Second-day road log frm Carlsbad to White City, Guadalupe Mountains National Park, Salt Flat, Washington Ranch and return to Carlsbad

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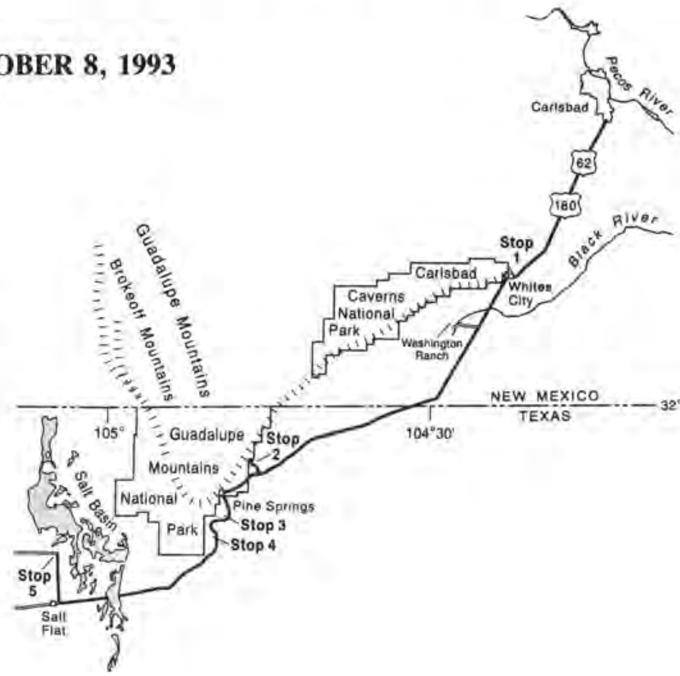
SECOND-DAY ROAD LOG, FROM CARLSBAD TO WHITES CITY, GUADALUPE MOUNTAINS NATIONAL PARK, SALT FLAT, WASHINGTON RANCH AND RETURN TO CARLSBAD

JIM W. ADAMS, JOHN W. HAWLEY, LLOYD C. PRAY and DAVID W. LOVE

FRIDAY, OCTOBER 8, 1993



Assembly point: Carlsbad Civic Center parking lot, National Parks Highway.
Departure time: 7:30 a.m.
Distance: 175.9 mi
Stops: 5

SUMMARY

Today's tour concentrates on the truly world-class geology and paleontology of the Guadalupe Escarpment from Whites City to Salt Basin. The Escarpment is largely an exhumed Guadalupian shelf-margin complex. Facies associated with the shelf margin include shelf-crest shallow lagoonal carbonates, shelf-slope carbonate shoals, backreef, reef, foreslope, toe-of-slope and basinal depositional environments. The basinal deposits of the Delaware Mountain Group include siliciclastic turbidites as well as carbonate debris flows from the reef and foreslope. In late Guadalupian time, water depth is estimated to have been 30 to 40 ft above the Capitan reef; the water depth increased basinward to 1800 ft. Progradational and cyclic sedimentation dominate most of the facies.

From the Carlsbad Civic Center, the tour route parallels the Guadalupe Escarpment along US-62/180 with detours and stops within the canyons cutting the escarpment. Stop 1 examines Tansill-equivalent reef facies and paleontology at the mouth of Walnut Canyon. By hiking up the escarpment near Stop 2, at the mouth of McKittrick Canyon, one can examine excellent exposures of all the major depositional environments from shelf-slope to basinal facies. For the less athletically inclined, alternative tours of McKittrick Canyon to Pratt's cabin, Pratt's historic Ship-On-The-Desert, the Pinery (Butterfield Stage station) and Park Headquarters are logged as well. The tour continues southwestward along US-62/180. West of Guadalupe Pass, Stops 3 and 4 concentrate on sedimentary structures related to submarine channels and deep-water deposition in the Delaware Mountain Group. After descending across basin-bounding faults cutting the western escarpment of the Guadalupe and Delaware Mountains, the route crosses the Salt Basin graben for a panoramic view of the west face of the Guadalupe Mountains, with boldly exposed shelf-margin carbonates and the playa-dune complex of Salt Basin in the foreground. The tour then returns along the same route to Washington Ranch (and a barbecue for 1993 field trip participants). The tour ends at the Carlsbad Convention Center.

Mileage

0.0 Milepost 32 on US-62/180 westbound. 1.0

1.0 Route is in the Delaware Basin. The reef escarpment and northwestern shelf of the Permian Basin lies north and west of Carlsbad. The following description of the Guadalupe Mountain area is taken from Hendrickson and Jones (1952, p. 7, 8) and is an appropriate introduction to both the second and third days' tours. An excellent illustrated guide to the geology of the Guadalupe Mountains recently has been prepared by Jagnow and Jagnow (1992) and is recommended particularly for the interested nongeologist.

The Guadalupe Mountains (Fig. 2.1) trend northwest for a distance of about 60 mi from the New Mexico—Texas line at the southwest corner of Eddy County and are continuous with the Sacramento Mountains to the north and the Delaware Mountains to the south. The highest and most rugged part of the mountains has the form of a southward-pointing "V." The northwest limb is the Guadalupe Mountains proper and the northeast limb is the "Barrera del Guadalupe." The apex of the "V" is Guadalupe Peak, which is about 7 mi south of the New Mexico state line. The altitude at the peak is 8751 ft and it becomes progressively lower away from the peak along both the northwest and northeast limbs of the "V." Between the limbs of the "V" is a lower land of moderate relief called the Seven Rivers embayment.

The northeast limb of the mountains widens to the north as the altitude becomes less and it disappears as a topographic feature a short distance north of Carlsbad. The segment of the northeast limb south of Dark Canyon is designated Guadalupe Ridge and Azotea Mesa, and is located between Dark Canyon and Rocky Arroyo. The northern upland between Rocky Arroyo and the Seven Rivers Embayment are the Seven Rivers Hills. The east boundary of the northeast limb of the mountains is the escarpment of the Capitan reef, which declines

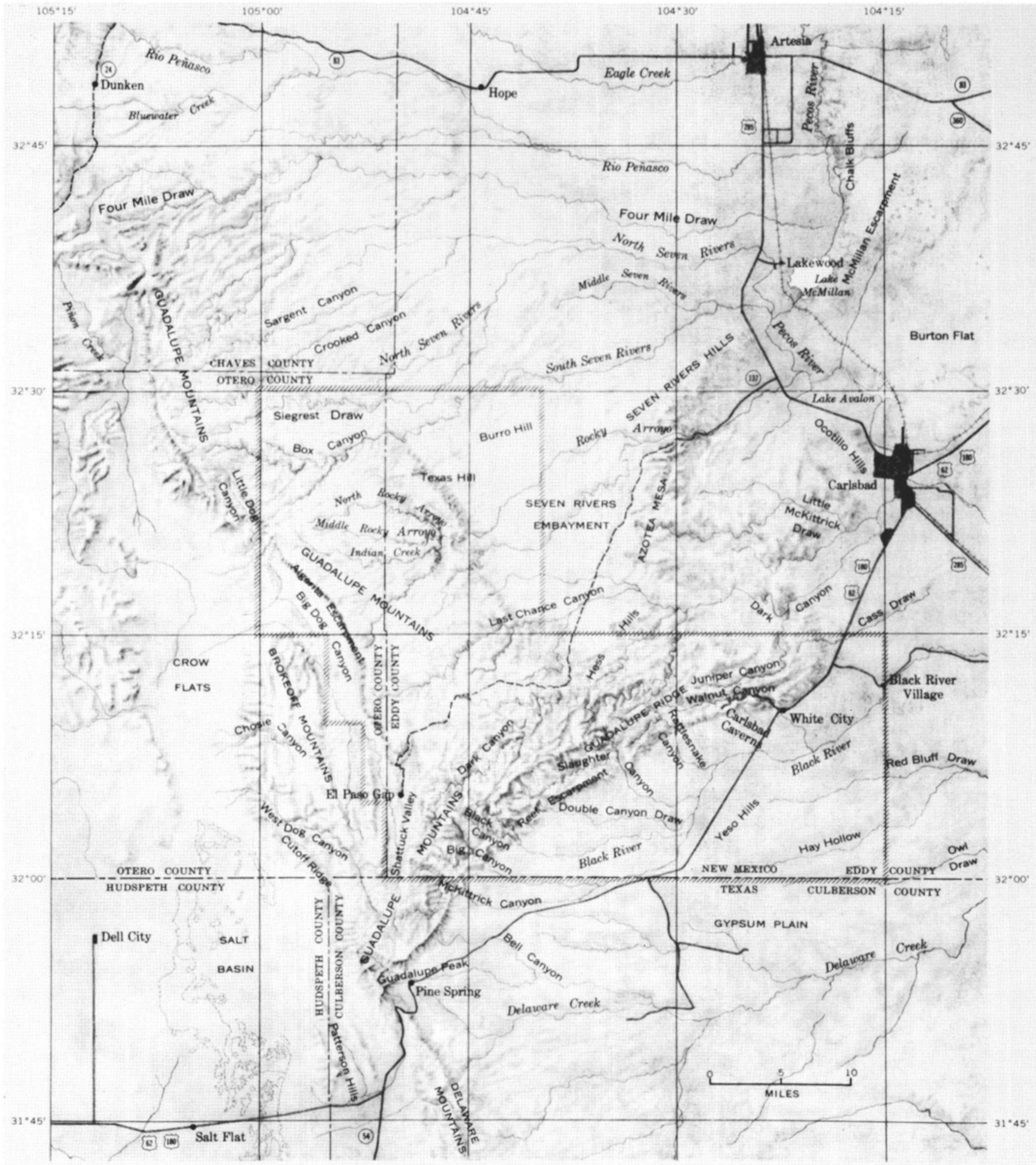


FIGURE 2.1. Index map of Guadalupe Mountains region showing major geographic features (from Hayes, 1964). Area within hachures mapped by Hayes (1964).

from a height of about 1700 ft at the south state line to about 500 ft near Carlsbad. South of Carlsbad this escarpment is concave to the east, forming the Cueva reentrant. East of and paralleling the escarpment in this reentrant are the Frontier Hills.

The northwest limb of the mountains, or Guadalupe Mountains proper, is bounded on the southwest by a fault scarp 1200 to 1500 ft high and on the northeast by an escarpment on the Huapache monocline about 500 ft high. The upland surface of this part of the mountains has moderate relief and a general slope to the north and northeast. The upland surface is cut by steep-walled canyons as much as 500 ft deep.

The Seven Rivers Embayment, between the two limbs of the mountains, widens to the north from its apex near Sitting Bull Falls (Day 3, Stop 4). The Embayment, an area of moderate relief, has comparatively shallow arroyos and some small undrained depressions. The chief drainage channels from the Guadalupe Mountains to the Pecos River are the North and South Seven Rivers, Rocky Arroyo and Dark Canyon. North and South Seven Rivers drain the Seven Rivers Embayment and cross the northeast limb of the mountains just south of the Seven Rivers Hills. Dark Canyon (Day 3, Stops 1 to 3) originates near the south boundary of the county in the high part of the mountains, flows northward across the south tip of the Seven Rivers Embayment and turns eastward to cross the northeast limb of the mountains and the Frontier Hills about 10 mi south of Carlsbad. 0.7

1.7 Route passes through the South Carlsbad gas field discussed in Day 1 log. 0.9

2.6 The hills on the horizon to the west are thin-bedded dolomites and sandstones of the Tansill and Yates Formations immediately behind and overlying the Capitan Reef. The reef is present as porous limestone in the subsurface from Carlsbad to outcrops at the mouth of Dark Canyon and the next canyon to the north. Exposed eastward depositional dip averages 5° on these beds. 3.0

5.6 Roadside park. Frontier Hills in the foreground to the west contain Rustler dolomite, red beds, fine-grained sandstone and gypsum dipping southeast into the Delaware Basin. In the Frontier Hills, the lower Rustler Formation and underlying Salado dissolution residue overlap the Castile Formation and the Rustler comes within a few feet of lying directly on the Guadalupian Tansill dolomite. 1.0

6.6 Junction with NM-408. This road provides access to Dark Canyon and the Day 3 route north and west of the reef front. The Capitan reef facies and Tansill backreef beds are exposed at the mouth of Dark Canyon. Continue on US-62/180. 2.4

9.0 Milepost 23. Porous Culebra Dolomite Member of the Rustler Formation exposed in roadcuts ahead. Route from here to the state line crosses area mapped by Hayes (1957, 1964). 2.0

11.0 The Capitan reef, overlain by thin-bedded Tansill forms the core of the Guadalupe Ridge to the west. The reef front makes a sharp curve to the west here and continues 40 mi to Guadalupe Peak. This major exhumed landform of mid-to-late Permian age is designated the Reef Escarpment. 0.2

11.2 Junction with NM-396 to Black River and Malaga. **Continue southwest** on US-62/180. Bedded Tansill underlain by Capitan reef core to right. Kelley (1971) noted on aerial photographs the sharp linear change in vegetation pattern near the base of slope from here to Guadalupe Peak and mapped a fault on the surface separating the Delaware Basin from the reef escarpment. Hayes and Bachman (1979) reexamined the localities where Kelley had described surface faults and concluded that the steep dip observed along the Guadalupe escarpment was unfaulted original sedimentary dip. The linear pattern, marked by a vegetation change near the base of slope, appears to reflect the long and poorly understood process of reef-front exhumation that has probably been taking place episodically since earliest Triassic time. Route cuts through several outcrops of Ochoan Rustler Formation. **0.6**

11.8 Route passes Whites City gas field. Production is chiefly from Pennsylvanian rocks. The Wolfcamp reservoir at a depth of 9390 ft has produced 2.6 BCF gas and 0.003 MMBO. The Morrow reservoir at a depth of 11,400 ft has produced 142.3 BCF gas and 0.04 **MMBO. 1.9**

13.7 On clear days, Guadalupe Peak and El Capitan are visible to the west. The sheer cliffs facing south are composed of steeply dipping forereef debris in Capitan Peak (elevation 8078 ft). To the north, the higher peak is Guadalupe Peak, cored by lower Capitan reef overlain by flat-lying backreef facies. Guadalupe Peak is just south of the New Mexico state line; its elevation of 8749 ft is the highest point in Texas. **2.3**

16.0 Enter Whites City. Prepare for right turn onto Carlsbad Cavern Highway (NM-7). 0.2

16.2 **Turn right** and continue 0.4 mi north through Whites City business strip to Rushmore Drive at Campground area. Park to left of NM-7 beyond campground entrance and walk west to large exposure of reef limestone at the mouth of Walnut Canyon. (Tour transportation will meet participants at cafe on east side of road. In order to pay rent to visit the White's reef outcrop, everyone needs to buy a cup of coffee). **Leave hammers in vehicles.** Take canteen instead to wet the rocks to bring out fossils and textures. Remember, the only reason you see these features is because previous visitors have left them alone. **0.4**

16.6 **STOP 1.** The massive limestone at the mouth of Walnut Canyon is the most accessible locality to inspect the Capitan reef facies (Fig. 2.2). For this reason, we ask you **please do not hammer or mutilate this outcrop.** Basinward of this reef (to the south), equivalent beds are probably steeply dipping forereef limestone conglomerates that grade laterally into sandstones of the Bell Canyon Formation. This reef grades laterally to the north into bedded bacicreef strata of the Tansill Formation. Much of this massive outcrop is covered with a weathered crust that makes the sponge-algal reef boundstone difficult to see. Large calcareous sponges (e.g., *Guadalupia)* can be seen in growth position at the bottom of the outcrop where polished by river grav-els. Also in evidence on the east side are large crack-filling light and dark laminae of the sheet-like encrusting problematic algae (?) *Archaeolithoporella,* which also encrusts fossils and itself. Other algae recognized are

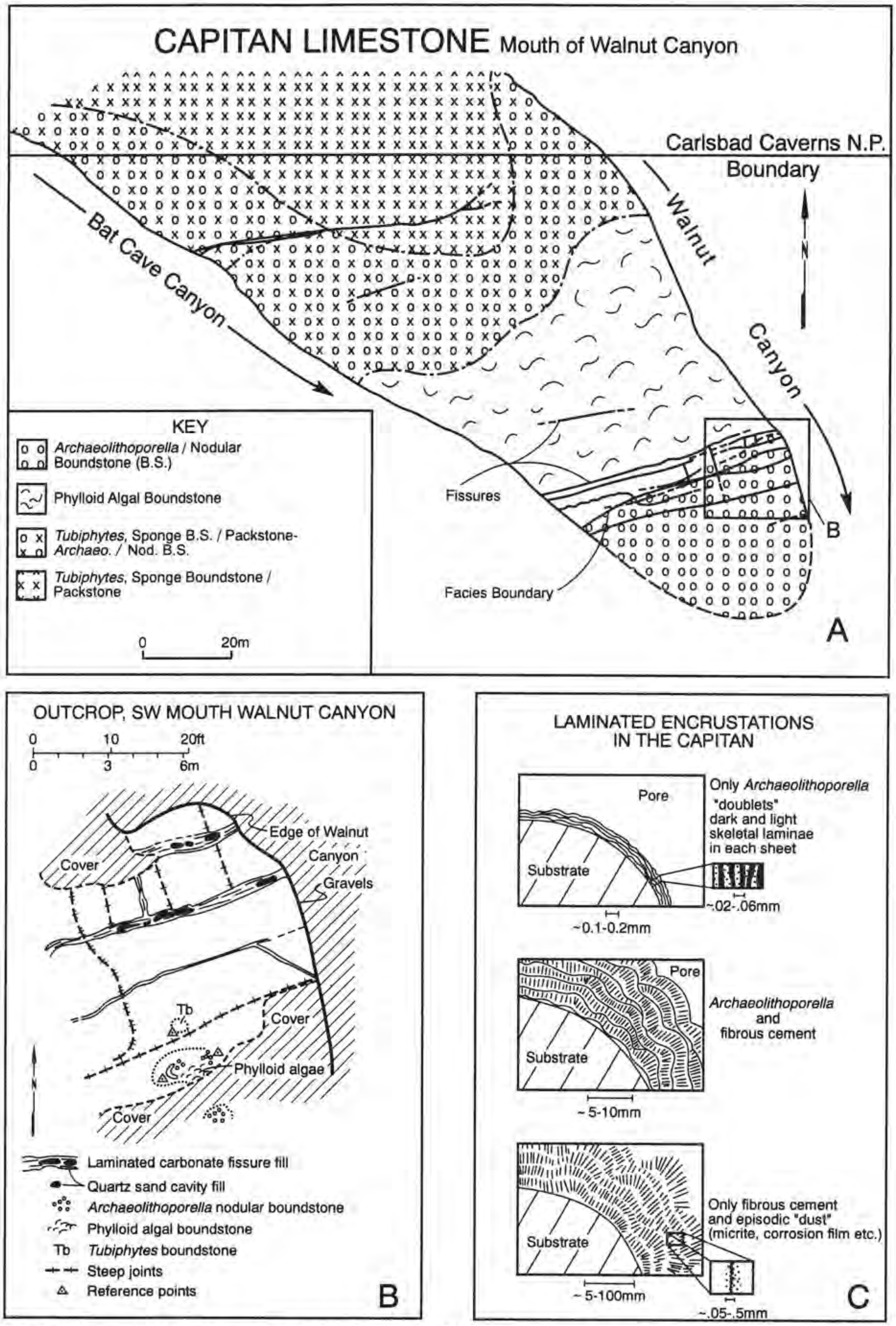


FIGURE 2.2. Geologic features in Capitan Limestone ridge between mouths of Walnut and Bat Cave Canyons at Stop 1 (modified from Pray and Estaban, 1977, and Babcock, 1974).

Alenopea, Mizzia, Macroporella. Ramose bryozoa, fusulinids, and *Codonofusiella* are also present. Low on the west side of this spur, in *Bee* Cave Canyon, are problematic 3- to 5-ft-long slim fossils that may be calcareous sponges that once waved above the ocean floor as sea whips do today. At the top of this spur are small brachiopods. Dips are up to 12° southeast into the Delaware Basin. The Capitan reef contains a surprising amount of submarine calcite cement (up to 55%). *Tubiphytes* and phylloid algae also form boundstone. NM-7 enters Carlsbad Caverns National Park immediately north of this outcrop and follows fascinating exposures of the Tansill and Yates bacicreef equivalents of the Cap-itan reef between here and the cave entrance. Use log compiled by the West Texas Geological Society Road Log Committee (1988, p. 101-112) and see Toomey and Babcock (1983). Return to vehicles and return to junction with westbound US-62/180. **0.4**

17.0 Junction with National Parks Highway; **turn right** (southwest) on US-62/180. **2.4**

19.4 Route is approximately at the top of the Castile Formation. Carlsbad Caverns National Park Headquarters is on summit of Guadalupe Ridge at 3:00. Elevator and natural (Bat Cave) entrances to Carlsbad Cavern are located at that point. See cave log by Hill (this volume). **0.8**

20.2 Approaching Black River; cemented stream gravels and finer valley-fill facies of Plio-Pleistocene age (see First-Day Road Log, mi 19.5). **0.2**

20.4 Crossing Black River. Mouth of Rattlesnake Canyon in Reef Escarpment at 2:30. **1.3**

21.7 Milepost 11. Route ascends to surface of Gypsum Plain and is on the Castile Formation for the next 9 mi. **0.7**

22.4 Washington Ranch to right; last stop of today's tour. **1.3**

23.7 Milepost 9. Optional stop of First Day's tour at junction with Dillahunty Road (Eddy-424) to left. C-P Hill "karst mound," with Rustler cap, rises above the Gypsum Plain 1.8 mi to southeast (10:00). **1.3**

25.0 **OPTIONAL STOP.** Roadside park. Overview of Washington Ranch gas field and the Huapache Monocline. For discussion of gas production from the Pennsylvanian in the Washington Ranch Field, see minipaper by Burton, Adams and Engwall at the end of today's road log. To the north along the Capitan Reef Escarpment is Rattlesnake Canyon. West of it is Slaughter Canyon and New Cave. The Huapache Monocline (trending northwest-southeast) crosses the escarpment between these two canyons, thus causing the escarpment to rise to the west. Early to Middle Pennsylvanian movement along the Huapache fault may have had a considerable left-lateral strike-slip component. Erosion of the Pennsylvanian section on the uplifted (southwest side) has been mapped at Washington Ranch and in the subsurface of the Last Chance Canyon areas with Pennsylvanian conglomerates deposited on the downthrown (northeast) side. The present monocline is probably a Laramide reactivation of this same fault; unfaulted Grayburg dolomites dip 12° to the northeast over the subsurface high-angle reverse fault. Refer also to mi 24.4 comments on First-Day Road Log. **1.4**

26.4 **OPTIONAL STOP** on First Day's tour (mi 25.7). This is the area where Pratt (1954) mapped a northeast-trending zone of lamprophyre dikes cutting the Castile Formation (Calzia and Hiss, 1978). **1.2**

27.6 Road to left leads to First Day Stop 1 sites in Yeso Hills area of Gypsum Plain. **2.8**

30.4 Descending through roadcuts in Castile Formation. First Day Stop 2 at "State Line Gypsum Outcrop" is at west end of cut. This very accessible Castile outcrop is a favorite stop on all field trips (Anderson, 1987). The crinkly laminae of alternating gypsum and limestone make good bookends. Minifaults of millimeter throw are preserved. It is astounding how many of these laminae have been correlated for miles across the Delaware Basin in oil field cores. **0.3**

30.7 Milepost 2 at west end of cut is at the edge of a broad alluvial flat on the northwestern margin of the Gypsum Plain-Yeso Hills area. **2.0**

32.7 New Mexico-Texas state line. Entering Culberson County, Texas. 0.1

32.8 State Line Bar and Cafe to right at junction with Texas Farm Road (FR) 652. **Continue west** on US-62/180; entering area mapped by P. B. King (1948, 1949). The First-Day Road Log via FR-652 and US-285 covers the Delaware Basin area of northern Culberson and Reeves Counties, Texas and Eddy County, New Mexico. **0.9**

33.7 Route for next 8.5 mi crosses terraced apron of older (Plio-Pleistocene) alluvium deposited in the broad (dissolutional-erosional) depression between the Reef Escarpment and the Yeso Hills-Delaware Mountain area. Bouldery terrace gravels along McKittrick Canyon Draw to right are capped by strong pedogenic calcretes (Hawley, First Day minipaper). **3.6**

37.2 Road curves to right. McKittrick Canyon at 2:00. The exposed Capitan reef becomes progressively older toward Guadalupe Peak. The crest of the reef there is 1000 ft lower in the section than the outcrop at the mouth of Walnut Canyon at Whites City. The flat-lying beds on top of the escarpment are backreef carbonates that are more resistant to erosion than the massive reef wall. The reef facies is exposed in these canyons along the Guadalupe Escarpment. It is evident that as accommodation permitted, the reef facies migrated basinward over its own steeply dipping forereef debris with thinner bedded backreef carbonates following this basinward shift to cover older Capitan reef facies. **4.6**

41.8 Highway curves at roadside park. Hills to left are basal Castile Formation capped by Plio-Pleistocene terrace gravel. **0.5**

42.3 Cut in older gravel to right. Route ahead crosses dissected bedrock terrane at foot of the Guadalupe Mountains and from here to Guadalupe Summit (mi 63.4) is in the transition zone between the Sacramento section of the Basin and Range physiographic province and the Pecos Valley section of the Great Plains (Hawley, 1986). Late Cenozoic alluvial cover for the next 30 mi is (thankfully) discontinuous and relatively innocuous. **0.3**

42.6 Black massive Lamar Limestone exposed in roadcuts. This is the top member of the Bell Canyon Formation and the top of the Guadalupian Series in the Delaware Basin. Several limestone tongues of reef debris thicken toward the reef and interfinger with sandstone facies of the Bell Canyon. In descending order, they are the Lamar, McCombs, Rader, Pinery and Hegler limestones. This exposure is about 4.5 mi from the reef; the Lamar was deposited here in about 1700 ft of water. These dark, silty basinal limestones are sparsely fossiliferous, but abundant fusulinids from Lamar outcrops closer to the reef have been correlated to the Tansill Formation (top of the Guadalupian Series in the backreef facies). Unusual in marine limestone, tiny gypsum rosettes are present in these outcrops. **0.3**

42.9 Thin-bedded Lamar Limestone in roadcuts. **0.7**

43.6 Roadcut in piedmont alluvium. **0.5**

44.1 Slow! Prepare for right turn ahead. **0.2**

44.3 **Turn north** off US-62/180 onto McKittrick Canyon Road. Route enters Guadalupe Mountains National Park. **No collecting of rocks or anything else** (except wits and litter, of course). **0.3**

44.6 Lamar Limestone capping hills at 2:00 is underlain by upper Bell Canyon sandstone. **0.2**

44.8 Water well to left is 400 ft deep. **0.6**

45.4 Bear Creek on the left. One of Wallace Pratt's water wells encountered more than 100 ft of alluvium before reaching bedrock. **0.5**

45.9 Cut in older alluvium to right. **0.3**

46.2 Turnoff to Wallace Pratt's Ship-On-The-Desert Research Center. Continue on paved road to McKittrick Canyon. Route follows a stray limestone of reef talus debris swept out into the Delaware Basin from the reef crest. **0.8**

THE WALLACE PRATT SHIP-ON-THE-DESERT RESEARCH CENTER, GUADALUPE MOUNTAINS NATIONAL PARK

Jim W. Adams' and Larry E. Henderson'

'Exxon USA, Box 3116, Midland, Texas 79702;
'Superintendent, Guadalupe Mountains National Park, HC-60, Box 400, Salt Flat, Texas 79847

The everlasting beauty of the Guadalupe Mountains has attracted the attention of people throughout the ages. Ancient Indians camped and hunted here and gathered the valuable salt from Salt Flat graben to the west. The Mescalero Apaches did the same; they also gathered and baked the mescal agave here, which gave this tribe their name. Expeditions of U.S. soldiers, as well as occasional freight wagons traveling from San Antonio to El Paso, passed through Guadalupe Pass. The colorful stagecoaches of the Butterfield Overland Mail rumbled through this pass for less than a year, starting in September 1858. Early ranches were established at the foot of the Guadalupes before the Indian menace was entirely removed during the 1870s.

In 1921, an intrepid petroleum geologist by the name of Wallace E. Pratt drove a Model T Ford over dirt roads to see the mountains that formed, what he had been told, was "the prettiest spot in Texas." Pratt was the first geologist (and Chief Geologist) of Humble Oil & Refining Company (now Exxon). He relished the scenery of these desert mountains, so with partners "and largely on borrowed money," Pratt started accumulating ranch acreage in the McKittrick Canyon area. The Pratts built their first ranch home in 1930, out of native limestone, deep in the mountains at the junction of North McKittrick and South McKittrick Canyons.

In 1937, Pratt was promoted to Exploration Vice President and Director of Standard Oil Company of New Jersey. He and his wife took an apartment overlooking Central Park, as his office was in downtown Manhattan. Then, after World War II, he retired. Can you imagine a busy executive with his finger on the pulse of operations around the world retiring to the quiet and solitude of McKittrick Canyon--without telephone and no nearby neighbors? But that is what the Pratts did upon moving to the rock cabin in McKittrick Canyon. Even the roof was made from marine limestone flagstones. The trail that visitors now take to Pratt's cabin was the road he built for his automobiles. Some people called this first home "Pratt's Hunting Lodge," but that is a misnomer. He was an environmentalist before the term ever became popular and never hunted on his ranch nor permitted others to do so. Regular hunts did take place on the larger Grisham-Hunter Ranch, west of Pratt's, where elk had been reintroduced into the Guadalupes.

A flash flood marooned Mr. and Mrs. Pratt at their first home for a week, causing them to build a second house on the alluvial plain in front of the mountains. Their architect designed an unusual structure: a long rectangular house 16 by 110 ft in the shape of an oil tanker. The flat roof of the first story forms a "foredeck" and "afterdeck." These are separated by a second story "Captain's bridge" in the middle (Fig. 2.3). The only stairs to the bridge consist of a brass pole from which steps radiate outward and upward in a spiral with an associated handrail, the entire structure similar in appearance to those found on submarines. The second story bridge has large picture windows, which provide magnificent views of the mouth of McKittrick Canyon and El Capitan Peak. At the end of the foredeck is a large barbecue pit; the deck roof was thus designed for dining and entertaining. Wallace Pratt named his oil tanlcer "The-Ship-On-The-Desert." Jim Adams once erred by calling it "The-Ship-OF-The-Desert." Pratt quietly corrected him by saying, "Jim, the Ship-OF-the-Desert is a camel." This home was also con-structed of marine limestone flagstone columns and stucco.

The idea of a national park in the western Guadalupe Mountains had lain dormant for twenty years until revitalized by proposals from both Judge J. C. Hunter and Wallace E. Pratt. In 1958, Wallace Pratt suggested donating part of his ranch to the National Park Service as health considerations forced the Pratts to move closer to medical facilities. In 1959, 1960 and 1961, the family donated a total of 5672 acres in the vicinity of McKittrick Canyon, to the National Park Service, including the Pratt Lodge and the Ship-On-The-Desert. The Pratts built a third home for family use on their remaining 10,000-acre ranch in the foothills east of the Guadalupes. In 1963, Mrs. Pratt's arthritis required better treatment, so they moved to Tucson, Arizona, for her health. Congress authorized the establishment of Guadalupe Mountains National Park in 1966, and in 1969 over 72,000 acres of the J. C. Hunter Jr. Guadalupe Mountains Ranch was sold to the government.

During the first years under Park Service care, Pratt's Ship-On-The-Desert had several uses, as the District Ranger (then Area Manager's house), as dormitory for trail crews and a residence for researchers. Pratt's stone cabin in McKittrick Canyon was also used by those doing research, such as botanist Dr. Barton Warnock and others. It continues to serve as a ranger post for the protection of McKittrick Canyon. When the roof started leaking several years ago, the Park Service photographed and numbered each flagstone on the cabin roof, made structural repairs and replaced each stone where it had originally laid.

Contemplating the future role of the Ship-On-The-Desert, then-Superintendent Karen Wade suggested it be used as a research center by

FIGURE 2.3. The Wallace Pratt Ship-On-The-Desert Research Center with second story "bridge."

geologists, biologists, botanists, speleologists, ecologists and others studying park resources. Because of the remoteness of the park from food and lodging, this proposed role was heartily endorsed by National Park Service Regional Director, John E. Cook, in Santa Fe. The Ship was badly in need of repairs. Most serious were roof leaks that required immediate attention before researchers could occupy the building. These problems came to the attention of Wallace Pratt's friends in the oil industry. Generous contributions were made for these repairs by the Mobil Oil Corporation; Exxon USA; L. Austin Weeks; The Carlsbad Caverns—Guadalupe Mountains Association; Ambassador and Mrs. Roy Buffington and other friends. The repairs were completed by National Park Service staff under the supervision of Superintendent Larry Henderson. The National Park Service does not wish to enter the motel business by using Pratt's house for tourist groups, but for those doing legitimate research in the park, the Wallace Pratt Ship-On-The-Desert Research Center offers an alternative to camping out or long daily drives.

Whenever geological groups came to study the Guadalupes, they would stop by the Ship to pay their respects to Wallace Pratt. Sometimes he would join them on their outings. A letter Jim Adams received from Wallace, written 24 September 1981, is reprinted below. It is not the last letter Wallace Pratt wrote because he was up late on Christmas Eve, 1981, dictating letters to his friends. He passed away the next day at the age of 96. Wallace Pratt will long be remembered for his monumental contributions to the science of petroleum geology; however, he may be best remembered for the priceless gift he gave to all of us in the legacy that is now Guadalupe Mountains National Park. For more information about Wallace Pratt, see references in Table 2.1.

47.0 Cuts in older piedmont alluvium. **0.6**

47.6 Lamar Limestone has thickened in outcrops east of arroyo (McKittrick Canyon Draw). Note that dips in the Lamar increase toward reef. **0.3**

47.9 Lamar on Bell Canyon in cliff to left and older terrace gravel across channel to right. **0.5**

48.4 Cattle guard. Entering Visitors' Center parking area. 0.1

48.5 **STOP 2.** Visitors' Interpretive Center of Guadalupe Mountains National Park at the mouth of McKittrick Canyon. At this point, we request that everyone (1) fill canteens, leave rock hammers, and prepare to leave vehicles, (2) bypass exhibits (see them later) and gather north of the Interpretive Center to study excellent outcrops of basinal sandstones of the Bell Canyon Formation of the Delaware Mountains Group, (3) stay on trail and do not get ahead of field trip leader, (4) after group discussion convenes on Bell Canyon outcrop, make decision on the following options.

For the next 3 hours, the group will split into three groups, opting for (a) hiking the strenuous but rewarding Geology Trail, following the excellent new trail guide published by the Texas Bureau of Economic Geology. This guide was a committee effort led by Dr. Don Bebout. There is a hike leader. You will not learn much geology if you try to reach the top. (b) hike the stream-gradient route (5 mi round-trip) to Pratt's cabin at the junction of main McKittrick and North McKittrick Canyons. (c) take a bus to Wallace Pratt's second house ("The Ship-On-The-Desert"), Park Headquarters and the interesting history exhibits at the Pinery (Butterfield Stagecoach Station ruins) and Frijole Ranch and 1870 ranch built by the Rader brothers. Let your vehicle-mates know which option you have chosen, so vehicles don't lose riders.

Please rendezvous at the Interpretive Center at the mouth of McKittrick Canyon at the designated time.

TABLE 2.1. Some references relating to Wallace E. Pratt.

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WALLACE E. PRATT
2820 NORTH TORINO AVENUE
TUCSON, ARIZONA 85712

September 24, 1981

Mr. Jim W. Adams, Special Coordinator
Exxon, USA
1700 West Broadway

Dear Mr. Adams:

Many thanks for your thoughtful letter of 15 September. Mrs. Pratt and I are grateful and we thank you for your invitation to join your field trip to McKittrick Canyon. We must decline however because at the moment I am confined to my room with a fractured pelvis.

But I am sure Superintendent Dumire, to whom I am sending a copy of this letter, will gladly cooperate fully with you. I suggest you follow up your letter to him with a telephone call to arrange details.

We built our first home in McKittrick Canyon in 1930 (we had to go clear to Sweetwater, Texas to get a stonemason). Our first home was located at the mouth of North McKittrick where it joins Main McKittrick. I think no vehicles are permitted in McKittrick today but you can walk up Main McKittrick to get an intimate cross section of the anatomy of the Capitan Barrier Reef Complex. Our first home is generally known as "Pratt's Hunting Lodge" although we have never hunted nor permitted hunting on our property.

In 1943 a heavy rainfall flooded the Canyon and imprisoned us in the mountains for a week. This experience led us (at the end of the war in 1945) to build our second home outside McKittrick Canyon at the base of the Barrier Reef Complex.

Both of our former homes are constructed of fine-grained closely laminated, silty limestones of the marine facies of the Bell Canyon. Both were included in our gift of McKittrict [*sic*] Canyon to the National Park Service to become the nucleous [*sic*] around which it accumulated all of the present Guadalupe Mountains National Park.

Please have a good field trip to McKittrick Canyon and take care of Exxon!

With every good wish,

Yours Sincerely,

Wallace E. Pratt

WEP/dl

According to the Permian Reef Geology Trail Guide by Bebout et al. (1992 and in press) the sides of McKittrick Canyon expose one of the world's finest examples of a rimmed carbonate platform. The present 2000-ft topography approximates that formed during Permian (late Guadalupian) time along the edge of the Delaware Basin (Figs. 2.4 and 2.5). The Capitan reef separates shallow-water shelf deposits to the northwest from deep-water deposits to the southeast (Fig. 2.6). Carbonates dominate the outer-shelf and reef facies and alternate with siliciclastics on the lower-slope and toe-of-slope deposits. Deep-water equivalents are siliciclastic fine-grained sandstones intercalated with basinward-thinning limestones. Maximum water depth is estimated to have been 1800 ft. Outer-shelf and backreef units are the Yates and Tansill Formations (Fig. 2.6). Reef and slope units are the Capitan Limestone. Toe-of-slope Bell Canyon Formation comprises sandstone and several thin, interbedded limestones (Fig. 2.7). In descending order, the limestone members are Lamar, McCombs, Rader, Pinery and Hegler.

The McKittrick Canyon Visitor's Center is situated some 400 ft below the top of the Bell Canyon Formation at about the level of the Rader Limestone Member. Stratal dips increase into forereef talus, which grade into the sheer cliffs along the north wall of McKittrick Canyon which are devoid of bedding in the reef facies itself. These magnificent exposures reveal how the Guadalupian Capitan Reef built upward and shifted basinward due to accommodation over its own forereef talus. The reef, in turn, is overlain by bedded carbonate sediment of the Yates and Tansill backreef facies which also shifted as the reef prograded basinward. Fusulinid dating and bentonite layers correlate the Lamar limestone of the basin with the Tansill Formation of the backreef. Erosion has removed much of the equivalent reef facies from the crest of the ridge 2000 ft above us so that only lower Tansill remnants cap the higher elevations here. Maximum water depth of the Delaware Basin is based on this Lamar-Tansill correlation.

The Capitan Reef limestone and forereef debris shed basinward from it consist of bryozoans, calcareous sponges, brachiopods, foraminifera (including excellent time-marker fusulinids), calcareous algae, solitary corals, ostracodes and crinoids. Depositional dips in the immediate forereef beds vary from 20° to 35°. Syngenetic and diagenetic calcite crystals comprise up to 55% of reef volume.

The bacicreef Yates Formation (the beds above the reef cliffs seen here) is chiefly dolomite with large pisolites and fossils such as dasyclad algae, foraminifera, brachiopods, gastropods, sponges and bryozoa. Very close to the Yates-age Capitan Reef facies, the dolomites of the backreef Yates contain fine-grained sandstones. In the subsurface of the Permian Basin the hallmark of

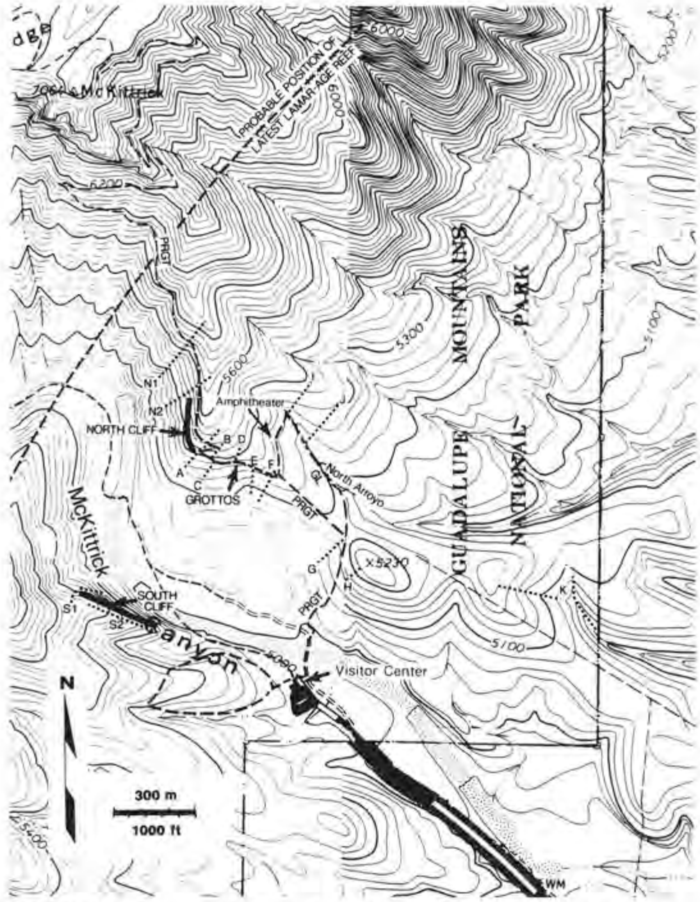

FIGURE 2.5. Topographic map of mouth of McKittrick Canyon, showing geologic interpretive trail and stops.

FIGURE 2.4. Geologists visiting McKittrick Canyon on May 7, 1964, were introduced to the area by Wallace Pratt himself. Courtesy of Southeastern New Mexico Historical Society of Carlsbad.

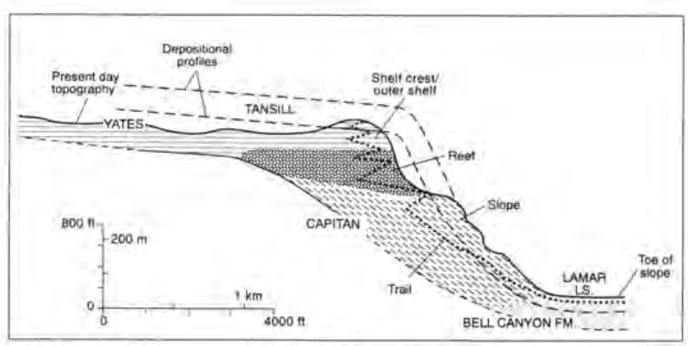

FIGURE 2.6. Diagrammatic topographic profile, position of interpretive trail, and cross section of facies and stratigraphic units exposed along the north wall of McKittrick Canyon (modified from Bebout et al., 1992).

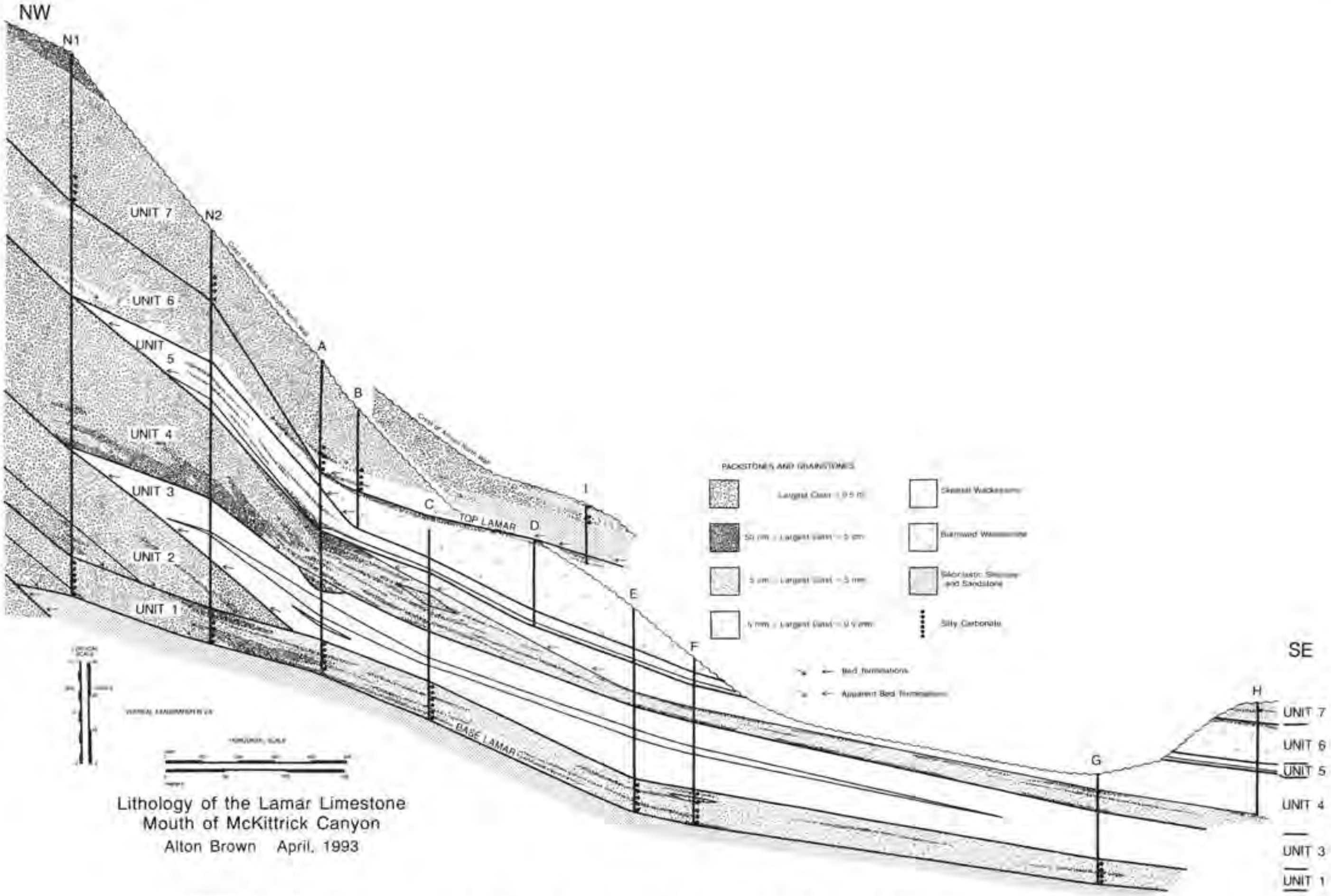

FIGURE 2.7. Detailed lithology of the Lamar Limestone at the mouth of McKittrick Canyon (courtesy of Alton Brown).

these Yates sandstones are large erratic frosted quartz grains and both bedded and porosity-plugging salt and anhydrite.

The Bell Canyon sandstones are well sorted, very fine grained and here contain massive boulder beds of Capitan sponge-algal reef debris that increase shelfward into forereef carbonate turbidites.

The following abstracts prepared for the Texas Bureau of Economic Geology summarize information on the four facies seen along the new Geology Trail, starting at the top and working down (Fig. 2.5):

Permian Reef Geology Trail Guide, McKittrick Canyon, Guadalupe Mountains National Park

WEST TEXAS SHELF FACIES

CHARLES KERANS, Bureau of Economic Geology, University of Texas at Austin, Austin, TX and PAUL M. HARRIS, Chevron Petroleum Technology Company, La Habra, CA

The Permian Reef Geology Trail, Guadalupe Mountains National Park, serves as one of the best exposed and most accessible sites for examining facies relationship at a carbonate platform margin. The highest part of the trail includes progradational outer shelf facies of the uppermost Yates Formation and retrogradational basal Tansill Formation shelf-crest and possible outer shelf facies. Shelf strata are particularly important for understanding the evolution of the platform-to-basin system because they provide the most sensitive record of relative sea level oscillations. The shelf facies provide the best record for identifying zones or surfaces within the massive reef that should reflect important baselevel changes. Integral to understanding the linlc between shelf and reef-margin facies is the "fall-in-bed" or deep-rimmed shelf geometry of the Capitan margin, which represents, at least in part, primary depositional topography.

A record of high-frequency/low-amplitude changes in relative sea level in the Yates and Tansill formations is displayed by (1) ten 30—ft-thick, upward coarsening, skeletal/peloidal/pisolitic wackestones-grainstones and (2) ten 20—ft-thick, skeletal carbonate to siliciclastic siltstone cycles. Analysis of a single cycle in a dip profile from shelf crest to reef shows a trend from cross-stratified skeletal-pisolitic grainstone near the crest to massive burrowed skeletal pacicstone nearest the reef. These facies changes occur within the reefward sloping profile of the individual cycles and together these data demonstrate that the Capitan reef equivalent to the uppermost Yates Formation strata was deposited in 30-40 ft of water depth.

A more substantial relative sea level shift interpreted from the shelf strata on the trail is a fall that brings shelf-crest facies in juxtaposition with outer shelf and uppermost reef facies. The fall in profile indicates a minimum downward facies shift of 30—40 ft. The surface formed by this shift coincides with the highest occurrence of the fusulinid *Polydiexodina,* which is widely distributed in the outer shelf, slope and toe-of-slope facies, thereby providing a potential time surface for evaluating the impact of the fall in terms of offset within reef and slope facies. Yates cycles above this surface record an upward-thinning trend and increase in siliciclastics consistent with long-term progradation. Basal Tansill cycles record landward-stepping facies of a transgressive systems tract, comparable to that recorded elsewhere in the Tansill.

WEST TEXAS REEF FACIES

BRENDA KIRKLAND, University of Texas at Austin, Austin, TX and SUSAN LONGACRE and EMILY STOUDT, Texaco, Inc., Houston Research Center, Houston TX

The massive Capitan or reef facies is a prominent cliff-forming unit along the Permian Reef Geology Trail. The presence of the fusulinid *Polydiexodina* through much of the reef facies indicates that the Capitan Formation along most of the trail is age equivalent to the middle and upper Yates Formation, hence older and stratigraphically below the Tansill-equivalent reef facies frequently visited in Walnut and Dark canyons.

Modern reefs contain four dominant components: (1) a diverse frame-building and binding community, (2) marine cement, (3) internal sediment that, along with marine cement, fills framework void spaces and (4) bioeroding organisms. Similar distinctive elements are present in the Yates-equivalent Capitan Formation, except that evidence of bioerosion is rare. Frame-building organisms are dominated, not by corals as in modern reefs, but by calcareous sponges and bryozoans. A number of binding organisms are also present. Volumetrically, the most important of these encrusters is the red alga *Archeolithoporella*, which is associated with precipitation of prodigious amounts of marine botryoidal aragonite cement; a similar association of red algae and aragonite cement exists in modern reefs. Other prominent binders/encrusters include the problematic organism *Tubiphytes* and various bryozoans. In addition to marine botryoidal aragonite cement, other marine cements include isopachous rims of Mg-calcite. Spectacular examples of layered, skeletal-derived and pelletal internal sediment fill framework voids and fractures throughout the Capitan reef along the Permian Reef Geology Trail.

Carbonate cements are prominent features of the Capitan Formation. They record changing fluid chemistries from marine to meteoric to burial conditions. The most prominent cements include the following, listed in order from first to latest formed: (I) marine botryoidal aragonite fans, (2) marine isopachous fi-brous calcite crusts, (3) marine inclusion-rich prismatic calcite crusts, (4) dolomite crystals precipitated on marine cements and calcspars, (5) fine to medium crystalline, luminescent meteoric calcspar, (6) very coarsely crystalline, cloudy, luminescent burial calcspar and (7) medium to coarsely crystalline, dully lumines-cent burial calcspar.

WEST TEXAS SLOPE FACIES

DON BEBOUT, Bureau of Economic Geology, University of Texas at Austin, TX; DENNIS MRUK, Marathon Oil Company, Midland, TX; and ALTON BROWN, ARCO Oil and Gas Company, Plano, TX

The Permian Reef Geology Trail, McKittrick Canyon, Guadalupe Mountains National Park, provides one of the best exposures of slope sediments equivalent to the upper Guadalupian Capitan reef. Two major depositional styles are represented by the slope sediments along the trail. Lower slope cohesive debris flows, which dip into the basin at 15-20°, are equivalent to the Tansill sediments on the shelf and post-Lamar sediments in the basin. Upper slope carbonate and sandstones, which dip into the basin at 20-35°, are equivalent to the Yates sediments on the shelf and Lamar Limestone in the basin.

The Tansill-equivalent lower slope is represented predominantly by massive megabreccia made up of large blocks, up to 15 ft across, of *Archaeolithoporella-sponge* boundstone. Matrix between the blocks is sparse and consists of poorly sorted, silty, dolomitic skeletal wackestone and packstone. Locally preserved at the base of these debris-flow deposits are remnants of burrowed wackestone of the upper part of the Lamar Limestone. Associated with the megabreccias are beds of skeletal packstone and grainstone that were deposited by high-density turbidity currents and grain flows.

The Yates-equivalent upper slope facies are diverse and include interbedded autochthonous slope wackestones to packstones with fenestrate and ramose bryozoans, sponges, brachiopods and crinoids; siliciclastic beds of fine-grained sandstone with dolomite matrix; steeply dipping, fusulinid-rich beds; breccias of locally derived slope material; and reef blocks. The blocks are comparable in fabric and faunas to those of the Yates-equivalent reef exposed along the trail above.

In addition to differences in position along their depositional profiles, changes in slope facies also reflect changes in growth styles of the shelf margin from more progradational (Yates) to more aggradational (Tansill). The siliciclastic sandstone beds just above the uppermost occurrence of the fusulinid *Polydiexodina* on the slope are thought to correlate with a significant siliciclastic bypass surface resting immediately on the last occurrence of *Polydiexodina* (base of Yates C) on the shelf. This proposed correlation provides the best opportunity for reconstructing the depositional profile of the Capitan shelf margin.

WEST TEXAS TOE-OF-SLOPE FACIES

ALTON BROWN, ARCO Oil and Gas Company, Plano TX

Decrease in paleoslope at the transition from the Capitan foreslope to the Lamar basin deposits is associated with a change in grain size and a change in depositional processes. Lower slope, reef-derived boulder conglomerates were deposited by debris flows and modified grain flows. Upper and medial toe-of-slope intraclastic and skeletal packstones were deposited by debris flows and high-density turbidity currents, whereas lower toe-of-slope skeletal wackestones were deposited by low-density turbidity currents.

Units dominated by steeply dipping boulder conglomerates downlap onto gently dipping wackestone units and wackestone units onlap steeply dipping boulder conglomerate units. This bedding termination pattern is caused by differences in depositional processes. Matrix-poor boulder conglomerates were deposited on steep slopes because gravity flows could transport these coarse-grained sediments only on steep slopes. Mud-rich, low-density turbidity-current and debris-flow deposits had low angles of repose, so they were remobilized if the slope became too steep.

The systematic bedding terminations are related to changes in the types of sediment supplied to the basin margin, which was a function of sea level. Matrix-poor boulder conglomerate units were scoured by fringing reefs when the shelf was emergent (early transgression). The carbonate mud in toe-of-slope wacke-stones was derived when the shelf was flooded (highstand). Boulder conglomerates with lime-mud matrixes formed after the Capitan reef had caught up with the sea level rise (late highstand).

The sea level history interpreted from sediment supply is almost the opposite of that indicated by siliciclastic sequence stratigraphy criteria. This example demonstrates the need to understand the cause of bedding termination patterns before using them to interpret sea level history.

After exercising options, return to vehicles and count noses. Retrace route to US-62/180. 4.3

52.8 Junction with US-62/180. **Turn right** and continue southwest on National Parks Highway. Route crosses Lower Bear and Bell Canyons, which join downstream to form Lamar Canyon. **0.3**

53.1 Canyon walls to left in Bell Canyon Sandstone with cap of older piedmont deposits. **0.2**

53.3 Bell Canyon sandstone crops out in walls of Lower Bell Canyon. Flowing water is usually present in creek bottom. **0.8**

54.1 This roadcut exposes an interesting submarine debris flow in the Rader Member of the Bell Canyon Formation. The boulders encased in a matrix of sandstone in the Rader are carbonate rocks from the shelf. Total thickness of the Rader in this area is 15 to 20 ft with about 10 ft exposed here. The underlying Bell Canyon sandstones are fine grained, well sorted and thin bedded alternating with siltstones and shales. Two miles to the west, the Rader thickens to 90-120 ft as it gets closer to the reef front (4 mi to the northwest). **0.2**

54.3 Roadcut in carbonate-cemented gravels of Plio-Pleistocene age on Manzanita limestone. The Manzanita limestone is the uppermost limestone member of the Cherry Canyon Formation. It is 100 to 150 ft thick with individual beds ranging from a few inches to over a foot thick. It contains waxy green bentonitic clays in this roadcut and in outcrops to the south along the escarpment of the Delaware Mountains. These are altered volcanic ashes. The Cherry Canyon Formation passes underneath the Capitan Reef and is equivalent to the Goat Seep Reef, which was deposited north of the later Capitan Reef. The Cherry Canyon contains three limestone members, the Manzanita at the top, the South Wells in the middle and the Getaway at the base. Manzanita means "little apple" in Spanish. Early workers thought the red-skinned tree in the Guadalupe Mountains was the same as the Manzanitas of the Siena Nevada of California. Actually, it is a close cousin, the Texas madrone. Both grow "little apples." **0.9**

55.2 Niclde Creek Station. The owner of the Nickle Creek Station will cook you a hamburger if you like and you can play on the pipe organ while you are waiting. The hill straight ahead is Rader Ridge. The limestones halfway up the ridge are the Manzanita. Above this are the Hegler and Pinery, with the Rader limestone capping the ridge. **0.9**

56.1 Beginning of roadcut in South Wells Member of Cherry Canyon Formation. The Cherry Canyon is about 1000 ft thick in this area. The thin-bedded sandstones (1-10 cm) are similar to those in the Bell Canyon. In the Delaware Basin, oil production comes from submarine channel sandstones that have better porosity and permeability than the flanking submarine fan deposits in the Bell Canyon, Cherry Canyon and Brushy Canyon Formations. On the west end of this outcrop (south side) is a submarine erosion surface with relief greater than one meter that is overlain by a carbonate debris flow more than 6 ft thick. **0.3**

56.4 End of South Wells roadcuts. **0.4**

56.8 Roadcuts in older (piedmont) gravels. 0.3

57.1 Nipple Butte a.t 1:00 exposes Cherry Canyon sandstone below the Manzanita limestone. **0.2**

57.3 Guadalupe Mountains National Park boundary. **0.4**

57.7 Crossing Lower Smith Canyon. **0.5**

58.2 Roadcut in older gravels. **0.5**

58.7 Prepare for right turn. **0.2**

58.9 **Turn right** for side trip to Frijole Ranch and U.S. National Park Service Cultural Museum. 0.1

59.0 Corral for trail rides (bring your own horse). Climbing alluvial fan at base of mountains; exposures of carbonate-cemented older fan alluvium ahead. **0.6**

59.6 **OPTIONAL STOP.** Frijole Ranch Cultural Museum and Smith and Manzanita Springs Trailhead. This is the oldest ranch in the Guadalupe Mountains. The first house was built by the Rader brothers in the 1860s. On the return trip to US-62/180 is an excellent view (to south) of the east-tilted Delaware Mountain block (King, 1949), with cuesta ridges formed on resistant units of the Delaware Mountain group. Petroleum geologists consider this area to be the boundary between the Permian Basin and the Basin and Range structural provinces. **0.7**

THE FRIJOLE RANCH COMPLEX: PIONEER LEGACY OF THE GUADALUPES

Brent Wauer[1] **and Ben Gilmore**[1]

[1]Park Interpreter; Nolunteer-in-Park, Guadalupe Mountains National Park, Salt Flat, Texas 79847

Artifacts reveal that the Frijole area has been a popular place of settlement for many centuries. This is not surprising when one considers that Pine, Juniper, Smith, Choza, Manzanita and Frijole springs are all within a 1-3 mi radius of the Frijole Ranch Cultural Museum. Mescal pits, petroglyphs and artifacts discovered in nearby caves reflect early Native American occupation and dependency on the essential water, vegetation, cover and game found in the vicinity.

Although not well substantiated, some believe that a four-room dugout, constructed by the Walcott family in the early 1860s, was perhaps the earliest Anglo dwelling in the region. It is certain that the first substantial, permanent structure at the site was built by the Rader brothers in 1876. These two bachelor brothers operated a small cattle ranch out of their sturdy rock home, which consisted only of the present front or south-facing living and dining rooms of the structure. The house was constructed 40 ft from Frijole Spring. It had double walls of native stone with a filler of mud between; interior walls were also plastered with mud. While the brothers were the first permanent settlers on this side of the mountain range, it appears they never filed a deed on the cattle ranch. Apparently, they had moved on by the late 1800s, after which the Hefting family, about which little is known, lived there.

In 1906, John Thomas Smith filed on the Frijole site as vacant land, referring to the house and property as the "Spring Hill Ranch" until 1912. Mr. Smith had moved from Wisconsin to Texas, where he married Nella May Carr in 1889, in Sherman, Texas. Eventually, they moved to Van Horn, Texas, and from there acquired the Frijole site. They were married for 63 years and had ten children. The Smiths made a living by truck farming and had a 15-acre orchard and garden east and north of the house. Over the years, apples, peaches, apricots, plums, pears, figs, pecans, blackberries, strawberries, currants and some corn were grown, the springs providing more than adequate water for at least two plots. Periodically, the Smiths would load up their wagons in the eve-ning, covering the fresh produce with wet paper and linen. They would then travel for two days to Van Horn (60 mi south) where they would sell the fruits of their labor. They also raised cattle, horses, pigs and chickens.

The Smith family greatly expanded the Frijole Ranch House in the 1920s. The rear kitchen and two bedrooms were added, as well as a second story and dormers (Fig. 2.8). A gable roof, with wood shakes, eventually covered the house. The building on the northeast corner of the lot was first erected as a bunkhouse for hired help, but was later

FIGURE 2.8. Frijole Ranch house with Walter Glover, circa 1930s.

used as a guest house. Like the original home, that structure and the double toilet (a luxury) were constructed of stone masonry with shed roofs. A spring-house of wood and stone was also built for water protection and storage. The area's first hydraulic "Ram Jet Pump" was installed to pump water up the tower located in the front yard to a storage tank for domestic use. Because of its location and cool interior, the small stone building south of the spring-house was first used to store fruits, vegetables, milk, meat and other perishables. Later, with the availability of electricity, a more sophisticated pump system was installed there. A barn with a hay loft was also a necessity.

The red schoolhouse was built with vertical wood siding and a low pitched roof covered with corrugated tin. Up to eight children from the Smith family and local ranches once attended school there. The Smiths provided room, board and a horse, in addition to a $30.00 per month salary for the teacher. Later, the schoolhouse served as a storage shed and bunlchouse.

Frijole Ranch House has seen many changes in lighting since its construction in 1868. Originally lit with tallow candles and kerosene lanterns, the Smiths installed a carbide lamp system, which produced acetylene gas that was piped through the house. This advance was followed by battery-powered lights, the former charged with a wind generator. Today, of course, the house is lit with electricity, perhaps waiting for yet another technological advance.

As the only major building complex in the region for several decades, the Frijole Ranch House served as a community center for dances and other social gatherings, as well as the region's official post office, from 1916 to 1942. Although not built until 1950, the present barn complements the other buildings and is of wood frame construction. Today park livestock utilize the barn and a stone masonry wall encloses most of the Frijole complex.

In 1942, after 36 years, John Smith sold the Frijole Ranch House and associated property to Judge J. C. Hunter for the price of $5,000.00. He then moved with his family to Hawley, Texas, near Abilene.

Jesse Coleman (J. C.) Hunter first moved to Van Horn, Texas, in 1911, to serve as Superintendent of Schools. Before his death in 1945, he also served as Director and Vice President of the Van Horn State Bank, was a Culberson County Judge and Treasurer, successful in the oil and gas business and a rancher. J. C. Hunter began buying land in the Guadalupe Mountains in 1923 and by the 1940s he owned 43,000 acres, including John Smith's Frijole Ranch House and properties. His "Guadalupe Mountains Ranch" concentrated on raising angora goats, sheep, cattle and horses. At one time, 22 tons of mohair wool were produced annually by 4000 angora goats. The mountain high country was utilized as a summer range for livestock; water pumped from lowland springs by pipeline to metal storage tanks on top was crucial to their survival. The Frijole Ranch House served as ranch headquarters for J. C. Hunter's foreman, Noel Kincaid and his family, who lived there from 1942 to 1969.

Judge Hunter was an early conservationist and initiated the first attempts to make the region a park in 1925. The idea failed to gain momentum and was dropped. Because Judge Hunter continued to hope for a park in the future, he permitted only limited hunting on the ranch and allowed no grazing in McKittrick Canyon. Under his stewardship, elk, turkey and rainbow trout were returned, or introduced, to the Guadalupe Mountains ecosystem.

In 1945, J. C. Hunter's son, J. C. Hunter, Junior, inherited the ranch. Although mayor of Abilene and a successful oil man, Mr. Hunter took an active interest in his lands in the Guadalupe Mountains. By the 1960s he had purchased an additional 24,312 acres in the mountains, the Guadalupe Mountains Ranch totaling 67,312 acres by 1965. In 1966, he fulfilled his father's dream and sold the ranch to the National Park Service, at the bargain price of $1.5 million, or about $22 per acre.

From 1969 to 1980, the ranch house served as a ranger residence. During the next three years, rehabilitation and renovation of the Frijole Ranch buildings was completed by the National Park Service. Visitor Protection and Resource Management staff used the ranch house as an operations office from 1983 until 1991. In 1992, the Frijole Ranch House was again renovated and finally opened to the public as a cultural museum (Fig. 2.9), reflecting the early ranching era and reminding us of local involvement in a post—Civil War economy that opened the region to settlement.

FIGURE 2.9. Frijole Ranch house, Guadalupe Mountains National Park, 1992.

Today's Frijole Ranch Cultural Museum is on the National Register of Historic Sites and the access point for the beautiful Smith Spring loop trail, an easy 2.3 mi walk. Smith Spring, an oasis in the desert, was named for the Smith family and is the major attraction on the hike. The National Park Service will continue to preserve Frijole Ranch Cultural Museum, so that future generations may come to appreciate our diverse heritage.

60.3 Junction with US-62/180. Turn right. Housing for National Park Service personnel to the south. **0.1**

60.4 Continuing west on US-60/180. El Capitan (elevation 8085 ft) at 12:15; the cliff face is about 1100 ft high. **0.3**

60.7 Crossing Pine Springs Canyon Creek. **0.6**

61.3 Site of the old Pine Springs Motel. Channel sandstones in the Cherry Canyon at 9:00. **0.2**

61.5 Butterfield Stage Coach ruins at Pinery Station. **0.2**

THE PINERY STATION OF THE BUTTERFIELD OVERLAND STAGECOACH LINE

Jim W. Adams

Exxon Company, USA, Box 3116, MidIsmd, Texas 79702

These are the ruins of the Pinery Station of John Butterfield's Overland Stagecoach line. The first coach to stop here was westbound on September 28, 1858 (Fig. 2.10). Only the corral had been built and the crew was living in tents. They served a meal of venison pie and baked beans, but the beautiful scenery overwhelmed one passenger who wrote: "It seems as if nature has saved all her ruggedness to pile it up in this colossal form of Guadalupe Peak, sometimes called Cathedral Peak, which rears its head up 4000 feet above the level of the plain . . . the wild grandeur of the scene is beyond description" (Conkling and Conkling, 1947, p. 392). A few hours later, the first eastbound stage met the first westbound stage at the foot of Guadalupe Pass. Butterfield's 2795-mi route from St. Louis to San Francisco was prob-ably the longest stagecoach line in the world (Fig. 2.11). Only three towns were along the route: El Paso, Tucson and Los Angeles (pop-ulation 6000). But Butterfield insured its success by building waysta-tions like The Pinery where horses (or mules) could be changed every 40-50 mi; he also had the mail coaches run day and night.

We are indebted to an Army officer at Ft. Bliss in El Paso for much of our knowledge about the Butterfield line. From 1931-1947, Roscoe

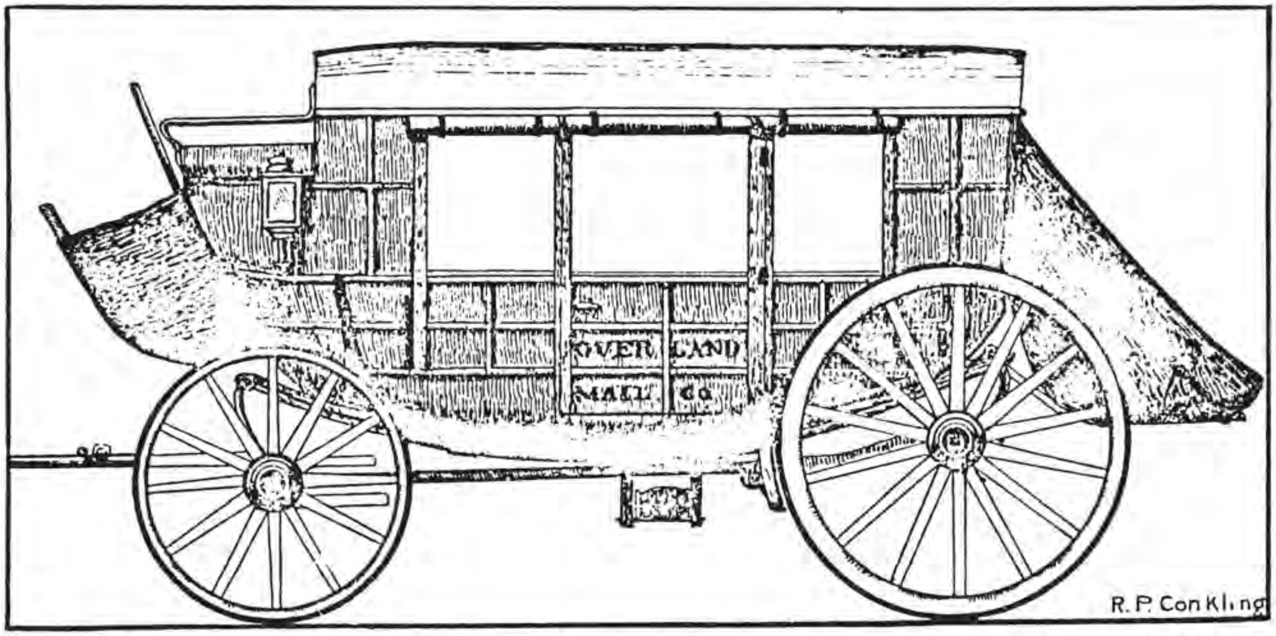

FIGURE 2.10. Butterfield stagecoach drawn by R. P. Conkling (from *Butterfield Overland Mail* by Roscoe and Margaret Conkling, reproduced by permission of Arthur H. Clark Company).

and Margaret Conkling travelled the entire length of the route three times in order to document the remaining waystations. They state that the ruins we see here are, unfortunately, the best-preserved of any of Butterfield's stations. This conflicts with the claim of La Posta Restaurant in Old Mesilla west of Las Cruces, New Mexico, which vows that it occupies the Butterfield Station there and is still serving the public from that very fine old building. It is certain that Mesilla was on the stagecoach route. When Roscoe Conkling retired from the Army, the Conklings (1947) published a three-volume tome which, unfortunately, is now out of print.

After treating its passengers to the beautiful scenery of these mountains for about one year, the Postmaster General ordered that the route be shifted to the south in order to serve Ft. Davis and Fort Quitman and the colorful Butterfield stagecoaches ceased to roll through Guadalupe Pass. This stagecoach line was eminently successful in that (1) to everyone's amazement, it never once failed to meet the contract schedule of 28 days between St. Louis and San Francisco, (2) it was of great importance to the nation, because it bound California to the Union as nothing else could do and (3) despite that fact, it existed only two and a half years before being severed by the Civil War in 1861. For additional information on historic Guadalupe Pass, see Adams (1968).

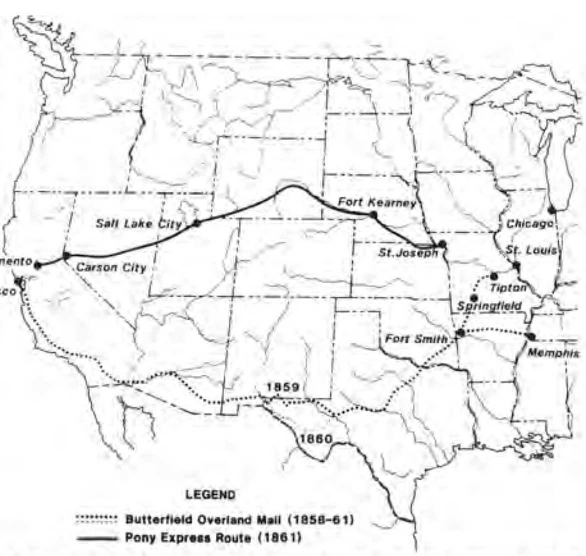

FIGURE 2.11. Butterfield Overland Mail and Pony Express Routes (from *Butterfield Overland Mail* by Roscoe and Margaret Conkling, reproduced with permission of Arthur H. Clark Company).

61.7 **Turn right** to Guadalupe Mountains National Park Headquarters. **0.2**

61.9 **OPTIONAL STOP** at Park Headquarters. Excellent exhibits on park geology and natural history. 0.1

62.0 **Turn right** on road to Pine Springs Campground and Trailhead. Route continues north on bouldery surface of Quaternary alluvial fan. **0.6**

62.6 Turn around at Pine Springs Trailhead and access to Guadalupe Peak (highest point in State of Texas, 8749 ft). Return to US-62/180. **0.6**

DIVERSITY OF LIFE IN GUADALUPE MOUNTAINS NATIONAL PARK

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Guadalupe Mountains National Park is a remarkable region set aside for the geological and biological treasures found within its boundaries and the educational opportunities it provides. Although geologists have focused on the reef system that evolved during the Permian Period, the biological diversity of the park poses a surprise to biologist and casual visitor alike. The geography of the land is such that it harbors distinct life zones that provide an opportunity for greater understanding of the natural world. More importantly, by establishing Guadalupe Mountains National Park, our ever-consuming species has provided an area where wildlife and wildness can continue to flourish with minimum human impact.

The approach to Guadalupe Mountains National Park from any direction is awe-inspiring, with El Capitan looming majestically above the horizon for fifty miles. Surrounding the mountains is the great Chihuahuan Desert, a seemingly inhospitable and desolate landscape, inhabited by a variety of plants and animals. Once thought to bloom every "century," several species of spectacular agaves are found within this park. The Lechuguilla *(Agave lechuguilla) is* a major indicator of Chihuahuan Desert (Fig. 2.12). During a three- to four-year life span, the plants store energy that will enable them to rapidly produce the flowering stalk required for reproduction; they then normally die.

The Cane Cholla *(Opuntia imbricata)* is also found within this great desert and is common within Guadalupe Mountains National Park. The magenta bloom of the Cholla is a remarkably beautiful sight to behold, yet, when faced with lack of moisture during drought, segments of the cholla will fall to the ground. This is an attempt to reduce surface area, thus limiting the loss of valuable moisture through evaporation.

Found in the harshest environs of the park, the Fourwinged Salt Bush *(Atriplex canescens)* grows about 3 ft high and occurs in saline soils. Being drought resistant with a well-developed root structure and edible fruit, the Salt Bush not only reduces soil erosion, but provides food for various marmnals, such as Kangaroo Rats and Antelope Squirrels, that inhabit the desert.

The diversity of life within Guadalupe Mountains National Park becomes apparent as one climbs upward from the Chihuahuan Desert. Hiking the park's canyons any time of the year can be a visual delight, but during the fall, the deep orange of Big Tooth Maple *(Acer grandidentum),* the deep reds of the Fragrant *(Rhus aromatica)* and Flame Leaf Sumacs *(Rhus copallina),* the yellows of the Little Leaf Walnut *(Juglans microcarpa)* and the greens of the Alligator Juniper *(Juniperus deppeana* var. *deppeana)* present an unforgettably brilliant display.

Although visitors tend to favor the fall color season, the canyons teem with blooming plant life throughout the spring and summer. Algerita *(Berberis trifoliolata) is* a small shrub that flowers early in the spring. The yellow flowers furnish pollen for bees and the red fruits are a source of food for mammals. A relict of cooler, wetter times, the Texas Madrone *(Arbutus xalapensis)* is one of the most striking trees in the Guadalupes. Its smooth limbs leave little question as to why the name "Lady's Leg" was used when describing this tree (Fig. 2.13). Small white flowers are produced in March. The dark red fruit, maturing in September, is a favorite of small mammals and birds. The Mexican Orange *(Choisya dumosa)* is the only true citrus in the Guadalupes. Although this shrub is very common, it is not browsed, for animals find its strong odor and taste unappealing.

Hidden from view except to those who climb into the relict forest known as the "Bowl," the vegetation of the high country is unique and takes on the characteristics of forests in northern latitudes. Originally, a forest covered the entire region, but as the climate became warmer and drier, it survived only in the high country because of the more abundant moisture and cooler temperatures. It is composed primarily of Limber Pine *(Pinus strobiformis),* Ponderosa Pine *(Pinus ponderosa)* and Douglas Fir *(Pseudotsuga menziesii).* Upon closer observation, however, one quickly identifies a great many wildflowers that enhance and contribute to the forest ecosystem.

One of the more recognizable flowers of the Bowl, Indian Paint Brush *(Castilleja indivisa),* with its reddish orange flowers, grows in the lime-rich soils of the park and is moderately browsed by mule deer. Found at altitudes above 5000 ft, the Nodding Onion *(Alhum cernuum)* is recognized above ground by its purple flowers and below ground by its distinctive bulbs. Mescalero Gooseberry *(Ribes mescalerium)* is found in the upper reaches of the Guadalupes. The small white flowers are followed by a tasty berry that is a favorite of birds and manunals.

A wide variety of animal life inhabits Guadalupe Mountains National Park. Found throughout the entire park, Mule Deer *(Odocoileus hemionus)* feed on the various grasses, shrubs and berries. The Coyote *(Canis latrans)* is seldom seen, for it is a nocturnal animal that hunts rabbits and small rodents at night. Black-tailed Rattlesnakes *(Crotalus molossus),* like the coyote, are nocturnal hunters. Because they are cold-blooded reptiles, they can be seen, mid-moming, basking in the sun trying to increase body temperature. The Western Box Turtle *(Terrapene ornata),* burrowing throughout the day to escape the sun, is most active in the early morning and after a heavy rainfall.

More than 200 species of birds call Guadalupe Mountains National Park home. The Canyon Towhee *(Pipilo fuscus) is* a very common resident of the park. It can be found hiding in the dense scrub Oak and other brush. The Perigrine Falcon *(Falco peregrinus),* due to the effect of pesticides, is an endangered species. In order to prevent the bird's extinction, rehabilitation efforts are under way across the country. Sev-eral pairs have produced offspring within this National Park.

Guadalupe Mountains National Park has drawn people to its beauty and resources for centuries. The desert, the mountains and the canyons have been viewed with great awe, admiration and fascination by people who have lived, studied or just wandered through this part of west Texas. It is the diversity of life found within the boundaries of this magnificent national treasure which draws so many to its interior. But the value of Guadalupe Mountains National Park cannot be measured by its recreational opportunities alone, for it was not set aside for the conquerors or those who crave shallow pleasures. Guadalupe Mountains National Park was established in part for the unique habitats it contains, the wildlife within and the educational opportunities it provides; in short, the things we need so much for a meaningful existence on this planet.

63.2 Turn right at stop signs ahead. 0.1
63.3 **Turn right** (west) at junction with US-62/180. 0.1
63.4 Guadalupe Summit (elevation 5695 ft); start 2000-ft descent to floor of Salt Basin (mi 80.9). The following quote provides a description of the landscape between the Pecos River and El Paso from A. B. Gray's report on a "survey of a route on the 32nd Parallel for the

FIGURE 2.12. The *Agave lechuguilla* contains a natural cortisone in its sharp spines so that a wound hurts like a hypodermic needle prick. Lechuguilla also contains soponin, a natural surfactant Native Americans use as soap.

FIGURE 2.13. The Texas Madrone (*Arbutus xalapensis*), commonly known as "Lady's Leg."

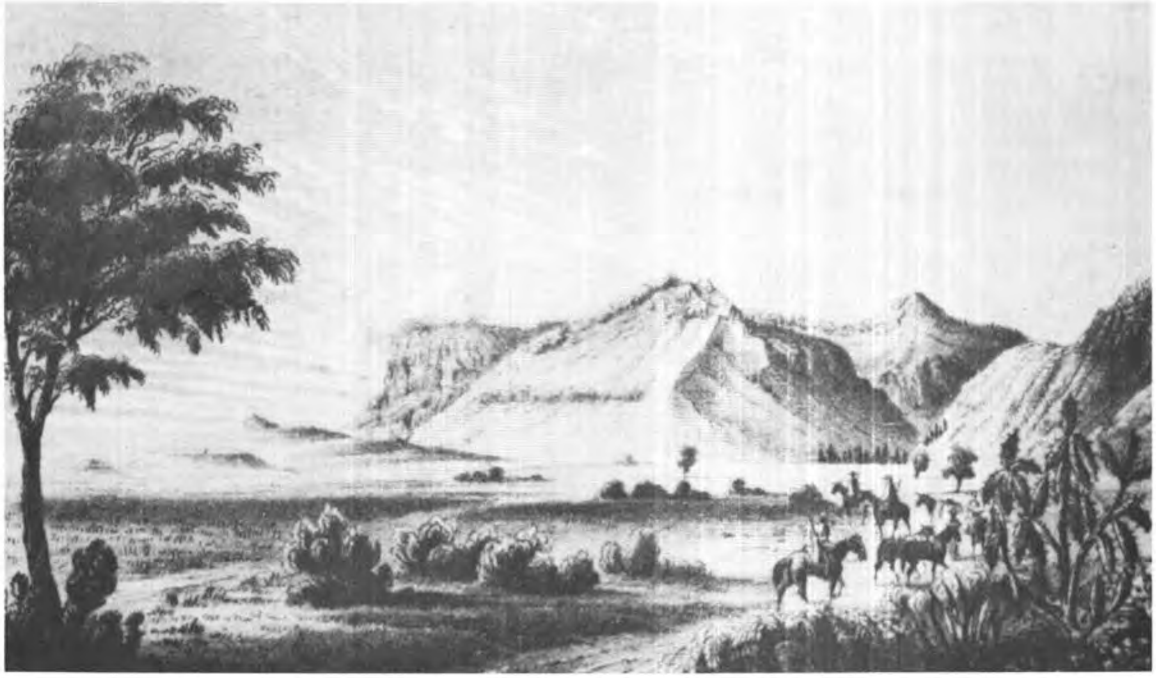


FIGURE 2.14. Guadalupe Mountains near Pine Springs viewed from east. Drawing by Charles Shuchard, 1854. From the A. B. Gray Report, edited by L. R. Bailey, courtesy of Westernlore Press.

Texas Western Railroad, 1854," as edited by L. R. Bailey (1963). Permission from Westernlore Press, Los Angeles, CA for reproduction of the 1854 drawings by Charles Shuchard [Schuchard] is gratefully acknowledged.

Three ranges intersect the parallel of 32 deg. between the Pecos and Rio Grande. First the Guadaloupe *[sic]* and Sacramento range; 2d, Sierra Hueco; and 3d, mountains of El Paso or Sierra de los Organos. The two last ranges are much broken and in detached parts toward the south. The Organ mountains are not crossed on either of the propoSed lines, but turned at the point where the river breaks through and forms the pass of the Rio Grande [El Paso del Norte]. The Sierra Guadaloupe [Fig. 2.14] is more conspicuous, but breaks at latitude 31 deg. 50 min., where there is an abrupt and precipitous cliff of columnar rock [El Capitan], of a thousand or fifteen hundred feet from its base, resting upon vast limestone terraces, with a general elevation of several thousand feet above the plain. The Peak can be *seen* at a great distance, owing to the clear and rarified atmosphere of the country [Fig. 2.15]. This stupendous basaltic *[sic]* structure is perpen-dicular and looks as if it had been shaped by some sudden

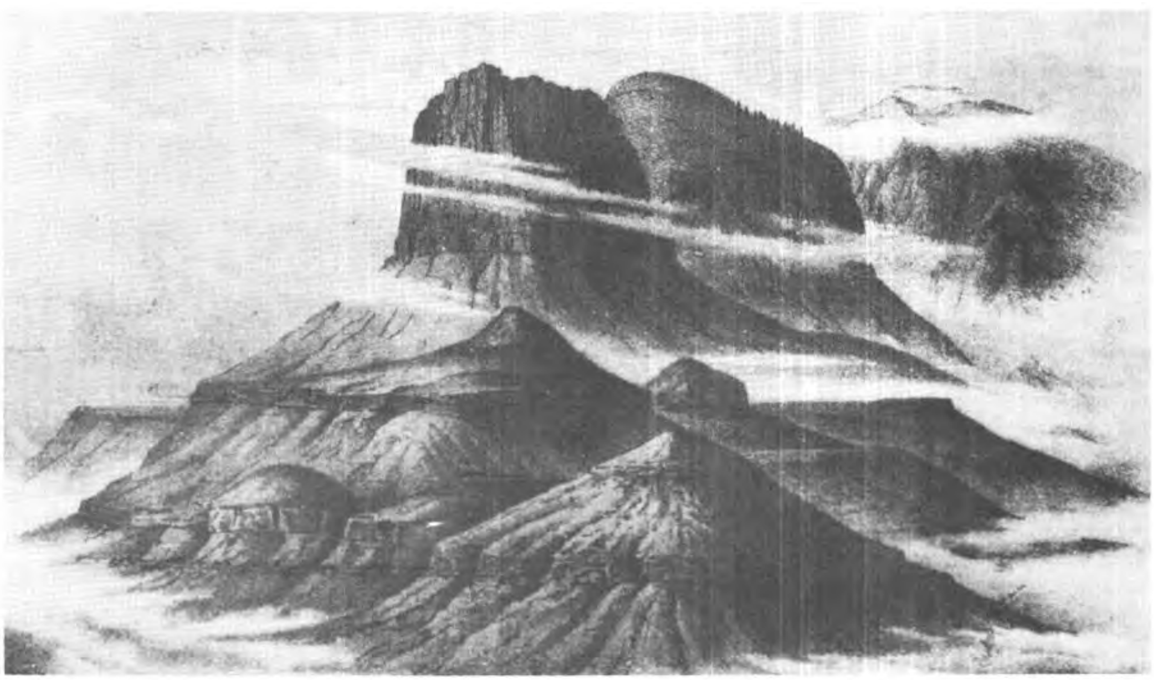


FIGURE 2.15. Cathedral Peak (El Capitan). Drawing by Charles Shuchard, 1854. From the A. B. Gray Report, edited by L. R. Bailey, courtesy of Westernlore Press.

and powerful convulsion of nature into the form of a large edifice or church, from which circumstance we gave it the name of Cathedral rock. Viewed from the deep gorge below, it is truly sublime and beautiful—its lofty pealc towering to a great altitude and crowning the terminal point of an extensive range of mountains. At the foot of this great cliff is one of the routes proposed for the Pacific railway between the Pecos and the Rio Grande on the parallel of 32 deg. To the southeast the mountains taper into butes *[sic]* or conical hills and spurs, forming depressions near the parallel of 31 1/2 deg. . . . *Footnote 18 by L. R. Bailey (p. 153): Cathedral Rock which "rears its rocky head in solitary splendor" was named by Lieutenant William C . Whiting on Apri129, 1849, as he passed that way while determining a practicable and convenient route for military purposes between El Paso and the Gulf of Mexico. See R. P. Bieber (1938).*

The Sierra Guadaloupe range is the commencement of the back bone of the Continent, the Rocky Mountains and continuation of the great "Sierra Madre" of Mexico. Its Eastern slope is drained by the Pecos until reaching the Rio Grande in latitude 29 deg. 45 min., when the latter river pursuing a similar course receives the waters of the "Mother Mountain" [Sierra Madre] till discharging itself into the Gulf. . . . p. 25-27.

From the Pecos River to the Guadaloupe Mountains, a distance of 62 miles, there will be an average ascending grade of 31 and 2/10 feet, for thirty-five miles; and for 27 miles a rise of 45 and 4/10 feet per mile. Thence by one or two practicable and easy curves around the south base of the peak, there will be for 7 miles a descent of 91 feet per mile and for 15 miles to the level of the [Salt Flat] plain near Ojo del Cuervo (Crowspring), a grade of 54 and 7/10 feet per mile. Descending more to the northward by the slope of the mountain, lower grades may be obtained. There will be from the Pecos river along Delaware creek, several culverts and some rock excavation and at the curve of the Guadaloupe Mountain, considerable cutting and filling; possibly a short viaduct, the material necessary for the construction of which is found on the snot

From the Crow spring to the Sierra del Cornudos (Horn Mountain), there would be an ascending grade for 30 miles of 37 4/10 feet per mile. This Sierra [Fig. 2.16] is named from a horn-like point at its eastern end and it contains vast natural reservoirs of good water. It is a small and isolated mountain of Feldspatic character, similar to the Sierra del Alamos (mountain of the cotton woods)—9 miles further west; to which there is an ascending grade of 35 and 9/10 feet per mile. p. 29-31 0.2

63.6 Roadcut in Cherry Canyon overlain by bouldery carbonate-cemented conglomerate of late Tertiary or early Quaternary age. 0.2

63.8 Roadcut through steeply dipping and faulted Cherry Canyon. Note influence of high-angle basin-and-range faults of Neogene age. 0.5

64.3 Roadside park. To south are the Delaware Mountains, type locality of the Delaware Mountain Group. The western escarpment of the Delaware Mountains and roadcuts along US-62/180 for the next few miles have spectacular exposures of the Brushy Canyon and lower Cherry Canyon sandstones deposited on the Delaware Basin floor. **0.6**

64.9 Roadcuts in flagstones of Cherry Canyon. South Wells Limestone Member in road cuts for 0.4 mi on left (east) includes several debris-flow units. **0.6**

65.5 Carbonate-cemented older gravels (Plio-Pleistocene) in roadcut. 0.2

65.7 Cherry Canyon in roadcut ahead. 0.2

65.9 **STOP 3.** Everybody walks through these roadcuts. **For safety's sake, be extremely careful if you cross the highway.** Top roadcut is in lower Cherry Canyon. This walk should familiarize participants with the Cherry Canyon and underlying Brushy Canyon sandstones. Watch for and note (1) large submarine channels cut into the Cherry Canyon sandstone, (2) flame structures, (3) rip-up clasts, (4) graded bedding, (5) flute and cast marks, (6) trace fossils characteristic of deep water deposition, (7) debris flows containing corals, algae, bryozoa and fusulinids, (8) sole marks, (9) phosphate nodules, (10)

FIGURE 2.16. Sierra del Cornudas. Drawing by Charles Shuchard, 1854. From the A. B. Gray Report, edited by L. R. Bailey, courtesy of Westernlore Press.

crossbedding, (11) ripple marks, (12) slump folds, (13) soft sediment deformation, (14) Bouma sequences, (15) plant fragments. The conspicuous channel in road cut on left (south) and fill are part of the Getaway Member of the Cherry Canyon (Fig. 2.17). The base of the channel is extremely sharp, truncating sands of the Cherry Canyon. The fill includes an initial drape of fine sandstone, a tapering wedge of dark, organic-rich siltstone and overlying, mostly onlapping allochthonous (debris-flow) carbonates. In the days before understanding of turbidites, Newell (1953) initially interpreted the lenticular carbonates containing corals, algae, bryozoa and fusulinids as patch reefs, but now they are seen as allochthonous channel-filling debris flows. This channel may be one of numerous ephemeral, minor channels on a broad submarine apron extending far into the Delaware basin. In this area, channels appear to show flow from northwest to southeast. 0.5

66.4 Tour vehicles will pick up passengers at turnout at west end of roadcut. This is an excellent spot for photographs of El Capitan Peak. 0.1

66.5 Rockwork to right is probably the original Butterfield Stage route, which descended the canyon to the south. A little farther on, we cross the upper end of Guadalupe Canyon. Go slow past Tertiary high-angle faults in Brushy Canyon sandstone. The faults trend N20°W. 0.3

66.8 Channel sandstone and conglomerate in Brushy Canyon sandstone. 0.3

67.1 Roadcut in bouldery older gravel. 0.5

67.6 **OPTIONAL STOP** at roadside park and view of Guadalupe Peak (Figs. 2.18 and 2.19). This stop provides a spectacular view of El Capitan Peak (elevation 8085 ft) composed mostly of Capitan forereef talus that dips south toward this vantage point. On the east side of the canyon wall to the north note the abrupt toe-of-slope transition from lower foreslope resistant carbonates to the less resistant basin-filling siliciclastics. The Pinery and Hegler Limestone members of the Bell Canyon lie below El Capitan. The distinctive green bentonitic Manzanita Member forms the top of the underlying Cherry Canyon Formation. The prominent sandstone ledge marks the top of the Brushy Canyon Formation (below white bar on left of Fig. 2.20). This sandstone is the northern part of a large northwest-southeast-trending channel fill of coarser-grained sandstone in the predominantly finer-grained sandstone and siltstone of the Brushy Canyon Formation. In the ravine to the right note two conspicuous thin and resistant layers (marked by arrows on Fig. 2.20) that are clearly discordant to master bedding. Harms (1974) pointed out that these resistant units are dark, organic-rich siltstones that mantle channels filled with fine-grained sediments similar to the "host" facies rather than coarser sandstone. The Brushy Canyon, Cherry Canyon and Bell Canyon formations are the basinal facies of the Delaware Mountain Group of Guadalupian age. All three of these formations produce oil in the Delaware Basin, but the most prolific zone is the top of the Bell Canyon just below the Lamar Limestone.

FIGURE 2.17. Channel fill of Getaway Member of Cherry Canyon Formation. Sharp basal truncation surface is overlain by fine-grained channel sandstone, followed by laterally thinning, dark, organic-rich siltstone, and on-lapping resistant carbonates. The Getaway carbonates have abundant marine fauna and were initially considered patch reefs (Newell, 1953), but are allochthonous channel fills.

FIGURE 2.18. El Capitan from roadside park at mi 67.6.

To the south are the Delaware Mountains. Many channel sandstones can be seen along this erosional escarpment. To the west is the Salt Flat graben, which extends to the Baylor Mountains, lying 45 mi to the south. West of Salt Flat is the Diablo Platform, with Victorio Peak to the southwest. The latter is composed of 800-ft-thick Leonardian Victorio Peak carbonate banks (Permian Basin SEPM, 1983, p. 21). The Sierra Blanca Tertiary intrusive is located 53 mi to the southwest while the Cornudas Mountains, mid-Tertiary intrusives, are to the northwest (see McLemore and Guilinger, and Kues and Lucas, this volume).

The Butterfield Stagecoach line went through Guadalupe Pass and down one canyon east of this highway. It crossed Salt Flat and headed for tinajas in the Cornudas Mountains and at Hueco Tanks east of El Paso. A surgeon and geologist attached to Captain John Pope's survey, Dr George G. Shumard, gathered fossils in Guadalupe Pass in 1855. His brother, professor Benjamin Franklin Shumard, correctly identified the fossils as Permian in age. This was the first geological study of the Permian Basin. That identification was noteworthy when we consider the fact that Murchison had just established the Permian System some 17 years earlier! **0.5**

68.1 **STOP 4.** The highway roadcut is conveniently placed to give us an intriguing view of cut-and-fill in a submarine channel of resistant sandstone truncating the finer-grained "host facies" of the Brushy Canyon Formation of early Guadalupian age (Fig. 2.21). Toward the south end of this roadcut is spectacular soft sediment defor-

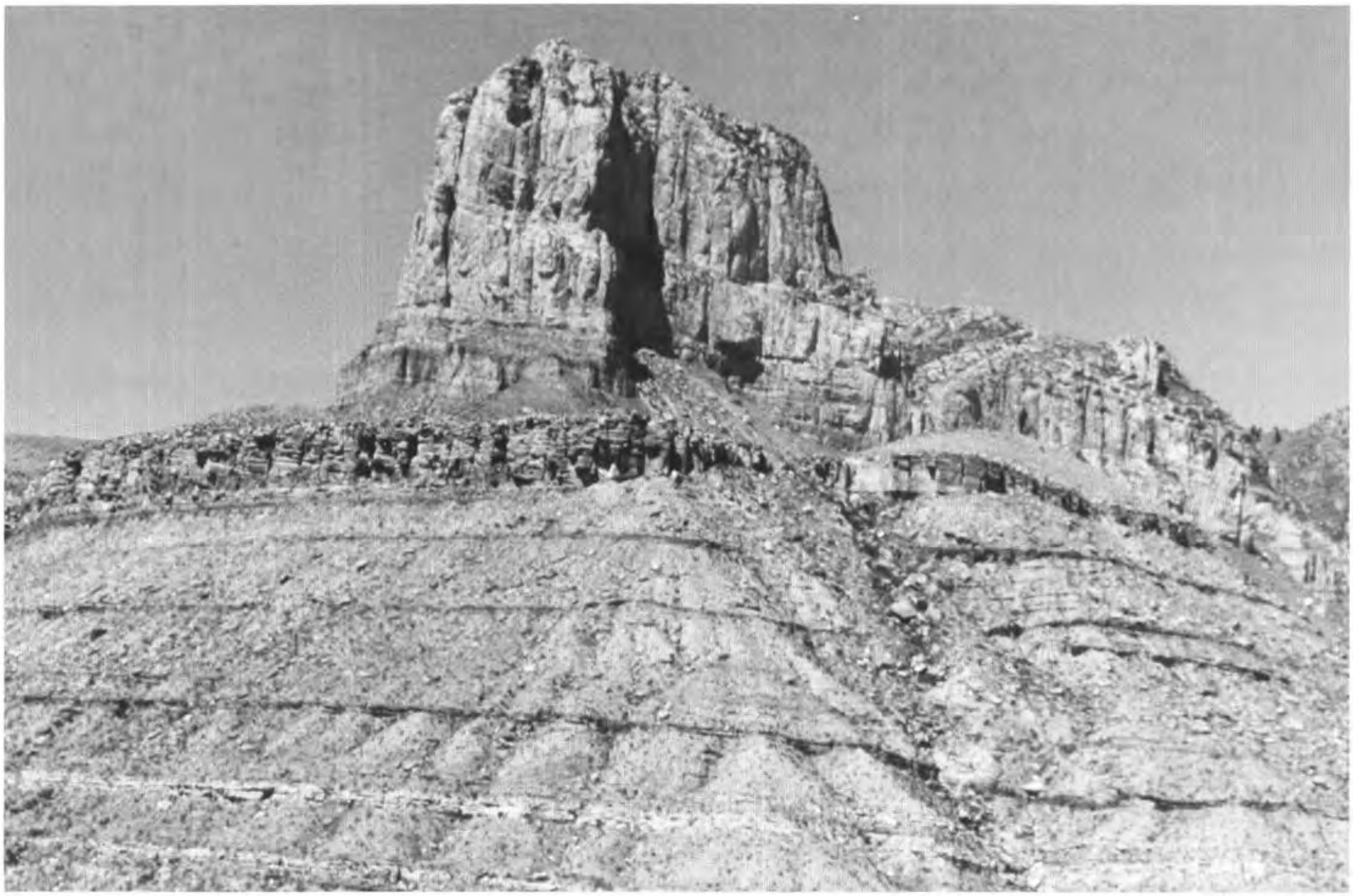


FIGURE 2.19. El Capitan. Massive reef and foreslope facies above bench-forming Delaware Mountain Group.

mation with convolute bedding, gravitational creep, submarine erosion and rip-up clasts. **0.2**

68.3 Excellent views of Delaware Mountain escarpment and of the Brushy Canyon (type section is here) and lower part of the Cherry Canyon (upper quarter of scarp; Fig. 2.22). Most of the strata of the Delaware Mountain Group here consist of laminated, very fine-grained sandstone and coarse siltstone, interpreted as subaqueous suspension deposits. An eolian source (Fischer and Sarthein, 1988) for these units seems more likely than density interflows (Harms, 1974). Light colored, relatively resistant discontinuous sandstone channel fills form conspicuous ledges north of the pipeline (such as the one between arrows in Fig. 2.22). Note the characteristic flat tops of the channel fills. These channels and fills, interpreted as products of bottom-hugging turbidites, are analogs for petroleum reservoirs of the Delaware Mountain Group in the subsurface to the east. The finer-grained enclosing sediments form seals. Channels trend to southeast into basin in this area, in contrast to southwesterly channels (reservoirs) in younger basin fill to the east. **0.7**

69.0 Gas pipeline crossing. Prominent sandstone beds on hill at 2:00 are in Brushy Canyon Formation. **1.2**

70.2 Roadcuts in Brushy Canyon. **0.4**

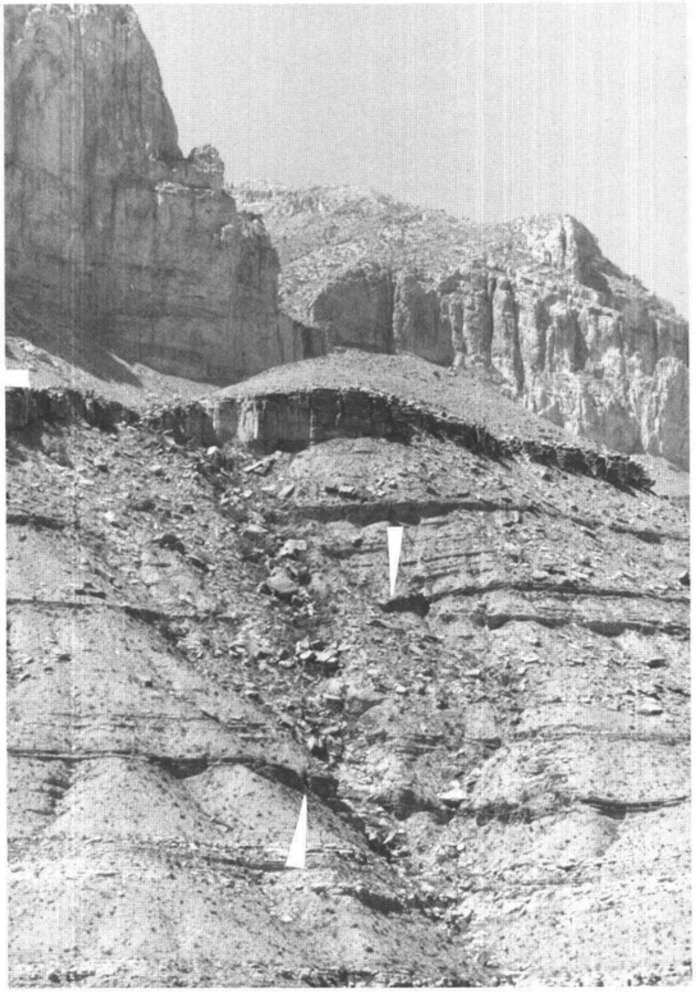
70.6 Cross Basin and Range fault, with dark lime mudstones upthrown to east. These euxinic basin facies, previously correlated with the Bone Spring Limestone of Leonardian age are now correlated with Harris' uppermost unit (No. 5) of the Cutoff Limestone (Harris, 1987). Ammonoids from these cuts (Spinosa et al., 1975) are considered correlative with the Roadian Stage of the early Guadalupian, as is fauna of Cutoff Unit 5. In the uppermost part of the unit, a few thin graded beds with pebble intraclasts and some poorly preserved fusulinids occur. Locally, between the dark limestone and the overlying basal Brushy Canyon, are nonresistant patches interpreted by Harris and Wilde as remnants of the Guadalupian Pipeline Shale (M. Harris, personal comm. 1993). **0.6**

71.2 Locked gate to the north on road to the old Williams Ranch, Bone Spring and the west face of the Guadalupe Mountains (Pray, 1988; Pray and Crawford, 1988). A key to this gate can be secured by registering at the National Park headquarters. 1.0

72.2 Guadalupe Mountains Restaurant (closed). 0.1

72.3 Junction with Texas Highway 54 to Van Horn. Continue west on US-62/180. The Trans-Pecos region to the south is covered in the 31st Field Conference Guidebook (1980) of the New Mexico Geological Society. Route ahead crosses a series of small, west-tilted Basin-and-Range blocks with down-to-east boundary faults (Henry and Price, 1985). **0.3**

72.6 Spheroidal weathering in sandstone of the Delaware Mountain Group. To north are Patterson Hills, formed by downdropped blocks of Capitan and Bell Canyon



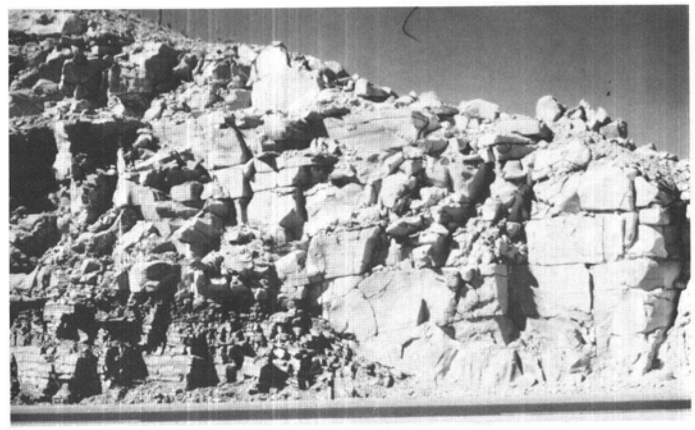


FIGURE 2.21. Roadcut in Brushy Canyon Sandstone, exposing left edge of east-trending channel, the overlying channel-filling, parallel-bedded, thick-bedded to structureless sandstone and the channel-truncated thinner-bedded siltstones and sandstones of the "host" strata.

←

FIGURE 2.20. Closer view of Capitan low-angle basinward foresets of forereef carbonates at base of El Capitan and underlying facies of upper Brushy Canyon Formation. At top of cliff on upper right are higher angle carbonate foresets. Top of Brushy Canyon (under white bar) is northwest-southeast-trending, channel-filling coarse sandstone. Arrows mark two thin resistant layers that are discordant to host bedding. These are dark, organic-rich siltstones that mantle scoured channels filled by sediments similar to host facies.

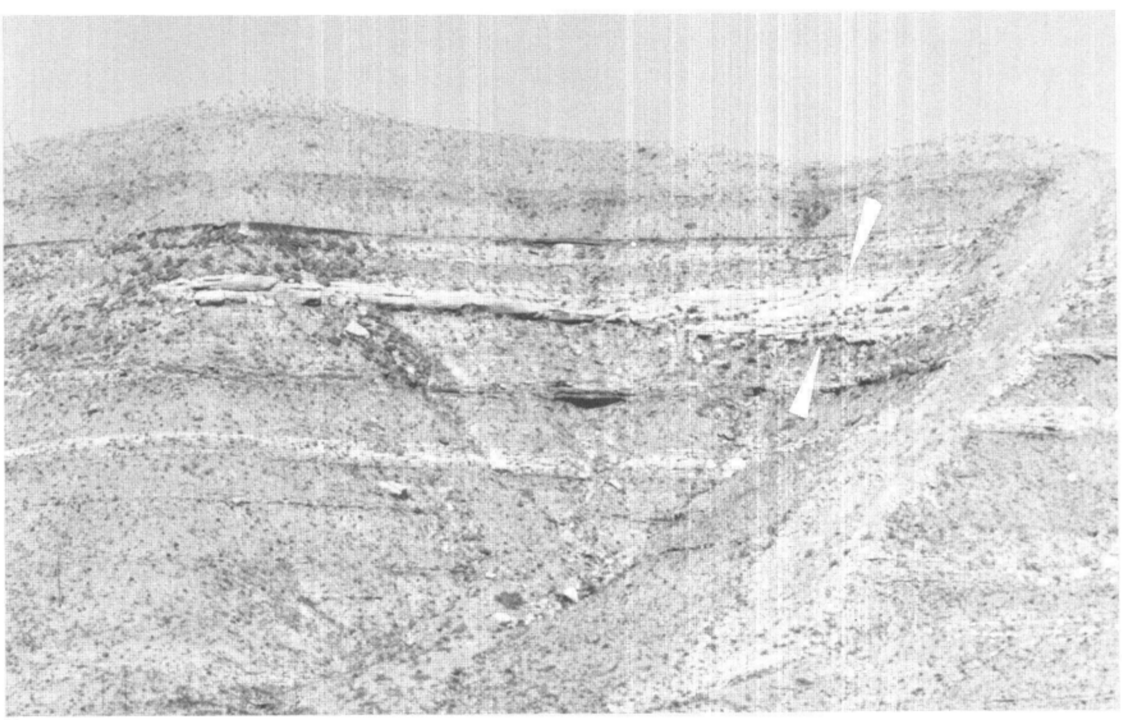


FIGURE 2.22. Delaware Mountain escarpment and pipeline cut east of US-62/180 showing Brushy Canyon and lower Cherry Canyon strata. The conspicuous resistant, light-weathering unit (between arrows) is a coarse-grained sandstone that pinches out to the north. Similar channel-form sandstone units in the subsurface are reservoirs of the Delaware Mountain Group. The dominant finer-grained facies form seals.

Formations (Texas Bureau of Economic Geology, 1983). **0.2**

72.8 Roadcut in west dipping Delaware Mountain sandstone. **0.6**

73.4 Roadcut in brecciated fault zone cutting Delaware Mountain Group. **0.6**

74.0 More roadcuts in Delaware Mountain sandstone, dipping to west. **0.3**

74.3 Roadcuts in gravelly piedmont-slope deposits on eastern border of Salt Basin (half) graben. **0.8**

75.1 More exposures of west-tilted Delaware Mountain Group sandstone and siltstone in next 0.8 mi. On the east end of the low roadcut on the right (north) at this mileage is a thin layer of greenish blue clay interpreted to be an altered ash-fall bed, probably of the Manzanita Member. **0.9**

76.0 Abandoned service station and town site for compressor station staff to right. Automation does take its toll. **0.3**

76.3 Road right to Guadalupe Compressor Station of the El Paso Natural Gas Co. **0.5**

76.8 Route crosses westernmost exposed belt of Guadalupian rocks (Capital) Limestone and Delaware Mountain Group) of the Delaware Mountain uplift (Texas Bureau of Economic Geology, 1983). To the north, the Patterson Hills contain both bacicreef Capitan and Goat Seep reef equivalents (King, 1948). **0.4**

77.2 Entering Hudspeth County, Texas. **0.7**

77.9 Heartbreak Motel. Descending on alluvial fan of Guadalupe Arroyo toward Salt Basin floor. The Salt Basin graben extends from here north into New Mexico and southward for some 60 mi to near Van Horn, Texas. The even, high skyline to the south is the Sierra Diablo Mountains, a fault block range tilted gently to the west. At 2:00 the Cornudas Mountains mid-Tertiary intrusives straddle the New Mexico-Texas state line. **1.2**

79.1 Outlying hills of Capitan Formation about 1 mi north and south of highway (3:00 and 9:00). Gypsiferous dune sand covers most of distal fan (bajada) surface from here to Salt Flat. **1.8**

80.9 Crossing gypsum dunes on east edge of Salt Flat. **0.4**

81.3 **OPTIONAL STOP** in central part of Salt Flat gypsum playa (elevation ,----3610 ft; Figs. 2.23, 2.24). There have been a number of studies of near surface sediments and evaporite facies in this area since an early note by Fried-man (1966) on the shallow occurrence of "Quaternary dolomite." Dunham (1972) identified (using x-ray) dol-omite, aragonite and calcite. In October 1985, a 6.5-ft-deep and nearly 1-mi-long trench was dug for a pipeline across the playa just south of US-62/180. Preliminary studies involving logging of this trench and mineralog-ical and geochemical analyses were described by Powers et al. (1987). Hussain et al. (1988) described their re-search on "depositional environments and facies in a Quaternary continental sabkha" in a larger geographical area of the basin, including parts of the piedmont slopes (bajadas) and sand flats adjacent to the playa-lake plain complex. Kreitler and Sharp (1990, p. 6) summarized recent investigations in the area by geology staff and students of the University of Texas-Austin (including the Bureau of Economic Geology) at a tour stop here for the 1990 Annual Meeting of the Geological Society of America:

> There are approximately 40 gypsum playas in the northern Salt Basin. They are characterized by a shallow water table at a depth of approximately 3 ft (1 m) and a capillary fringe as shallow as 8 inches (20 cm). Tensiometer data show upward flow. The saturated and unsaturated sections

FIGURE 2.24. Upper part of evaporite sequence exposed in cleaned wall of All-American pipeline trench just south of US-62/180 near the center of the modern playa. The trench depth is about 2 m. Black layer slightly below trowel level includes pyrite and small amounts of native sulfur. Fine laminar darker units include green algae and gypsum; some gypsum laminae in these units are enterolithic. Lighter gray beds are more carbonate-rich and include dolomite. October 1985; courtesy of D. W. Powers.

FIGURE 2.23. Modern surface of Salt Flat gypsum playa about 1 km north of US-62/180; view is toward the west with the Cornudas Mountains in the background. The upper 20–50 cm of sediment is poorly bedded brown granular gypsum. Gypsum dunes in the near background overlie bedded gypsum and carbonate. The brown granular gypsum is set into the bedded deposits, and it is interpreted to overlie a probable deflation surface. Courtesy of D. W. Powers.

contain Na-Mg-C1-SO4 brines. Sediment mineralogy is dominated by gypsum and smaller concentrations of dolomite, calcite, magnesite and halite and sporadic pockets of native sulfur. Horizontally bedded organic layers are common. King (1948) considered the salt flats to be remnants of a Pleistocene lake that was as deep as 40 ft (12 m). Today, the gypsum playas are formed by groundwater discharge and concomitant evaporation and mineral precipitation. The ground waters are recharged on the Diablo Plateau and along the western flanlc of the Guadalupe and Delaware Mountains. More detailed discussions of the hydrology, hydrochemistry and mineralogy of the salt flats are in Boyd and Kreider (1987) and Chapman and Kreitler (1990). Evaporite sedimentology was reviewed by Hussain and others (1988), who stressed the transition from alluvial fans (or bajadas) to sand flats to sabkha flats from the Guadalupe Mountains on the east to the salt flats on the west. The locations of the playas are generally adjacent to permeable rocks on either side of the graben.

No detailed characterization that integrates the surface and subsurface geology of the Salt Basin area has ever been made, so it is difficult to place the surficial geomorphic features and hydrogeochemical processes described above in a proper spatial and temporal perspective. Reconnaissance surface geophysical studies and relatively shallow drilling for ground-water development (Gates et al., 1980) demonstrate that this part of the Salt Basin is a west-tilted half-graben, as was originally recognized by King (1948). Basin fill attains a maximum thickness of about 1500 ft to the southwest of this site near the active faults that form the western margin of the structural basin (White et al., 1972, line 2-2'; Muehlberger et al., 1978; Goetz, 1980; Henry and Price, 1985). Recent and ongoing studies of structure and basin-fill stratigraphy in the southeastern Basin and Range province indicate that filling of Salt Basin started in early to middle Miocene time coincident with the onset of active basin subsidence and uplift of flanking range blocks (Seager and Morgan, 1979; Seager, 1980; Seager et al., 1984, 1987; Chapin, 1988; Henry and Price, 1989; Collins and Raney, 1991; Hawley and Lozinsky, 1992).

King (1948) demonstrated that the area occupied by the modern playa complex was much more extensively flooded in the past. However, there is no stratigraphic or geomorphic evidence for the existence of large permanent lakes that would have deeply inundated the basin floor during major glacial-pluvial intervals of the Pleistocene (Hawley, 1993). Studies of the regional groundwater system (Kreider et al., 1990) indicate that both inter-basinflow and evapo-transpiration are important ground-water discharge mechanisms in the Salt Basin. Paleohydrologic reconstructions of playa-lake systems in the basin must take these factors into account. **0.5**

81.8 **OPTIONAL STOP** to view Salt Flat and Guadalupe Mountains. **1.3**

83.1 Salt War Historical Marker at tall yucca to left. "Resentment over private control of the salt lakes in the region, often called Guadalupe lakes, led to the El Paso Salt War of 1877, which entailed the loss of many lives and much property." Erected by State of Texas, 1936. **1.7**

84.8 Rest area on north side of road. Note active dunes to north. 1.0

85.8 Sharp break in slope from basin floor to fan surface is a late Quaternary fault scarp along western boundary zone of the Salt Basin half-graben (Henry and Price, 1985). Route to west crosses eastern part of the Diablo Plateau uplift, which in this area is capped with Leonardian carbonate rocks. Remnants of the Lower Cretaceous clastic cover are also locally present (Texas Bureau of Economic Geology, 1983; Kues and Lucas, this volume). **0.8**

86.6 **Turn right** on Texas Farm Road 1576 route toward Dell City (20 mi). Exit Log from turnoff to Sitting Bull Falls through Queen, El Paso Gap, Crow Flat, Cienega School and Dell City ends here. Continue north across faulted toe of alluvial-fan complex at lower end of Antelope Draw, one of the largest drainage basins on the Diablo Plateau. **0.2**

86.8 Cattle guard. Fan surface with thin veneer of dune sand is downfaulted to the northeast along the northwest-trending boundary zone of the Salt Basin graben (Henry and Price, 1985). **0.6**

87.4 Cattle guard. About 15 ft of gypsiferous older alluvium, with discontinuous gravel beds, is exposed in borrow pit to right. **3.7**

91.1 Tour stop ahead. **Pull over to right** on shoulder area east of sharp curve in FR-1576. 0.1

91.2 **STOP 5.** Viewpoint of the west face of the Guadalupe Mountains from the western side of Salt Basin. Apaches called El Capitan Signal Peak. The Butterfield stagecoaches headed toward these spectacular cliffs; so did the early airline pilots taking off from El Paso. This coincidence is commemorated by marble monuments placed on top of Guadalupe Peak and at the Pinery by American Airlines. Today's modern jets still follow this route, but at a much higher elevation.

GEOLOGY OF THE WEST FACE OF THE GUADALUPE MOUNTAINS

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Spectacular outcrops of Leonardian and Guadalupian carbonate and siliciclastic strata and several associated submarine erosion surfaces along the west side of the Guadalupe Mountains provide one of the finest examples of exposed, seismic scale, shelf-to-basin transitions in the world—this is literally a "world-class" exposure. Maximum uplift here along the Guadalupe Mountains border fault is estimated to be about 7500 ft. The Guadalupe Mountain border fault is a high-angle normal fault with an irregular trace and commonly is exposed directly at the base of the steep mountain front. The strata of the middle and southern part of the escarpment are essentially undeformed since dep-osition; the northerly apparent dip of the strata on the northern part of the exposure reflects progressively less uplift along the main border fault. The trend of the escarpment and of the cross section (north-northwest to south-southeast) is somewhat oblique to the more south-easterly plunge of the shelf-to-basin incline during Middle Permian time, hence the true southeasterly basinward dip of the strata appears flatter on the cross section (e.g., note the "flat" toe-of-slope strata at the base of the El Capitan cliff). No major faults break across the escarpment within the main uplifted block so that lateral relationships can be traced with some confidence, but many vertical and lateral facies changes, pinchouts and several basin-margin sloping submarine erosion surfaces make the geology both complex and fascinating.

The major geological relationships are shown on the cross section of Fig. 2.25. The composite aerial photograph (Fig. 2.25, lower) is of the same area as the cross section, but taken from about the level of the crest of the escarpment. The cross section extends from the conspicuous El Capitan to within 3 mi of Cutoff Mountain (the highest point on the frontal escarpment to the northeast), only a mile south of the New Mexico border. The highest point of the rugged western escarpment of the Guadalupe Mountains is Guadalupe Peak (the highest point in Texas) at 8751 ft. Crestal peak heights diminish northward to Cutoff Mountain, 6910 ft. Northward farther into the distance from here, in New Mexico, the Guadalupe Mountains merge into a faulted complex of north-northwest-trending canyons and ridges and then into the west-facing Algerita Escarpment, which persists northward for over 20 mi.

The major stratigraphic units along the escarpment are discernible from here on the basis of their outcrop resistance. The least resistant units are the siliciclastics—which in the Guadalupe Mountains are almost entirely composed of fine to very fine sand and silt (shale is virtually absent in the Middle Permian strata here). The most resistant units that form the sheer cliffs are light-colored dolomite and limestone (bank-ramp and reef complex). Of intermediate resistance, generally forming gray slopes, are strata of dark, thinly bedded basin facies (Bone Spring and Cutoff limestones). Wolfcampian (Early Permian) strata (Hueco Formation) are more than 3000 ft below the oldest exposed strata of the escarpment (Bone Spring Limestone). The youngest Permian (Ochoan–Late Permian) and the youngest Middle Guadalupian of the Guadalupe Mountains are only preserved miles to the east and may have been removed prior to or during Early Cretaceous or younger episodes of erosion of the Guadalupe Mountains.

The reef complex strata, Goat Seep Dolomite and Capitan Limestone, form the crest of the escarpment from El Capitan to near Bush Mountain. Their giant foreset (forereef) strata sweeping down from more massive rock near sea level to depths of 1000-2000 ft into the siliciclastics of the Delaware Basin margin are a classic sequence of basinward prograding reefal carbonates. The Goat Seep–Capitan contact, placed by King at an overall change from reefal dolomite to limestone correlates to about the bacicreef Queen to Seven Rivers contact (top of the Shattuck Sandstone of the shelf) and to the Manzanita Member in the deep basin, which pinches out upward at the basin margin.

The Queen and Seven Rivers Formations cap the crest of the escarpment in the Bush Mountain and Blue Ridge area. They form the immediate bacicreef strata to the reef complex and are predominantly dolomitic units separated by a persistent shelf sandstone of the uppermost Queen Formation (the Shattuck Sandstone).

The Cherry Canyon and Brushy Canyon Sandstones, the lower two formations of the Delaware Mountain Group, each about 1000 ft thick, form the major mid-slope recessive units of the southern half of the exposures. The Brushy Canyon, with somewhat more resistant channel-filling sandstones than the Cherry Canyon, thins progressively from about 1000 ft to its pinchout between Bartlett and Shumard Peak. The Cherry Canyon Sandstone, a set of transgressive sequence tracts containing a condensed section basinward records a deepening of water across the old Victorio Peak bank and a shift of the shoreline far to the north. Basinal sandstones are deposited as far north as Sitting Bull Falls (New Mexico; where we will study them tomorrow). There the sandstones intertongue with San Andres carbonates.

The strata of the bank-ramp complex were deposited on low-angle slopes of a ramp extending from 5-10 mi into New Mexico to the area in the middle of the cross section of Fig. 2.25. Facies changes in the shelf-crest to toe-of-ramp setting are commonly gradual and high-relief steep slopes, characteristic of the forereefs of the reef complex, are lacking.

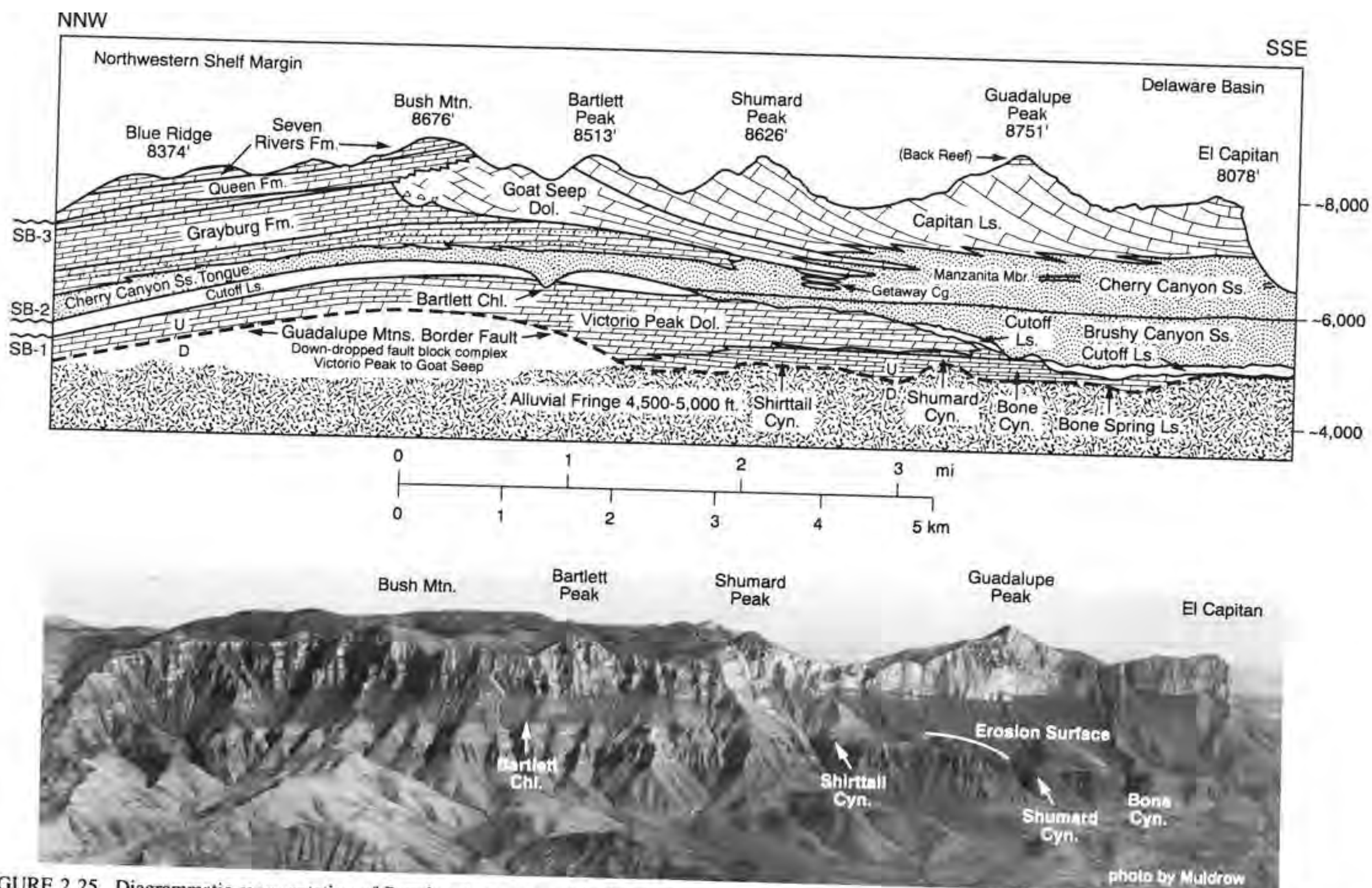

FIGURE 2.25. Diagrammatic representation of Permian strata exposed in the western escarpment of the southern Guadalupe Mountains, Texas (upper), and aerial view of western escarpment of the southern Guadalupe Mountains (lower).

The Grayburg Formation, largely dolomite with minor sandstone in the lower part, forms the highest unit of the bank-ramp complex seen here. Its dolomite units form the resistant bands that can be seen above a major recessive unit (Cherry Canyon Sandstone Tongue) below Blue Ridge. The younger Grayburg is abruptly truncated basinward by a listric-shaped unconformity of 100+ m relief that persists basinward, thinning the Grayburg progressively to its pinchout into sandstones. Farther basinward three megabreccia lenses (Getaway conglomerates) correlate with the Grayburg and oldest Goat Seep. Newell referred to the Grayburg as the Getaway Bank and considered it, as did King earlier, as transitional into the Goat Seep.

The Cutoff Limestone is a persistent black basinal limestone. It is a generally recessive unit of basinal facies (mudstone and wackestone). In the northern and middle area of the cross section it is about 230 ft thick but southward in the area of Shumard to Bone Canyon it drapes a basin-sloping (5-15°) submarine erosion surface of about 1000 ft of relief, before persisting southward across the basin floor. Erosion (SB-2) removed much of the Cutoff of the drape area. Northward the Cutoff extends to Cutoff Mountain, where some aerobic facies occur and farther north it intertongues with the San Andres carbonates.

The Leonardian Victorio Peak Dolomite forms the resistant cliffs of the lower escarpment as far south as Shumard Canyon, where it and some Bone Spring is abruptly truncated on a basin-margin unconformity (SB- I). The Victorio Peak is a marine bank facies, largely dolomite, that progrades southward at a low angle over the less resistant black limestones of the Bone Spring, deposited in dysaerobic to anaerobic water of the deeper basin as compared to the better oxygenated water of the Victorio Peak. Overall the Bone Spring—Victorio Peak succession shoals upward and shelfward in a classic bank-to-basin transition. Absence of the Victorio Peak southward was first considered an east-trending structure (the Bone Spring Arch of Blanchard and Davis). King later recognized the upper Victorio Peak unconformity, believed it to be a subaerial surface (as all unconformities were at that time) and designated a southeast-dipping flexure (the Bone Spring flexure), striking north-northeast at Shumard Canyon. Present evidence does not support a Bone Spring flexure, but instead a basin-sloping submarine unconformity truncating nearly 1000 ft of flat-lying Victorio Peak and some underlying Bone Spring limestone. Basinward (to the south) of carbonate buildups of the Leonardian Victorio Peak shelf margin, the lowstand deposits of the Lower Guadalupian Brushy Canyon sandstones lie on unconformities and are restricted in area so that they lap onto the older shelf margin. The exposures of the Algerita Escarpment to the north are shelfward facies of Yeso, San Andres and Grayburg Formations (San Andres and Grayburg Formation contain most of the Permian oil and gas reservoirs of the Permian Basin). The exposures of the equivalent strata along the Texas part of the escarpment are shelf and distal ramp facies of the Victorio Peak and Grayburg Formations and the basin facies of the Bone Spring and Cutoff limestones, the Brushy Canyon Sandstone and the lower part of the Cherry Canyon Sandstone, including the Cherry Canyon Sandstone Tongue.

Traceable major erosion surfaces of the strata in the cross section area are labeled SB-1, SB-2 and SB-3 on the left margin. These are now generally interpreted as major (third-order?) sequence boundaries. The SB-3 surface northward of the Goat Seep "headwall" is equivocal, perhaps it is partly a subaerial surface. SB-1 and SB-2 are interpreted by the Wisconsin group as submarine erosion surfaces, as well as the portion of SB-3 below the Goat Seep. They indicate erosion by deep marine currents, which mostly trended east to south into the basin from shelfward areas to the northwest. The Brushy Canyon is a fine example of marine onlap and of bypass transportation of at least the coarser channel sands across a marine shelf to the northwest. Bartlett Channel, a part of SB-2, is the only deeply incised abrupt channel recognized in the area. It truncates all of the Cutoff and part of the uppermost Victorio Peak in its 300-ft depth and undoubtedly helped funnel some of the Brushy and Cherry Canyon sands toward the basin. In later Cherry Canyon and Bell Canyon (middle and upper Guadalupian) time, the highstand deposits were characterized by the remarkable progra-dational basinward shift of the reef facies. The Goat Seep reef returned to the vicinity of the earlier Leonardian Victorio Peak bank and the Capitan Reef prograded basinward even farther.

The exposures in view and to the north into New Mexico have attracted much interest of "sequence-discerning" geologists in the past decade and there is much yet to learn from this fascinating shelf-to basin transition.

We would like to acknowledge major early references: P. B. King's (1948) masterly USGS Professional Paper 215 and the more sedimentologically focused volumes of N. D. Newell et al. (1953) and R. J. Dunham (1972). For recent regional correlations from the Algerita Escarpment and Last Chance Canyon areas of New Mexico to the Texas part of the Guadalupe Mountains and for detailed correlations of the crestal backreef to reef complex see Kerans et al., Sonnenfeld and Fitchen (this volume) and earlier Permian Basin Section of SEPM volumes 86-25, 88-30 and 91-32, especially for interpretations of Kerans, Nance, Lehmann, Rossen, Sarg and Wilde. The volumes of West Texas Geological Society 88-84 and the 1989 SEPM Core Workshop No. 13 have summary articles from the stratigraphic work in the area of the cross section by Crawford, Fekete, Franseen, Hampton, Harris, Kirkby and Rossen based on University of Wisconsin—Madison graduate theses of the 1980s. A 1989 University of Wisconsin thesis by New on the Cherry Canyon Sandstone tongue is also pertinent, as is Fitchen's (1992) thesis. Working with all these students in the fascinating area has been exciting and rewarding. We hope to learn in time as much from the new wave of sequence stratigraphers, including Rick Sarg (U. Wisconsin Ph.D., 1978), as we have from thesis students in the 1980s.

Retrace route to US-62/180. **4.6**

95.8 Junction with US-62/180. **Turn left** and return to Carlsbad, with optional stop at Washington Ranch (55 mi). **52.4**

148.2 Milepost 10. **Prepare to turn left** on Eddy-418 to Washington Ranch. **0.3**

148.5 **Turn left** on Washington Ranch Road and continue north across stepped sequence of Pleistocene terraces flanking the inner Valley of Black River (see Sares and Wells, 1987). **1.5**

150.0 Y in road. **Take left fork** to Washington Ranch. This road also leads to campground and Slaughter Canyon. **0.4**

150.4 Descend from Pleistocene terrace to floor of inner Black River Valley. Cuts ahead in deformed (cobble and boulder) terrace gravel. **0.2**

150.6 Cross Black River. 0.1

150.7 Junction. **Turn right** on road to Washington Ranch Headquarters and Retreat Complex. Left fork leads to the Washington Ranch gas field and the Slaughter Canyon (New Cave) section of Carlsbad Caverns National Park. The Washington Ranch gas field has produced 0.1 BCF from the Delaware (discovered in 1974). The Strawn (1974) produced 0.005 BCF and 0.004 MMBO and is now abandoned. The Morrow (1974, 6800 ft depth) produced 56.2 BCF and 0.001 MMBO before conversion into gas storage (see minipaper by Burton et al. below). **0.2**

150.9 Rattlesnake Springs picnic area to left. 0.1

151.0 Entering Washington Ranch. **0.3**

HISTORY OF THE WASHINGTON RANCH, EDDY COUNTY, NEW MEXICO

Peggy L. Burton', Jim W. Adams' and Carl EngwalP

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By today's standards, W. E. Washington, aka, Bill Washington, aka, "Uncle Bill" would be called "a colorful character." He *was* an unusual individual. With his intermarriage into the Chickasaw tribe, he was able to start what would become a small empire. The father of his bride was a wealthy man in his own right in Mississippi until he was forced into exile and marched over the terrible Trail of Tears to Indian Territory (now Oklahoma).

By marriage to May Ellen, Bill was entitled to rights to some of the Chickasaw range. Around 1886 he was running cattle, growing cotton and printing his own script money that was good at his other enterprises that included a commissary, a store and a scale house. He prospered in Oklahoma with the help of a hundred or more of his hands whom he paid fifty cents per day.

The story goes that by the age of 38, Bill was a millionaire. There are pieces of history to confirm this. In Marietta, Oklahoma, a mansion he built still stands today. It would take imported carpenters and artisans two years before Bill's "castle" was completed. To lay the beautifully inlaid hardwood floors would take more than one year. The ceilings are 12 ft high. Much of the interior of the house is "gingerbread." The walls of this unusual house were filled to more than head height with fine gravel 6 in. thick. You may ask, "Why fill the walls with six inches of gravel?" The reason was six inches of gravel could really slow down a .45 caliber bullet.

Bill flaunted his wealth and perceived power. He made the mistake of getting cross-ways with the Chickasaw. When a law was passed in 1894 that called for the payment of a grazing fee of one dollar per head per annum on the Chickasaw range, Bill refused to pay. There was retaliation by the tribal leadership, which, of course, Bill reacted to. Eventually Bill received orders from the Chickasaw nation to leave.

It was indeed time for Bill Washington to move to greener pastures. He found them in New Mexico, first settling near Hagerman around 1908. By 1910 he was in the Black River area at Rattlesnake Springs where he bought property from the Lucas family who were among the first homesteaders of the area.

Once again, history tells us that Washington was surrounded by much controversy. Because of his many "deals" going sour, he had a reputation that he could not be totally trusted. He played both sides of the fence, sometimes playing one side against the other. Some disputes had to be decided by a judge, others he settled himself with a .45 caliber pistol. There are those who believe that he murdered a man and allowed an African American "cowboy," who was faithful to May Ellen's father and who came to New Mexico with her, to do the prison time for this crime.

Bill's visionary dream of capitalizing on the tourist traffic that was traveling along the then county road that ran near Rattlesnalce Springs was a desperate act to save what was left of the property that still bears his name. A judge had ordered Washington to sell off part of his large herds of cattle to satisfy his overdue payment to the Lucas family. This action left Washington without enough cattle to profitably run the vast holdings of land that he owned and/or leased. He was barely able to find someone to start building his dream of a gas station and "motor courts" to provide overnight facilities for tourists traveling to Carlsbad Caverns. His dream was never realized. The highway was moved 2 mi east of his location and people no longer traveled through his property. The main ranch house is attached to what was the old filling station and the old "motor courts" are now used in the daily operations for Washington Ranch (Figs. 2.26 and 2.27).

Washington Ranch changed hands many times through the pages of history. Many Carlsbad families have been a part of that history. They have lived there and farmed the land. The Black River and Rattlesnake Springs were a source of water for personal use, pleasure, crop irrigation and livestock. The New Mexico Game and Fish Department operated the property for a number of years as a picnic resort and experimental wildlife refuge, but sold it when the water source played hide-and-seek and turned much of this lush area back into desert.

When J. W. Miller, a Texas oil man, first heard about the property and bought it, it was on speculation that oil or natural gas could be found there. Indeed they were! To this day, just down the road from the Washington Ranch Headquarters is the Washington Ranch Plant of El Paso Natural Gas Company.

FIGURE 2.26. Washington Ranch headquarters. The car is a 1946 Ford, so this photo was probably taken in the late 1940s or early 1950s.

Jay Miller was owner and president of Globe Geophysical Corporation in Midland, Texas. He assembled a brilliant and innovative technical staff that pioneered in the development of thumper trucks as a seismic energy source. Globe's facilities in Midland were a large industrial complex. Shell Exploration and Production Company was particularly impressed with Globe's technology and started monopolizing usage of Jay Miller's geophysical crews. Shell finally decided to buy control of Globe and its technology. When the tedious negotiations were concluded, Jay took great pride in a statement made by Shell's lawyers who told him that of all the companies which Shell had absorbed over the years, Jay Miller exacted more favorable terms than any other negotiator (J. W. Miller, personal cotrun.). Jay retained ownership of Washington Ranch and also spun off and retained ownership of Globe's division that was engaged in defense projects with the military in El Paso. That made it desirable to move his family from Midland to the Washington Ranch.

Jay Miller was Jim Adams' Sunday school teacher in Midland in 1966. He once loaded the class into several private airplanes and flew us to the Texas coast for a deep-sea fishing trip. Another summer he flew us to Dayton, Ohio, for a week-long mission trip. As a safety factor, his wife Pat also learned to fly their plane, which was as useful as their car when they moved to the ranch.

Jay Miller and his brother Forrest (a geologist in Carlsbad) formed the Black River Corporation to explore for hydrocarbons on the Washington Ranch. Seismic surveys showed structural closure on the upthrown (southwest) side of the Huapache fault. The Black River Corporation #1 Cities Federal was the discovety well for the Wash-

FIGURE 2.27. Washington Ranch headquarters, 1993.

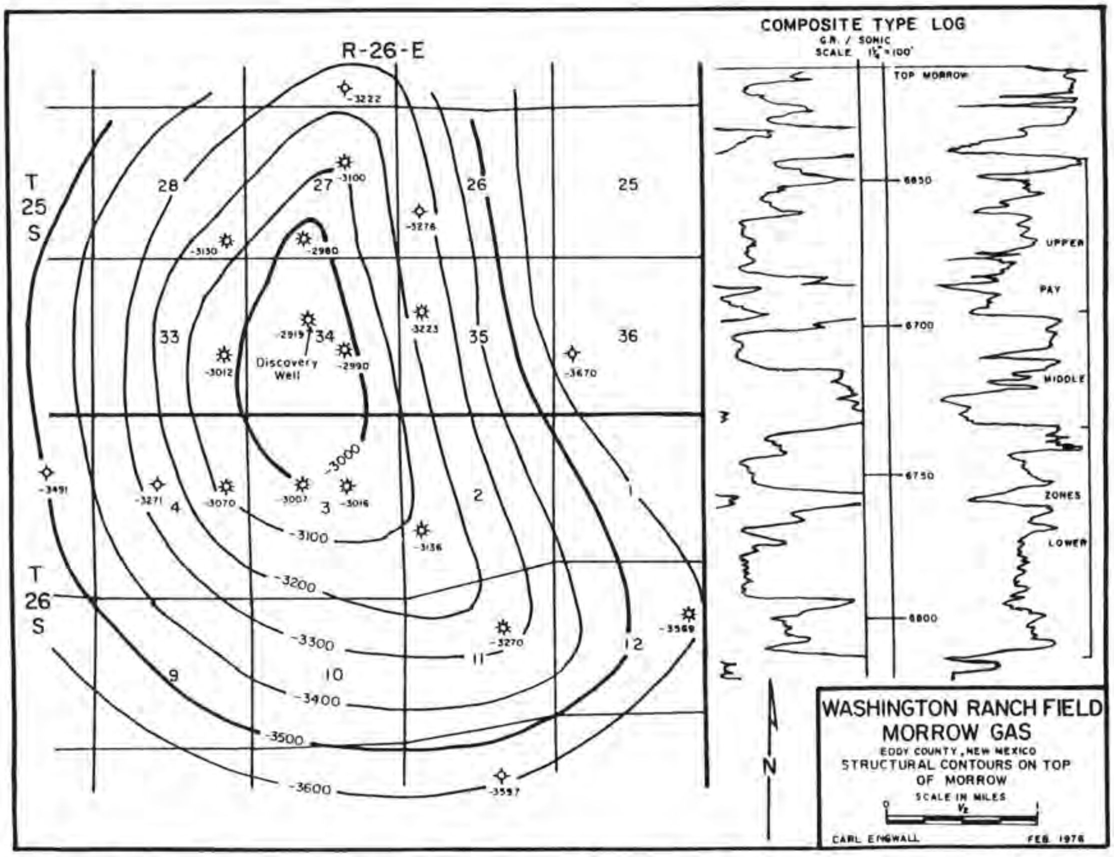


FIGURE 2.28. Structure contour map at top of Morrow and G. R./Sonic logs of productive interval (from Engwall, 1977).

ington Ranch Morrow Gas Field with a potential CAOF of 54 MMCFGPD of dry gas from Morrow sandstone perforations at 6800 ft in June of 1971. Thirteen wells have developed the Morrow reservoir while minor production was also found in the Strawn and Delaware sandstone. Subsurface mapping and seismic records show 600 ft of structural closure on the base of the Morrow sandstone (Fig. 2.28). The Huapache monocline can be seen on the skyline north of the ranch where the monocline intersects the Permian reef front at Rattlesnake Canyon. The monocline is faulted at depth with the same northwest-southeast trend having more than 2000 ft of displacement (downthrown to the northeast). The Huapache fault is present along the northeast side of the field. Forrest Miller reported, "The crest of the structure has lost 1700 ft (518 m) of Wolfcampian and Upper Pennsylvanian section through erosion and nondeposition" (Miller, 1981, p. 766). Reservoir pressure declined with a cumulative production of 56 BCFG and El Paso Natural Gas now uses this field for storage of surplus gas from other fields on their pipeline.

Jay Miller, in developing the property as a home base for his family, became a cattle man, running some of the finest Charolais cattle in this area. Washington Ranch became a show place for the Miller family, entertaining on a grand scale, but with a country style all their own. Jay loved to hunt and fish. It was on the return from a fishing trip to the Gulf of California that thick cloud banks hung over the peaks at El Paso and the Miller's plane augered into Juarez Mountain, killing them and another couple. Jay and Pat are buried by a quiet lagoon on Washington Ranch.

Following their death, the property was managed for several years by their eldest son, Jim. When the Ranch was put up for sale, the Carlsbad Association for Retarded Citizens (CARC) Farm, Inc., bought it in May of 1987. The CARC Farm had been founded previously in 1973 by Barbara and Bob Forrest, whose youngest son has Down's syndrome.

Washington Ranch is now the home for sixteen developmentally disabled adult males. Not only do these individuals live at the ranch and consider it their home, they also each have an assigned job site five days a week for six hours per day on the ranch property. Some work in the greenhouses; some are part of the maintenance crew. An individual personalized program is designed for each client to meet their social, work, physical and recreational needs.

Out of a desire to share the wonderful beauty and charm that is so much a part of the Washington Ranch property, the CARC Farm, Inc., continues to allow outside organizations, groups and individuals to use the Washington Ranch complex for workshops, seminars, retreats and social gatherings. A full-fledged "Challenge by Choice" Ropes Course has just been completed and a campground has a targeted completion date of spring 1993. This campground will be a summer camp for multi-use groups of children with special needs. Most of the usual camp activities will be offered. In the off-season, the facilities of the campground will be available to outside groups just as the main headquarters of the Washington Ranch complex is now.

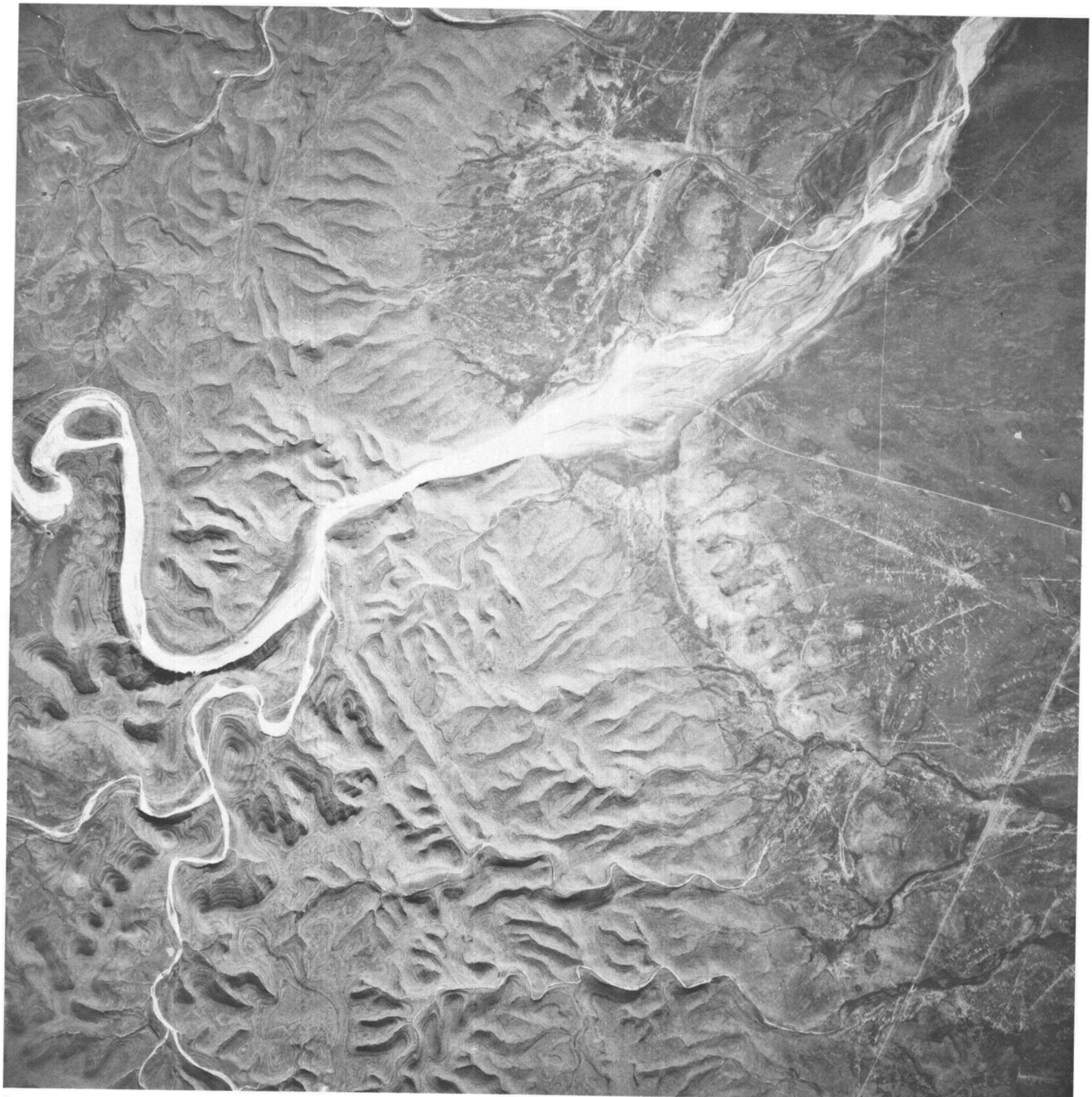
For more information about Washington Ranch, see articles by Brewster (1979), Engwall (1977), Henry (1974), Miller (1975, 1981) and Pipeliner Magazine (1972).

151.3 Parking lot at Ranch Office. After optional visit to ranch, return to Carlsbad, via National Parks Highway. **2.8**

154.1 Turn left on US-62/180. **21.8**

175.9 Carlsbad Civic Center.

End of Second-Day Road Log.



January 1, 1942, aerial photograph of the mouth of Dark Canyon and area of Day 3, Stops 1 and 2. Sinuous north-trending Cueva escarpment is formed on upper Guadalupian (Tansill/Capitan) carbonate rocks at the reef front and marks the boundary between the Guadalupe Mountains (west) and the Delaware Basin (east). At west edge of basin, Dark Canyon Arroyo crosses the Frontier Hills, a series of low, east-dipping cuesta ridges capped by the Culebra Dolomite Member of the Rustler Formation.