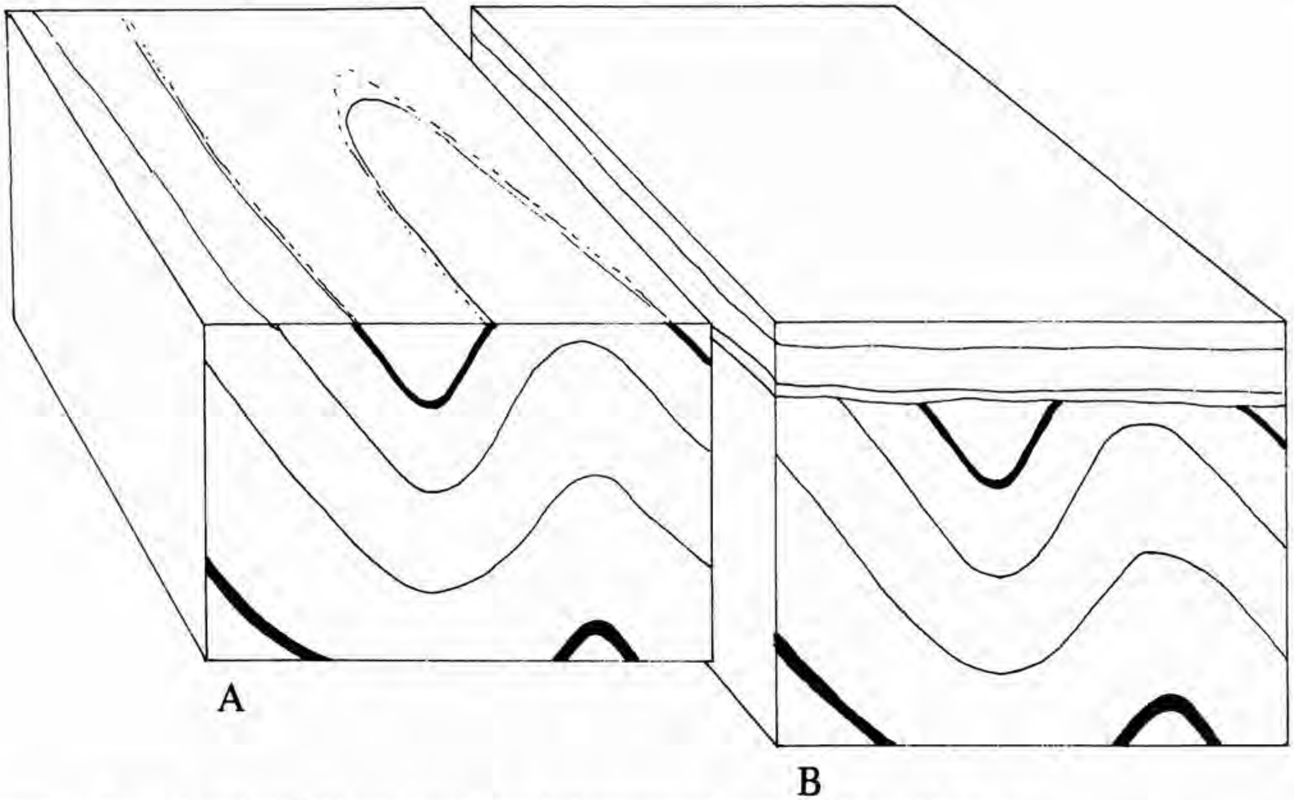


FIGURE 48.–Diagram illustrating the folded Cretaceous and older rocks that were eventually overlain by deposits of Tertiary age.

86.4 Pass beneath the thick-bedded Mississippian-Pennsylvanian Round Valley Limestone into thin-bedded, more slope-forming Great Blue Formation (fig. 57) where the canyon widens out.

87.0 Well-bedded Madison and overlying Humbug-Deseret beds are steep cliffs and roadside bluffs on the north side.

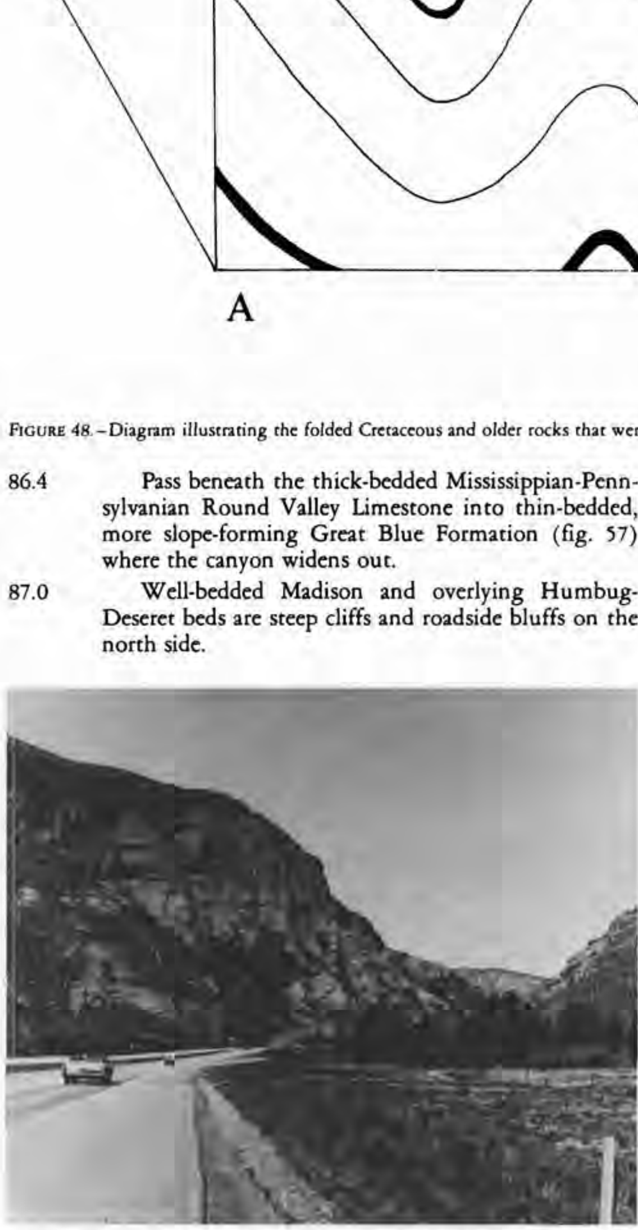


FIGURE 49.–Mile 77.3. Boundary fault at mouth of Weber Canyon separates Tertiary from Mesozoic rocks. See figure 50.

87.3 Vuggy, deeply weathered Madison Limestone exposed in cliffs just east of the Morgan East exit.

87.5 CROSS OVER THE EASTERN ACCESS ROAD INTO MORGAN. Reddish exposures to the north of the road are downfaulted Tertiary sandstones and siltstones of the Wasatch or Knight Formation, here infilling Morgan Valley. Much of the rolling topography in the immediate vicinity of Morgan is on the Salt Lake Formation or the Norwood Tuff Member which forms the light colored, ashy-appearing exposures around the flanks of the hills.

89.1 Bridge over ranch road exit. Quarries to the north are in terrace gravel which has partially buried the Norwood Tuff. Several uintatheres have been collected from the Norwood Tuff, in the vicinity of Morgan. These fossils indicate an Oligocene age for the sequence. Francis Peak and the other glaciated high ranges to the west are in Precambrian rocks which are involved in thrust slices in the Wasatch Mountains (fig. 58).

90.5 Underpass beneath Morgan access road. Mount Ogden directly ahead to the northwest, is composed of Precambrian quartzites involved in one of the major thrust slices of the Wasatch Mountains. Hummocky topography in the area north of the road is related to minor slumping on the Norwood Tuff and underlying Tertiary beds.

92.5 Double cuts through gravelly terraces of the Weber River. Just beyond the double cuts, Norwood Tuff is exposed on the north side of the hill beyond the small farming community of Stoddard.

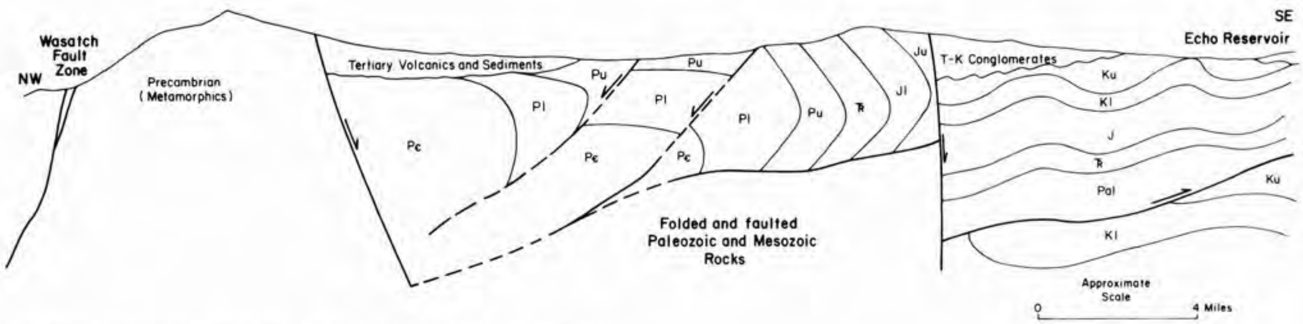


FIGURE 50.–Generalized cross section from Weber Canyon to Echo Reservoir.

93.4 Bridge over the access road to Enterprise.

95.3 Bridge over the Peterson, Mountain Green interchange. Exposures in the banks on the west side of the valley are in Norwood Tuff.

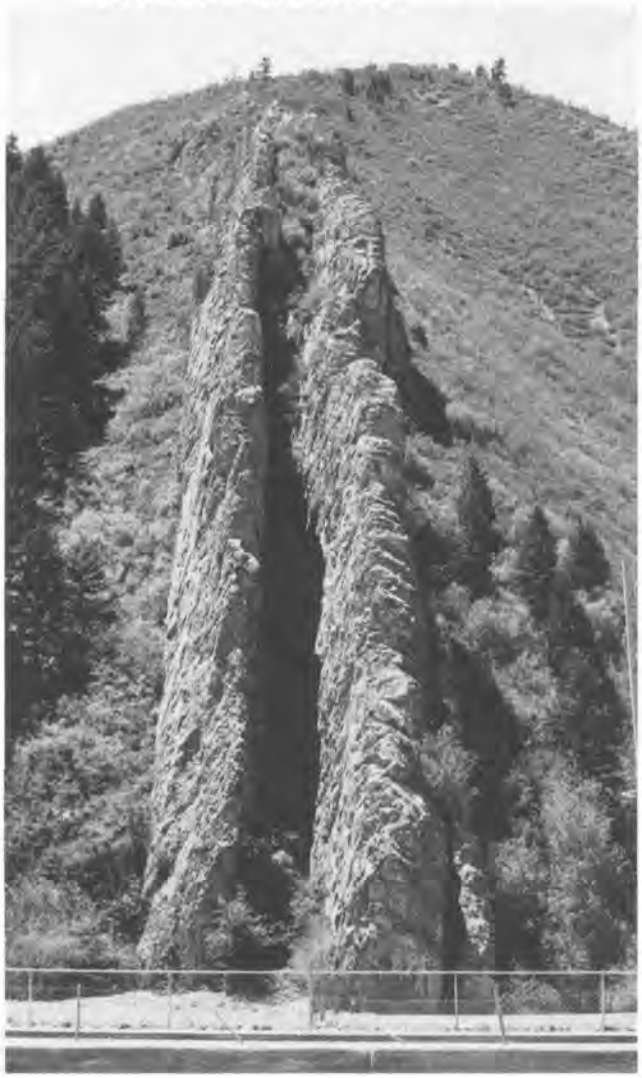


FIGURE 51.–Mile 80.2. Devil's Slide. Limestone units of the Twin Creek are nearly vertical. Cement is made from the Twin Creek Limestone at nearby Croydon.

96.3 The freeway drops down to near the Weber River floodplain. Moderately high terraces of the Weber River show immediately north of the highway.

98.0 Interchange entrance. The hummocky topography both north and south is on slide debris and is associated with movement in the tuffaceous volcanic rocks (fig. 59) which partially fill Morgan Valley. Slumping of the Norwood Tuft has caused occasional roadbed failure on the Union Pacific Railroad, resulting in derailments.

98.5 MOUNTAIN GREEN, on the north, is having some trouble with slumping. Mountain Green is on the backslope of Mount Ogden. The eastern escarpment of the Wasatch Mountains is a faultline scarp parallel to the one east of Devil Slide.

99.6 Bridge over the access road in the mouth of the canyon.

99.8 Double railroad bridge. This is approximately the location of the boundary fault which separates the Precambrian metamorphic rocks of the Wasatch Mountains from the Tertiary and Paleozoic rocks of Morgan Valley. V-shaped canyon is typical of streamcut gorges where rocks are resistant.

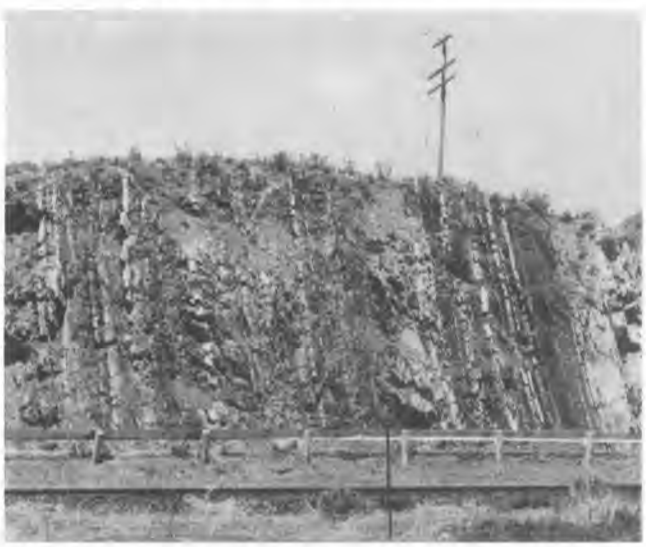


FIGURE 52.–Mile 81.7. Outcrop of the Triassic Woodside. Thin beds of siltstone and limestone are indicative of marginal marine sedimentation.

100.6 Rest area on the south side. Precambrian rocks are overgrown with conifers on the south side. Contrast with the scrub-oak-dominated cover on the north side is considerable.

101.0 Old highway side road off the freeway to the north, just before a major bridge over the Weber River and the railroad, leads to excellent exposure of Precambrian gneiss and schist (fig. 60) cut by coarse pegmatite dikes (figs. 61, 62).

101.6 Cross the Weber River on the freeway.

102.4 Ragged exposures in the V-shaped canyon are Precambrian metamorphic rocks, moderately high-rank gneiss and schist.

102.8 Weber Power Plant of Utah Power and Light Company. Notice the retaining wall on the uphill side, at the mouth of the small canyon with an alluvial fan.

103.8 Mouth of Weber Canyon. The highway crosses the Wasatch fault close in against the hills. Lake Bonneville reached to the Wasatch Front (fig. 63).

104.3 EXIT TO OGDEN AND U.S. HIGHWAY 89. Keep on the interstate west over the Ogden interchange.

104.4 Bridge. Continue west on Interstate 84. Exit for southbound U.S. 89 to Hill Air Force Base and Salt

FIGURE 53.–Ripple marks and mudcracks are common in the Woodside.

FIGURE 55.–Mile 82.9. Anticline in Weber-Morgan Formation.

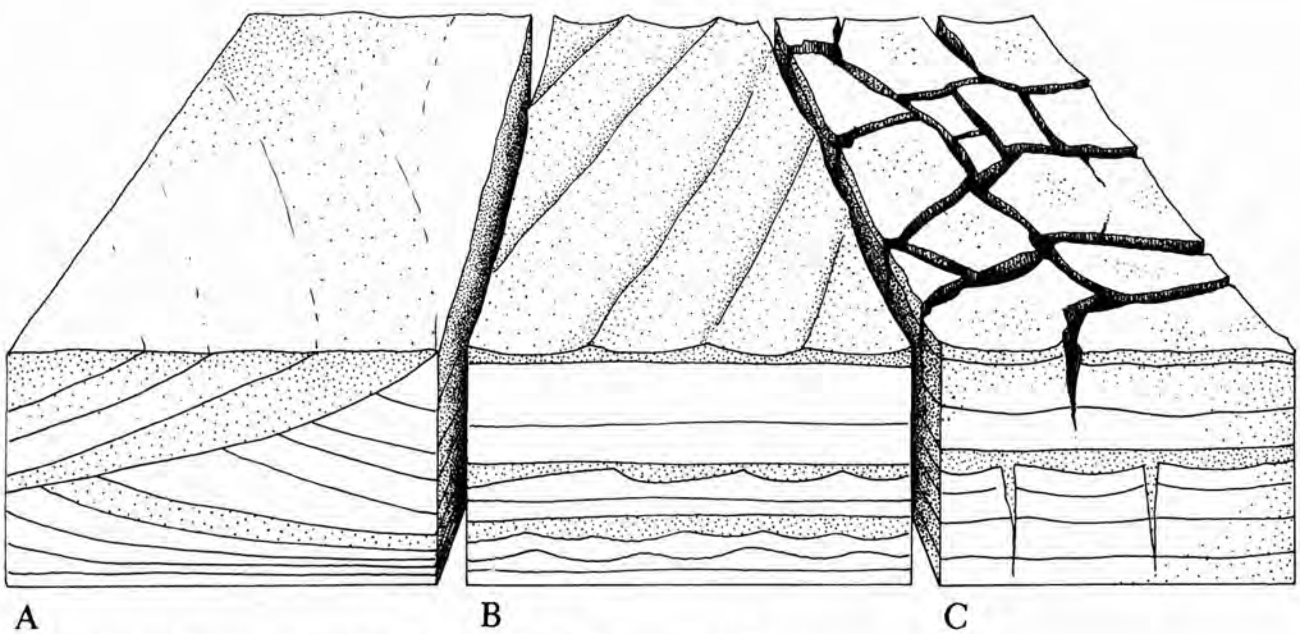


FIGURE 54.–Diagram of cross-beds (A), ripple marks (B), and mudcracks (C) common in the Woodside.

FIGURE 56.–Mile 84.4. Excellent outcrops of Morgan Formation.

Lake City at west end of bridge. Deep gravel pits (fig. 64) are in Lake Bonneville and Weber River gravels south of the highway.

104.7 Cross the "channeled" Weber River through gravel pits which expose the coarse cobbles and boulders of the valley fill. Terraces on both sides of the valley are the upper levels of a delta built out into Lake Bonneville by the Weber River, at the Provo stage of the lake. After higher stands at approximately 1,585 m, the lake level dropped to approximately 1,463 m following spilling out of the basin through Red Rock Pass north of Logan (fig. 63).

106.0 Major bend in the highway. Walls of the inner "gorge" have a hummocky topography characteristic of slumping and landslides (fig. 65). The water-saturated sediments of the Weber Delta are moving down into the river valley. Some of the slumps are still active, as indicated by prominent scars and escarpments, often marked by springs or boggy areas, where the slumped silt masses have pulled away from higher levels.

106.3 Most of the Lake Bonneville deposits here are Alpine Silt, a part of the delta which is particularly prone to slumping. It is largely responsible for the irregular topography of the walls of the valley.

107.5 Large landslide scars on the north (fig. 66), opposite the bridge over the interchange. Alpine Silt is well exposed in the arcuate escarpments at the head of the landslides.

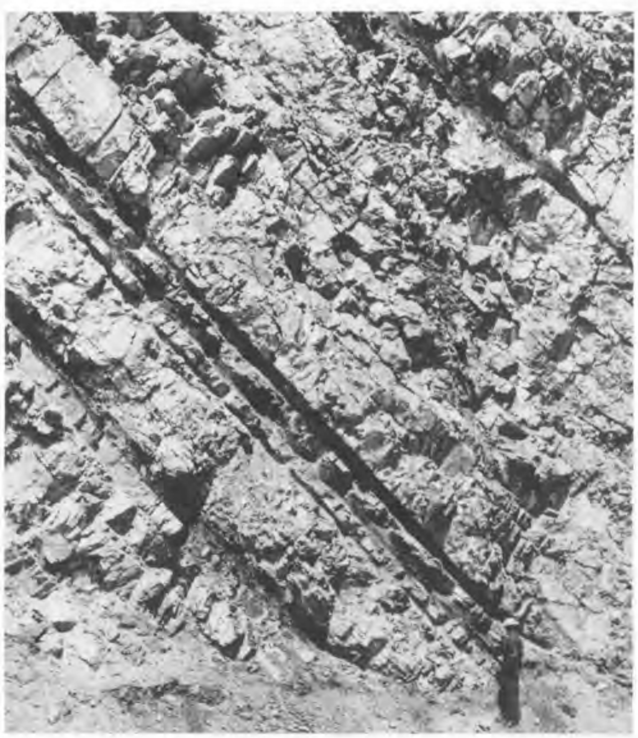


FIGURE 57.–Mile 86.4. Outcrops of the Mississippian Great Blue.

FIGURE 58.–Rugged, mildly glaciated mountain peaks of the Wasatch Range. Francis Peak is in the right background.

109.3 Weber River swings toward the north. Ben Lomond Peak and other high peaks of the Wasatch Mountains are visible toward the north. These mountains are part of thrust fault slices of Paleozoic and Precambrian rocks. The frontal part of the delta is still exposed to the south but is terminated toward the north where the Weber River has widened its floodplain.

110.5 RIVERDALE EXCHANGE. Access roads lead northward toward Ogden and southward toward Salt Lake City and Interstate 15. EXIT HERE FOR ACCESS TO SOUTHBOUND INTERSTATE 15. Northbound traffic continues ahead through the interchange. Beyond the bridge the road climbs from the Weber River floodplain onto the western part of the delta through which it has cut. The upland is gravel-capped silt at the Provo level.

111.0 Bridge provides an excellent view toward the east of the Wasatch Mountains, over the flat benchlands of the Weber River delta, to the V-shaped canyon of the river through the range. Higher levels of Lake Bonneville have notched wave-cut terraces into the Precambrian rocks of the front. Bedded rocks of the peaks are in fault slices.

111.3 JOIN INTERSTATE HIGHWAY 15, northbound, toward western Ogden. END OF ROAD LOG.

ALTERNATE ROUTE 1: MIDWAY TO THE HOMESTEAD AND AROUND NORTHWESTERN PART OF THE VALLEY

0.0 INTERSECTION OF UTAH 113 WITH UTAH 224 IN DOWNTOWN MIDWAY (mile 22.8 of main route). Turn westward along Main Street in Midway toward The Homestead and Wasatch Mountain State Park.

0.2 City Hall of Midway, a distinctive half-timbered structure, built of what the local people call "potrock." Potrock is tufa quarried from cones and sheets in the vicinity of the town.

0.3 Sharp turn toward the north onto 200 West Street.

0.5 Sharp turn toward the west. At intersection with 200 North Street, remain on Utah 224.

0.9 Cross Snake Creek and climb to the west onto terraces associated with the creek, at the eastern base of the oak-covered hills of Weber Quartzite. Older homes on the west side of the creek are stuccoed potrock or bare potrock, typical of structures built in the late 1800s by the Swiss population.

1.5 View over Heber Valley to the east. Most of the low, rounded hills within a mile or two to the east and northeast are tufa cones associated with springs along the west side of the valley.

1.8 SIDE ROAD TO THE HOMESTEAD, an inn. Continue on Utah 224. The high cone east of the road at The Homestead (fig. 67) is one of the most prominent tufa cones in the valley and was built by a thermal spring which was active until water was diverted to the swimming pool at the inn.

2.0 Low cones to the west (figs. 68, 69) in the immediate vicinity of the road are active springs. Turn left,

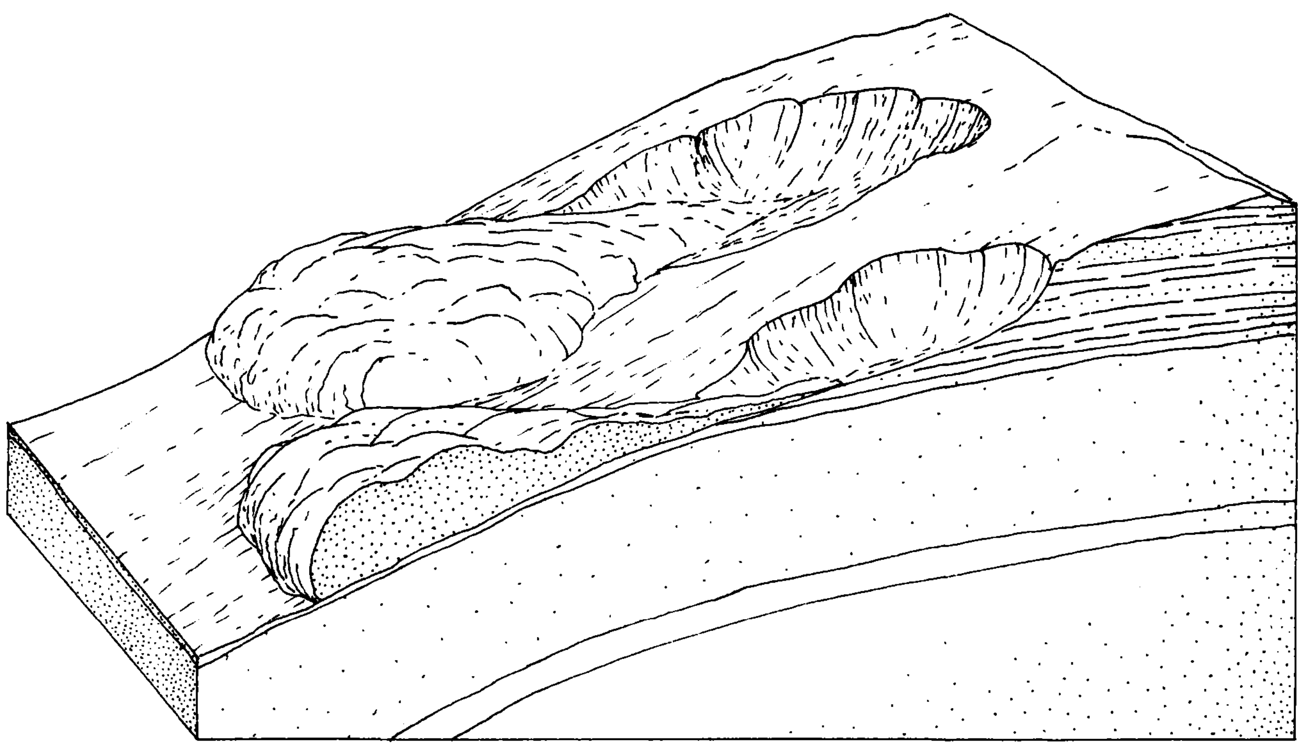


FIGURE 59.–Diagram of slope failure by mudflow. Mudflows are common in certain Tertiary units in the valley.

off Utah 224, and park near one of the cones. These cones were formed from calcium carbonate deposited by mineral-laden water flowing to the surface. The water is oversaturated with calcium carbonate precipitated as the spring water evaporates or as it loses dissolved CO_2 gas. The tufa, or potrock, formed by this process is porous and is the source for local building materials. Water associated with these tufa cones varies in temperature from spring to spring; most are warm, but some are cold. The warmer water is able to carry more calcium carbonate in solution and, hence,

FIGURE 60.–Mile 101.0. Precambrian gneiss and schist outcrops are among the oldest rocks in Utah.

FIGURE 61.–Precambrian metamorphics.

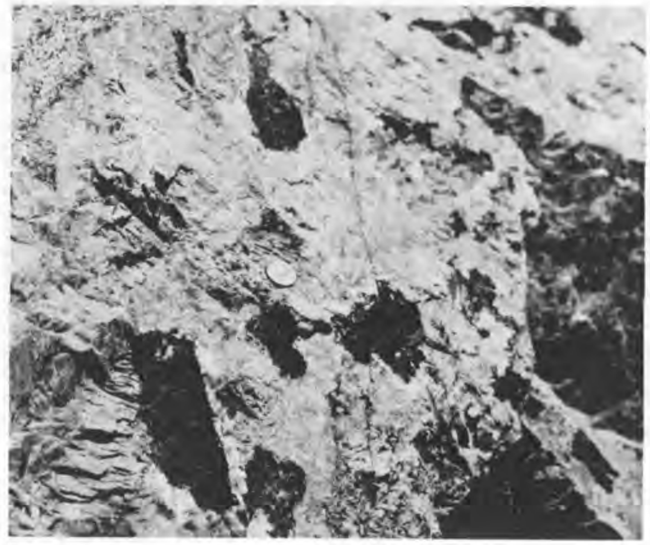


FIGURE 62.–Phenocrysts of hornblende and feldspar from pegmatite dikes in the metamorphic sequence.

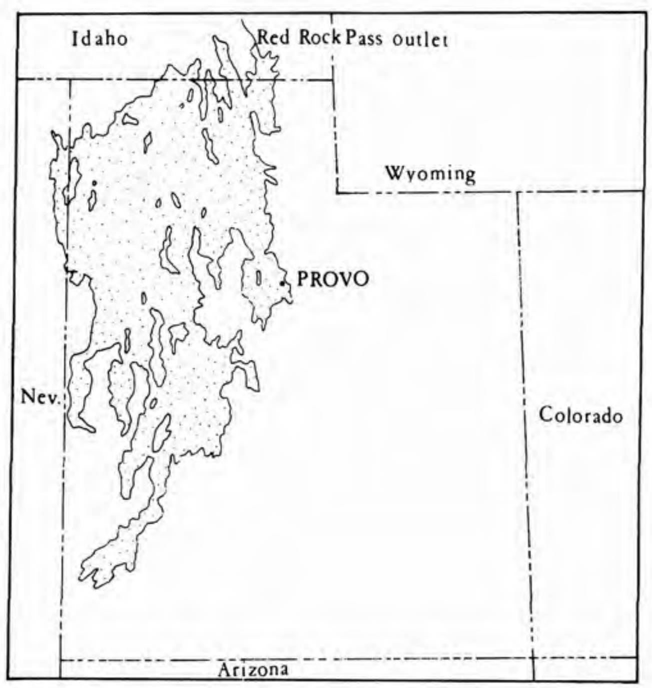


FIGURE 63.–Mile 103.8. Map showing extent of Lake Bonneville. Most of the features at the mouth of Weber Canyon are associated with this lake.

the larger cones are commonly associated with warm springs. These warm springs probably draw their water from a greater depth than do the cold ones. Sources of heat for the thermal springs are likely the buried, still warm, igneous intrusions associated with the Park City and Little Cottonwood complexes, directly to the north and northwest.

FIGURE 64.–Mile 104.4. Gravel pit in Bonneville sediments.

Return to Utah 224 and continue north toward Wasatch Mountain State Park. The park is in the mouth of Snake Canyon and has an excellent golf course, plus camping, picnic grounds, and other recreational facilities.

2.3 Turn east off Utah 224 and cross Snake Creek after a short distance in the bottom of the shallow grassy valley.

2.5 Small mounds on both sides of the road for the next mile are largely inactive tufa cones.

2.7 Intersection. Continue toward the east across sheeted tufa, somewhat obscured in the tilled fields.

2.8 Intersection. Continue eastward through tufa cone fields.

3.3 Low mound to the south is a cone from a large thermal spring which has been developed at The Spa, a recreation complex. Memorial Hill is the steeply conical hill southeastward beyond The Spa and is an erosional remnant of Thaynes Limestone. Burgi Hill, to the northeast, is also an erosional remnant of somewhat fossiliferous Thaynes Limestone. Some beds in that formation contain fossils which have green petroleum trapped in skeletal chambers.

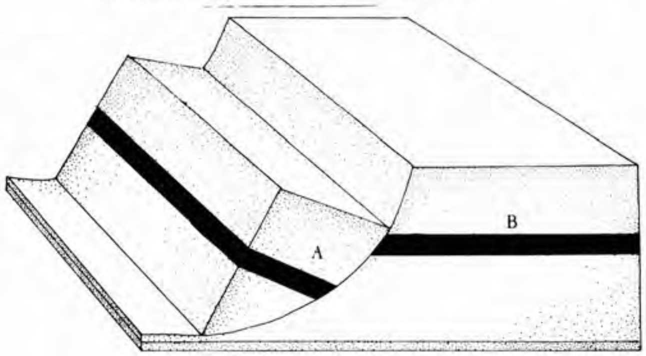


FIGURE 65.–Mile 106.0. Diagram of slump blocks. These blocks are common along the banks of the Weber River.

FIGURE 66.–Mile 106.0. Slope failure along the Weber River. Slope failure is limited to the silt deposits.

3.8 Rejoin the main route log at mile 24.6. END OF ALTERNATE ROUTE 1.

ALTERNATE ROUTE 2: HAILSTONE JUNCTION TO WANSHIP

0.0 JUNCTION OF U.S. ALTERNATE 189 EAST TO PEOA AND FRANCIS WITH THE MAIN U.S. 89 which leads north toward Park City, Silver Zone Junction, and Interstate 80. Junction is at mile 31.7 in the main route description. Continue north through the junction on U.S. 89, through volcanic rocks at the east edge of the Park City district.

0.4 Mine dumps of prospect pits (fig. 70) at the east edge of the district are visible in the volcanic hills ahead. The volcanic rocks here are part of the Keetley-Kamas volcanic sequence associated, presumably, with the intrusive belt exposed in the Park City district towards the west. The rounded terrain here is typical of the ease with which these volcanic rocks erode to produce fertile soils.

1.4 Farm to the west, with rolling pastureland on volcanic rocks. Peaks are held up by various intrusive masses of the Park City complex.

1.8 Enter Keetley. The dumps at the Mayflower Mine are to the southwest.

2.1 INTERSECTION AT KEETLEY. West, beyond Keetley, are visible the dumps and the building associated with the long drain tunnel of the Ontario Mine (fig. 71), one of the few mines still operating in the eastern Park City district. It follows sulfide ores under volcanic and granitic rocks that form the surface exposures to the west. All the hills to the east and northeast are made up of the agglomeratic Keetley volcanic sequence.

3.8 Road junction to the east. Secondary road leading into the rounded hills of Keetley Volcanics. The highway now climbs through poor exposures of the Keetley sequence.

4.7 Ashy agglomeratic exposures of the Keetley sequence are capped by thick terrace gravels exposed in roadcuts on the east side.

4.9 Stauffer Chemical Company loading docks and railroad yard area, for phosphate mined along the south flank of the Uinta Mountains in the eastern Uinta Basin. Ore is hauled by truck to here and then by railroad to processing plants.

5.5 Road junction of highway to Peoa with U.S. 40 and 189.

5.6 WASATCH COUNTY-SUMMIT COUNTY LINE. Excellent exposures of the agglomeratic facies of the Keetley volcanic sequence are visible on both sides (fig. 72).

6.0 Weathered and altered exposures of the Keetley volcanic sequence in roadcuts on the north. Ahead, to the southwest, are old tailing pits and piles of the mills associated with the Park City district. Park City is visible through the gap to the west at about 10 o'clock (fig. 73). Recently cleared ski trails cut through the forest on the Wasatch Range beyond.

6.6 Excellent exposures of conglomeratic Keetley volcanic rocks.

FIGURE 67.–Mile 1.8 (A-1). Travertine cone near The Homestead resort.

FIGURE 68.–Mile 2.0 (A-1). Profile of travertine deposit. Calcareous deposits result from warm groundwaters issuing along fissures. The fissures are thought to be associated with faults and have a general north-south trend.

FIGURE 69.–Closeup view of porous travertine texture.

6.8 Cross railroad spur line.

7.2 JUNCTION OF UTAH 248, SOUTHWEST TO PARK CITY, with U.S. 189 and 40. Continue on U.S. 189. Off to the west, on the skyline beyond Park City, can be seen the northwestward-dipping Mesozoic and uppermost Paleozoic rocks of the Park City district, an area long famed for sheetlike deposits of ores in the Permian beds and for vein gold in the older rocks.

7.9 Double roadcuts through deeply weathered Keetley Volcanics.

9.0 Double roadcuts through moderately fresh breccia and tuffaceous beds in the Keetley volcanic section. From just beyond the roadcuts the east side of the Wasatch Range is visible to the west, with trails of the Park City ski development cutting down across Triassic and Jurassic rocks. These units have been moderately folded and faulted in the north part of the Park City district.

10.1 Beginning of divided highway at the road junction in Silver Zone Flats, where U.S. 189 joins with Interstate 80. Swing eastward toward Evanston.

10.9 ROAD JUNCTION WITH INTERSTATE 80. Hills ahead and to the north are carved on the Keetley volcanic sequence, here veneering the older Mesozoic and Paleozoic rocks.

12.2 Bridge over railroad and Silver Creek, the drainage leading down the canyon. Double roadcuts beyond are through the darker lower part of the Keetley Volcanics, here typically brecciated and conglomeratic (fig. 74). Exposures to the north, down the canyon, show the rather characteristic ragged weathering behavior of the somewhat welded volcanic sequence.

FIGURE 70.—Mine dumps along the east side of the highway on the east edge of the Park City district. The mines here are in somewhat altered Keetley Volcanics, and to date only limited mineralization has been discovered.

FIGURE 72.—Roadcut exposures of the agglomeratic Keetley volcanic sequence. Large blocks, up to 1.8 m (6 ft) in diameter, are imbedded in finer-textured volcanic debris.

FIGURE 71.—Mile 2.2. View westward from the intersection at Keetley to the dumps and buildings at the entrance to the Ontario tunnel. The tunnel leads directly under the high peaks on the skyline, which are held up, in large part, by intrusive complexes in the Park City district.

FIGURE 73.—View to the southwest, across the old tailing pits of mills from the Park City mines, to developments at Park City. Some ski trails can be seen in the high peaks of the Wasatch Range beyond the community, which is just visible through the gap.

13.0 Excellent exposures of a coarse brecciated volcanic unit in cuts of the westbound lane (fig. 75). Rather characteristic ragged, ledgy exposures are developed on the east side of the valley. View directly ahead is also of coarse brecciated volcanic units in the Keetley sequence, with rather characteristic knobby, angular-to-castellate appearance.

13.6 Hoodoos of Keetley Volcanics are well developed high on the valley wall on the west..

14.0 Landslide scars in red Mesozoic beds along the east side. Exposures of Keetley Volcanics, both east and west, rest on the rather strongly folded Mesozoic rocks.

FIGURE 74.–Mile 12.3. Small hoodoos and erosional remnants formed by massive Keetley volcanic rocks.

FIGURE 75.–Mile 13.2. View westward of the west side of Silver Creek Canyon showing characteristic ragged, clifflike exposures of coarse breccia of the Keetley volcanic rocks. Fresh exposure of the coarse breccia can be seen in roadcuts below the darker and more irregular exposures of upper part of the canyon wall.

14.4 Excellent exposures of the steeply dipping Mesozoic beds in roadcuts on the westbound lane, south of the ranch exit.

14.7 Cross beneath ranch exit bridge. Probably Morrison beds exposed in hills to the southwest.

14.8 Exposures of alternating siltstone and sandstone in red Ankareh beds in roadcuts on the westbound lane. Roadcuts in the eastbound lane have slump structures and are rather badly covered. Young terrace gravels blanket the Mesozoic beds that have a brick red appearance and consist of alternating siltstone and shaly siltstone which form recessive units between more resistant sandstone beds that make up the slighter light ledges.

15.6 Poor exposures of what may be Thaynes Limestone in the westbound lane. A short distance beyond occur excellent exposures in old cuts of Thaynes Limestone along the railroad.

16.3 Excellent exposures of Thaynes Limestone in high roadcuts on the east side (fig. 76), at the position where the westbound lane is bridged over the railroad in the canyon bottom and where the westbound lane swings from the west side to the east side of the canyon. Thaynes Limestone exposures continue northward for some distance, although rather poorly exposed in the northern part.

17.0 Thaynes Limestone, or possibly Morrison beds, exposed in roadcuts, particularly on the west side of the canyon. Terrace gravels of coarse quartzitic blocks and volcanic rocks in exposures and roadcuts on the east side in the eastbound lane. High hills to the north are still capped by Keetley Volcanics.

17.7 Keetley volcanic rocks exposed in the old roadcuts and hoodoos on the north side and cuts on the south side, as well, but exposures on the northern side of the canyon are better.

18.0 Roadcuts on the south side, in the eastbound lane, in the Keetley Volcanics. The volcanic rocks also form some of the angular topography ahead on the north and the south sides of the canyon.

FIGURE 76.–Mile 16.4. High roadcuts in Thaynes Limestone exposed in the eastbound lane. Most resistant units are various kinds of bioclastic to oolitic limestone. Slope zones are red and gray green siltstone that represents more near-shore environments than do the limestones.

18.8 Exit off Interstate 80 onto the Alternate U.S. 89 at Wanship.

18.9 CROSS THE BRIDGE OVER ALTERNATE U.S. 189 IN WANSHIP. End of alternate route. Rejoin the main route at mile 58.5.

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