



## ***First-day road log, trip 4, from Washington Ranch to Dark Canyon, Mosley Canyon, Queen Highway (NM 137), Queen, Klondike Gap, and Cottonwood Cave***

Lewis Land, David Love, and Victor Polyak  
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# COTTONWOOD CAVE

## FIRST-DAY ROAD LOG, TRIP 4, FROM WASHINGTON RANCH TO DARK CANYON, MOSLEY CANYON, QUEEN HIGHWAY (NM 137), QUEEN, KLONDIKE GAP, AND COTTONWOOD CAVE

LEWIS LAND, DAVID LOVE, AND VICTOR POLYAK

**Assembly Point:** Washington Ranch Road near tufa dam.

**Departure Time:** 7.15 AM, in conjunction with

the McKittick Hill Cave trip.

**Distance:** 139 miles

**Four stops**

### SUMMARY

**Trip 4** of the first day of the conference diverges from trip 1 at the junction of CR 408/Dark Canyon Rd with the Queen Highway, after having examined Capitan Reef and backreef exposures at the first three stops in Dark Canyon. From here trip 4 continues south across the Seven Rivers Embayment into the high Guadalupe Mountains to visit Cottonwood Cave, which is formed in Seven Rivers dolomite near the contact with the overlying basal Yates sandstone. The hike from the parking area to the mouth of Cottonwood Cave provides impressive vistas of Black Canyon, where the Yates-Tansill contact is well-exposed in Canyon walls. Cottonwood Cave itself contains some of the largest and most spectacular cave formations in the Guadalupe Mountains outside of Carlsbad Cavern itself.

*Use road log for Trip 1 until arrival at the junction with Queen Highway.*

**40.2** Junction with Queen highway (NM 137). 0

**40.2** **Turn left** (south) onto NM 137/Queen Highway to go to Cottonwood Cave. We will be travelling for the next several km across a dissected plain underlain by bedrock of the Queen Formation, which was originally described by Crandall (1929) from outcrops near the old Queen post office ~26 km southwest of here. In this area the Queen Formation is represented by ~112 m of bedded dolomite, sandy dolomite, shaley sandstone and siltstone. Approximately 35% of the section consists of sand or silt. The uppermost 30 m of the Queen is a prominent siltstone designated by Newell et al. (1953) as the Shattuck Member,

which is generally regarded by subsurface geologists as equivalent to the Artesia Red Sand. The contact of the Queen with overlying massive dolomites of the Seven Rivers Formation is easily recognized in outcrop at the top of the slope-forming Shattuck Member. The contact with the underlying Grayburg Formation is somewhat arbitrary, since both formations consist of interbedded sandstone and dolomite. However, sandstone is dominant in the Queen Formation. Further east, the Queen grades into the upper part of the Goat Seep limestone, a reef facies that underlies the more extensive Capitan Reef. The dolomite facies of the Queen grades into evaporites and rebeds some 24 to 29 km behind the Capitan escarpment. 0.7

**40.9** MP 34. Crossing Sotol Basin on high terrace of Wagon-tire Draw. 2.0

**42.9** MP 32. Junction with CR 409 to Sitting Bull Falls to right. **Continue straight.** This intersection is near the southern edge of the Seven Rivers Embayment. Hess Hills to south and east are at the northern edge of the northeastern Guadalupe Mts. Resistant backreef dolomites of the Tansill, Yates, and Seven Rivers Formations form the upland surface. Main part of Guadalupe Mountains is to southwest. The broad summit area is the Queen Plateau, capped by resistant backreef dolomites of the Queen, Grayburg and San Andres Formations. These units dip up to 12° along the Huapache monocline, which forms the northeastern edge of the plateau for more than 25 miles. Continue south on NM 137. 0.1

**43.0** Descend to low Holocene terrace, floodplain and channel complex of Last Chance Canyon Draw. This large drainage includes Sitting Bull and Huapache Canyons and several other major watershed drainages to the west and northwest. 0.3

**43.3** Crossing channel of Last Chance Canyon Draw. 0.2

**43.5** Pleistocene terrace deposits overlie east-dipping Queen Formation in stream cut to right at 3:00. 0.4

**43.9** MP 31. Queen Formation to right. 0.5

- 44.4 Sinkhole ~5 m deep at 9:00 (east side of road). 0.1
- 44.5 Route leaves valley of Last Chance Draw. Continue southward across stepped sequence of Quaternary calcrete-capped strath terraces on deformed beds of Queen Formation. 1.2
- 45.7 Cattle guard. Small quarry in Queen Formation to right. Ridge to right capped by flaggy Queen dolomite. 0.2
- 45.9 MP 29. Gypsiferous Queen beds exposed on both sides of road. Road to left (east) leads to springs in the Queen Formation. **Continue straight.** Junction of Trimble and Huapache Canyons ~1.6 km to southwest (1:00) at base of escarpment. The route ahead is in the Guadalupe Mountains area mapped by Hayes (1964). 0.5
- 46.4 Deformed Queen flaggy dolomites exposed in ditch to right. 0.2
- 46.6 Junction, elevation 1370 m. **Continue south** on Queen Highway. The Huapache monocline ahead can be traced northwest to Texas Hill, around the west side of the Texas Hill dome and further northwest. West Hess Hills are to the south and east. 0.3
- 46.9 MP 28. Cuts to left in undulatory Queen red beds and dolomites (Figure 1.4.1). 1.0
- 47.9 MP 27. Huapache monocline is visible across drainage to west and north. Hill to left is capped with Queen dolomite over red and white flaggy sandstones interbedded with dolomite. 0.2



FIGURE 1.4.1. Undulatory bedding in redbeds and dolomite of the Queen Formation. See Plate 9B for a color image of this outcrop.

- 48.1 Crossing synclinal flexure at base of Huapache Monocline; leaving Seven Rivers Embayment. The remainder of the route will be in the northern prong of the Guadalupe Mountains, which forms the eastern edge of the Sacramento section of the Basin and Range province. 0.1
- 48.2 Junction. Road to left (east) crosses West Hess Hills, which are capped with limestone and dolomite of the Seven Rivers Formation. Hillslopes are in the gypsum and redbed facies of the Seven Rivers Formation. **Continue south** on Queen Highway. 0.3
- 48.5 Climbing steeper grade through roadcuts in Queen gray dolomites and sandstones. 0.4
- 48.9 MP 26. Gray to yellowish-gray dolomites and sandstones of Queen Formation in roadcuts and slopes. Thayer Hill and other high ridges to south are capped by the Seven Rivers Formation and canyons to north are cut into top of the Grayburg Formation. Sharp curves ahead. 0.5
- 49.4 CR 410 (X-Bar Road) to left (east) leads to Serpentine Bends of upper Dark Canyon. **Continue south** on Queen Highway. Outcrops in canyon to south are Grayburg and roadcuts are Queen Formation. In this area the Queen undergoes a facies transition with limestone and dolomite to the south and gypsum, mudstone, and dolomite to the north (Kelley, 1971a). Route crosses cattle guard to enter Guadalupe District, Lincoln National Forest and climbs to the summit of the Guadalupe Mountains. Exposures ahead are gray to yellowish sandstone and gray flaggy dolomites of the Queen Formation (Hayes, 1964). 0.5
- 49.9 MP 25. Thayer Hill to south at 9:00 is capped with Seven Rivers dolomites, and exposures along road are in the Queen Formation. The route ascends to the dissected surface of the Queen Plateau that is capped by resistant backreef carbonates of the Queen Formation and Shattuck Sandstone member. 0.3
- 50.2 Upper Trimble Canyon to right is joined by Huapache Canyon 4 km to the north. This area has excellent exposures of the Grayburg Formation, which is downwarped across the Huapache monocline. 0.6
- 50.8 Cattle guard. Crossing summit of Guadalupe Mountains (Queen Plateau); route for next 19 miles is primarily on Queen Formation. 0.3
- 51.1 Upper Dark Canyon at 9:00. 2.0
- 53.1 Red Lake to left (south). 0.2
- 53.3 Cattle guard. Forest Road 527 to south leads to Turkey Canyon. **Continue straight.** 0.3

- 53.6** Road and trail to right lead to head of Huapache Canyon and Guadalupe Administrative site (drinking water available). 1.1
- 54.7** Sitting Bull Falls Trail (No. 68) to right (elevation 1745 m). 1.1
- 55.8** Ridge Road (CR 431) to left. **Continue straight.** 0.2
- 56.0** Turkey Canyon Road (CR 530) to left. **Continue straight.** 0.1
- 56.1** Guadalupe Christian Camp Road (CR 411) to right, leading to Queen Cemetery. **Continue straight.** 0.1
- 56.2** Memorial monument to Frank A. Kindel on right, the “flying paper boy of the Guadalupes” (1892-1964). (Figure 1.4.2). 0.3
- 56.5** Entering Queen, elevation 1780 m (Figure 1.4.3). Elias Gilkon Queen and his family settled here in 1898. He later donated part of his ranch land as a site for a general store and post office which was run by J.W. Tulk. The nearest water was on the Queen ranch. Son Hillsman Queen and his bride, Abby Tulk, operated the store and post office until 1920. The village was abandoned but is currently resettled. 0.2
- 56.7** Queen store, café, and RV park to right, famous (as many cafes in New Mexico seem to be) for its green chile cheeseburgers. 1.2
- 57.9** MP 17. Route descends to valley side-slopes of Turkey Draw, which leads east to Turkey Canyon. 0.5



FIGURE 1.4.2. Memorial monument to Frank Kindel, the “flying paper boy of the Guadalupes”.



FIGURE 1.4.3. City of Queen, NM, elevation 1780 m. The Queen cafe is famous for its green chile cheeseburgers.

- 58.4** Road curves to left (south). Forest Road 524 to right leads to Pine Canyon, a headwater tributary of Last Chance Canyon. **Stay on Queen Highway.** 0.5
- 58.9** MP 16. Road is near Queen/Grayburg contact. Hayes (1964) mapped the exposed sandstone/dolomite section as Grayburg here, whereas Kelley (1971a) correlated these rocks with the basal Queen Formation. 1.0
- 59.9** MP 15. **Prepare for left turn ahead.** 0.2
- 60.1** **Turn left** (south) onto Forest Service Road 540/Guadalupe Ridge Road. For the next several miles, roadcuts are orange sandstone and gray dolomite of the upper Grayburg or basal Queen Formations.
- The Grayburg Formation was originally defined and named from a subsurface section in the Grayburg-Jackson oil field, Eddy Co., NM (Dickey, 1940). A surface type section near Sitting Bull Spring (NE/4 9-24S-22E) was proposed by Moran (1954), where the unit is 145 m thick. The Grayburg is composed of interbedded dolomite and sandstone, but the sandstone is much less prominent than in the overlying Queen Formation. The contact with the Queen is somewhat arbitrary, but is usually selected at the base of a prominent sandstone unit thicker than any in the Grayburg Formation. Hayes and Koogle (1958) mapped the base of the Grayburg on a horizon 12 to 15 m above that proposed by Moran, at the bottom of a prominent sandstone bed that can be correlated to the Premier Sand in the subsurface. Basinward, the Grayburg grades into the lower part of the Goat Seep reef. Shelfward, ~32 km from the Capitan escarpment, the carbonate facies grades into gypsum and mudstone. 0.6
- 60.7** Road forks. CR 412 straight ahead. **Bear right and stay on Guadalupe Ridge Rd (FS 540).** 0.5

- 61.2** Hamm Vista to right. Flaggy Queen sandstones in roadcut to left (Figure 1.4.4). 0.3
- 61.5** Crossing Robinson Draw. Note flood stage gage. Queen Formation in outcrops to right. 0.6
- 62.1** Road follows flaggy gray dolomite of Queen Formation. 0.5
- 62.6** Flaggy dolomite and red sandstone of Queen Formation in roadcuts. 0.5
- 63.1** Orange sandstone of Queen Formation in roadcut. 0.2
- 63.3** Cattle guard. Hill ahead is capped with Seven Rivers dolomite. 0.9
- 64.2** Cuts to left in Queen Formation. 0.3
- 64.5** Entering Klondike Gap, elevation 2004 m. Queen dolomite and sandstone capped with thick, dark, organic soil called a mollisol. **Turn left** onto CR 412A. 1.6
- 66.1** Bottom of Dark Canyon. High, cliffy wall to south. Grayburg in bottom of canyon, Queen in walls of canyon. 0.3
- 66.4** Crossing small arroyo. Queen Formation in bluffs to left. 0.2
- 66.6** Crossing arroyo. Queen in walls of arroyo to left. 0.2
- 66.8** Crossing arroyo. Campground to right. Queen sand in bluffs to right. **Prepare to turn right.** 0.1
- 66.9** **Turn right** onto Forest Road 69A to Cottonwood Cave. Over the course of the ascent to the cave the route crosses the poorly exposed contact between the Seven Rivers and Queen Formations, and the contact between the Seven Rivers dolomite and overlying basal Yates sandstone. 0.4
- 67.3** Nose of ridge. Now driving on Yates sandstone. 0.5



FIGURE 1.4.4. Flaggy Queen sandstones in roadcut at Hamm Vista. See Plate 9A for a color image of this outcrop.

- 67.8** Spectacular views to ENE of Dark Canyon and to west of headwaters of canyon. 1.3
- 69.1** Guadalupe Ridge. Cross cattle guard. 0.1
- 69.2** View south down Black River Canyon. Note outcrops of the unbedded Capitan Reef in the canyon bottom. Yates sandstone exposed as tan to brown rock in low roadcuts ahead and to left. 0.3

#### **69.5 Stop 4: Cottonwood Cave, Elevation 2121 m. Park next to lookout tower.**

Take short trail (~15 minute hike) down to mouth of Cottonwood Cave. Tan and brown-colored outcrops on ridge crests and upper hillslopes along trail down to cave are basal Yates sandstone (Figure 1.4.5). Along the trail, note exposures of Permian (Seven Rivers Formation) pisolites (Figure 1.4.6), stylolites, and fossils. Flowstone and fragments of speleothems at mouth of cave represent partial exhumation of cave by erosional retreat of canyon wall. Cottonwood Cave is formed in part in the pisolitic facies belt of the Seven Rivers formation at the contact with the overlying basal Yates sandstone. The caves of McKittrick Hill occupy a similar stratigraphic position. Much of the geology of Cottonwood Cave has been compiled and offered in Hill (1987).

From Cottonwood Cave's big entrance, there is an impressive view of large dry speleothems within the cave's twilight zone (Figure 1.4.7). The passage descends 60 meters vertically from the entrance to the end of the Entrance Hall more than 350 meters into the cave. Along the way, one descends through the Seven Rivers Formation and into the upper portion of the Queen Formation (Jagnow, 1977). The flat floor at the base of the breakdown slope from the entrance is made up of a relatively thick covering of dust, silt, and organic debris deposited by human visitation over the last 100 years. The large dusty formations are inactive today. These formations were kept clean by the late Ransom

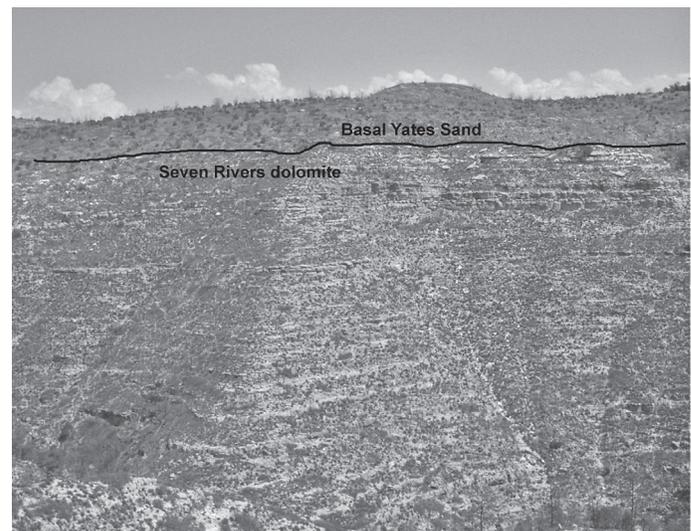


FIGURE 1.4.5. Basal Yates sandstone exposed on ridge crests in Black River Canyon, overlying Seven Rivers dolomite.



FIGURE 1.4.6. Pisolites in Seven Rivers dolomite on trail to Cottonwood Cave.

Turner, a Forest Service employee and volunteer, and primary caretaker of Cottonwood Cave and other nearby caves for the last two decades. He had a love for these caves that has evolved into organized cave restoration groups. Cave swallows frequent this front area of the cave.

The very large stalagmite approximately 300 meters into the cave is called Goliath, and stands more than 15 meters high. Rimstone dams at the base of Goliath are sometimes filled with water, indicating that the speleothems in this area are intermittently active. You may feel a chill in this area. The temperature in Cottonwood Cave is cool (~10-12°C). Just past Goliath is the Great Sand Slope. There are small passages at the end of the Entrance Hall that lead to other areas in the cave.

Geologically, Cottonwood Cave is one of the more important caves in the Guadalupe Mountains. In addition to the Seven Rivers strata being well-exposed along the walls of the Entrance Hall in many areas, this cave also contains an important assemblage of minerals formed during its sulfuric acid speleogenesis. Elemental sulfur was first noted in Cottonwood Cave by Davis (1973). Soon after, Queen et al. (1977) described gypsum replacement of dolostone where dolostone textures are preserved in the gypsum.

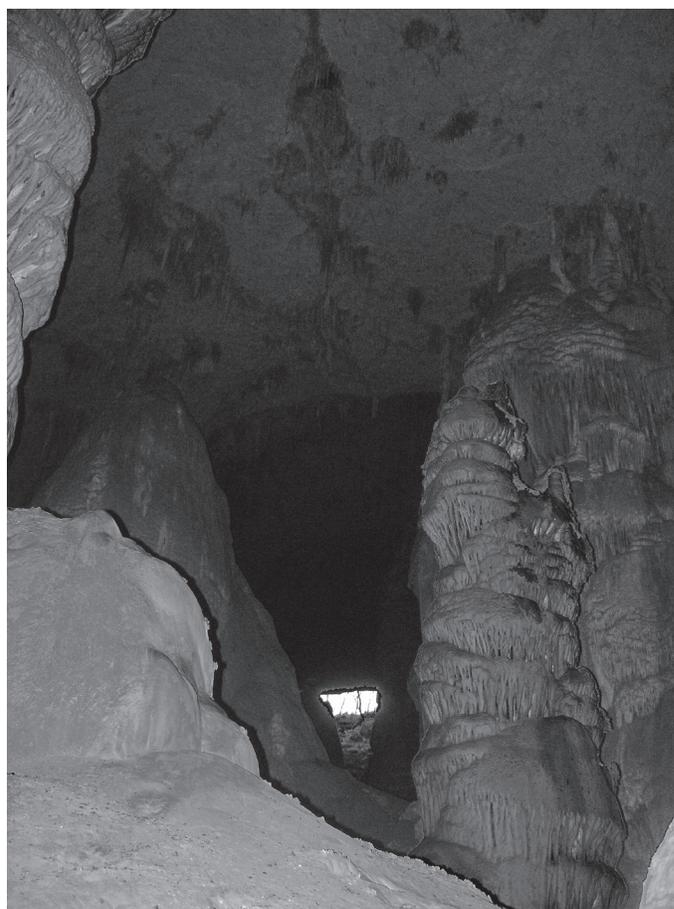


FIGURE 1.4.7. Large stalagmites near entrance to Cottonwood Cave.

Hill (1987) described the occurrence of blue hydrated halloysite (endellite). All three of these occurrences were eventually interpreted to be related to sulfuric acid speleogenesis. Other speleogenetic minerals occurring in Cottonwood Cave include quartz, alunite, jarosite, gibbsite, hydrobasaluminite, aluminite, and blue-tinted amorphous silica (Polyak and Provencio, 2001). The mineral alunite, a byproduct of the sulfuric acid speleogenesis of Cottonwood Cave, was dated by  $^{40}\text{Ar}/^{39}\text{Ar}$  at the New Mexico Geochronology Research Laboratory at New Mexico Tech. The age of the alunite, also representing the timing of cave genesis, is 11 million years. Cottonwood Cave formed earlier than the sulfuric acid caves to the east (Polyak et al. 1998). 69.5

**139.0** After touring Cottonwood Cave, return to Forest Service lookout tower and head back to Washington Ranch along same route. If time permits, turn left at Klondike Gap and follow FS540 approximately five more miles to view points along the faulted escarpment of the Guadalupe block (the Rim). The view of Dog Canyon and the Brokeoff Mountains to the west is impressive, to say the least.

**End of Day 1 - Trip 4 roadlog.**



Plate 8A from Darton (1928). Capitan Limestone and Delaware Mountain Formation (Guadalupe Group) at Guadalupe Point, Culberson County, Texas. The letter 'C' marks El Capitan Peak, highest point in Texas. See article by Kues, p. 127, for a discussion of the early geologic studies in the Guadalupe Mountains.