Supplemental road log 3: From Durango, Colorado to Pinyon Mesa and the Bluffs south of the San Juan River near Farmington

Spencer G. Lucas and Thomas E. Williamson

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SUPPLEMENTAL ROAD LOG 3, FROM DURANGO, COLORADO TO PINYON MESA AND THE BLUFFS SOUTH OF THE SAN JUAN RIVER NEAR FARMINGTON

SPENCER G. LUCAS and THOMAS E. WILLIAMSON

Assembly point: The south end of the parking lot of the Durango Mall, in front of the J.C. Penney store.
Distance: 76.3 miles
Stops: 3

SUMMARY

This route will traverse part of the northern and northwestern San Juan Basin in order to examine the stratigraphic relationships of the McDermott Member of the Animas Formation, the Ojo Alamo Sandstone and the upper part of the Kirtland Formation. To do so, a well-exposed section of the McDermott Member at Durango will be examined first; then the Kirtland Formation through Ojo Alamo Sandstone section on the west flank of Pinyon Mesa, north of the San Juan River in New Mexico, will be visited. Finally, we will examine a portion of the Kirtland–Ojo Alamo section in the bluffs south of the San Juan River at a place near Farmington where an *in situ* dinosaur bone was discovered in the Ojo Alamo Sandstone.

Mileage

0.0 Leave parking lot and head north on the frontage road to U.S. Highway 550. **0.2**

0.2 **Turn left** at traffic light onto US-550 and proceed south. **0.3**

0.5 **Turn right** and then **turn left** onto the road to the Animas Air Park (La Plata County Highway 213). The strata exposed on the steep hills to the right of the road for the next 0.7 mi are, from oldest to youngest (north to south), the Lewis Shale, Pictured Cliffs Sandstone, Fruitland Formation, Kirtland Formation and the McDermott Member of the Animas Formation, all of which are dipping south-southeast at about 20°. **0.4**

0.9 Note the Animas River on the right. The Spanish word *animas* refers to the soul of one who has died. According to Pearce (1965), the river was so named because of its treacherous crossings where many Indians and early Spanish explorers lost their lives. Formerly called the Rio de las Animas, it empties into the San Juan River at Farmington, New Mexico. **0.3**

1.2 As the road crests the hill, the McDermott Member of the Animas Formation is readily recognized at 12:00 by its predominantly purple color. **0.3**

1.5 **STOP 1.** Pull off on both sides of the road where it widens. The purpose of Stop 1 is to examine a well-exposed and very accessible section of the McDermott Member of the Animas Formation. Reeside (1924, p. 24) introduced the name McDermott Formation "for a series of lenticular sandstones, shales, and conglomerates containing much andesitic debris and usually in part of purple color." The type section of the formation is in McDermott Arroyo (secs. 18 and 19, T32N, R11W, La Plata County, Colorado) about 15–17 mi south-southwest of Stop 1. Previous to Reeside (1924), the strata he termed the McDermott Formation were called "andesitic beds on Animas River" (Cross, 1892), "Animas River beds" (Emmons et al., 1896) or "Animas Formation" (Shaler, 1907; Gardner, 1909).

Reeside (1924, pl. 1) mapped the McDermott Formation as a narrow outcrop belt in the northern and west-central San Juan Basin that extended from a point about 10 mi due east of Durango westward and then southward to a point about 6 mi south of Ojo Alamo, well south of the San Juan River in New Mexico. In so doing, Reeside (1924) assigned to the McDermott Formation strata south of the San Juan River that had been assigned to either the uppermost part of the Kirtland Formation or the lower part of the Ojo Alamo Sandstone by Bauer (1916) and Bauer and Reeside (1921). Reeside's (1924, p. 26) observation that "near the type locality of the McDermott formation indeterminable bones of dinosaurs, fragments of turtle bone, and fossil wood have been collected at a number of localities" is still the primary biostratigraphic basis for assigning a Late Cretaceous age to the McDermott.

Subsequent to Reeside (1924), two major changes have altered his concept of the McDermott Formation. First, Barnes et al. (1954) included this unit within the Animas Formation as the lower, McDermott Member. These authors justified their decision as follows:

> Reeside's typical section of the McDermott . . . is subdivided in this report as follows: the lowest 95 feet of pebble-bearing sandstone and sandy shale is part of the Kirtland shale, the overlying 127 feet of purplish beds is the McDermott member of the Animas formation, and the top 106 feet is included in the upper member of the Animas formation. It is thus proposed to reduce the McDermott from the status of a formation to that of a locally present member of the Animas formation. The two units are gradational, and aside from a contrast in color they show no consistent lithologic distinction. . . . Where the maroon and purple sequence is present in Colorado the Animas formation consists of the basal McDermott member and an upper member; elsewhere in Colorado the Animas formation is not subdivided. . . . The McDermott is conformable on the upper shale member of the Kirtland and is conformably overlain by the upper member of the Animas . . . The McDermott member is of Late Cretaceous age and probably records an

early outburst of volcanism during the time of Laramide mountain-building.

Work in other areas by Barnes (1953) and Zapp (1949) supported these observations.

The second change that altered Reeside's (1924) conception of the McDermott came through the work of Hayes and Zapp (1955), O'Sullivan et al. (1972) and other U.S. Geological Survey geologists. This work has restricted the distribution of the McDermott Member of the Animas Formation to north and east of the La Plata River and reassigned strata south and west of the La Plata that Reeside (1924) mapped as McDermott to the upper part of the Kirtland Formation (see, for example, Fassett and Hinds, 1971, pl. 1). We will further discuss this restriction at Stops 2 and 3, where we will examine strata south and west of the La Plata that Reeside (1924) assigned to the McDermott Formation.

About 300 ft of the purple McDermott Member is exposed at Stop 1. The McDermott here is overlain by "a sequence of olive-brown, olive-green, and gray and green tuffs in which the andesite detritus is more weathered and which contains increasingly greater amounts of normal sedimentary material" (Zapp, 1949). According to Newman (1982, 1983), palynomorphs from the McDermott Member at this outcrop indicate an early Maastrichtian age. Nevertheless, there are not enough biostratigraphic data to enable a precise placement of the Cretaceous-Tertiary boundary in this section, although most workers tentatively place the boundary between the McDermott and upper members of the Animas Formation (e.g., Fassett and Hinds, 1971) or stratigraphically low in the upper member of the Animas Formation (e.g., Baltz, 1967).

Leave Stop 1 by turning around and retracing route to US-550. **1.0**

2.5 Stop sign; go straight ahead. **0.3**

2.8 Stop sign; **turn right** and then make an immediate left onto US-550 and proceed northward. The strata visible within the Durango city limits are drab shales of the Upper Cretaceous Mancos Shale, capped in places by the ridge-forming Point Lookout Sandstone, the basal formation of the Mesaverde Group in this area. **2.0**

4.8 **Turn left** on US-160 and proceed westward. For about the next 35 mi the highway will pass through strata of the Mancos Shale and overlying Mesaverde Group north and west of the central San Juan Basin. **0.1**

4.9 Bridge over the Animas River. The hill to the left is Smelter Hill, the top one-third of which is Mesaverde and, below that, the remainder is Mancos Shale. **0.5**

5.4 For the next mile or so the roadcuts are in the Mancos Shale. **1.2**

6.6 At 12:00 the Point Lookout Sandstone is visible overlying the Mancos Shale. **0.8**

7.4 The two buttes to the right are Twin Buttes. The Point Lookout Sandstone caps these buttes, which both have long slopes made up of Mancos Shale. **1.5**

8.9 The gradational contact of the Mancos and Point Lookout Sandstone is visible in roadcuts. **0.5**

9.4 The Victory coal mine in the Menefee Formation (the medial, coal-bearing formation of the Mesaverde Group) is visible on the right. **0.5**

9.9 For the next mile or so the roadcuts reveal paludal shales and channel sandstones of the Menefee Formation. **1.8**

11.7 At 2:00–3:00 the La Plata Mountains are visible to the north. The high peak is Hesperus Peak (elevation 13,225 ft) and is capped by the Mancos Shale. **2.7**

14.4 At 4:00–5:00 escarpments capped by the Mesaverde Group are visible to the north of Durango. **0.9**

15.3 The road descends into La Plata Canyon. **0.3**

15.6 Junction with Colorado Highway 140. **Turn left** and proceed southward into Hesperus, Colorado. The highway will now proceed down the valley of the La Plata River. The Spanish word *plata* means silver, and the river took this name from early Spanish explorers who investigated rumors of gold and silver in this area (Pearce, 1965). **1.9**

17.5 Stay right and continue on Highway 140. **1.1**

18.6 Bridge over the La Plata River. **0.7**

19.3 Looking back at 4:00–5:00, the La Plata Mountains can be seen again. **0.7**

20.0 The Four Corners Bull Testing Center is on the right. **2.8**

22.8 Junction with Colorado Highway 120; proceed south on Highway 140. **0.3**

23.1 Bridge over the La Plata River. **0.4**

23.5 Breen, Colorado. **0.7**

24.2 On the right the floodplain of the La Plata River is visible. **0.5**

24.7 At 10:00 in the far distance the Chuska Mountains in northwestern New Mexico are visible. The Chuskas are on the far western edge of the greater San Juan Basin and are capped primarily by middle Tertiary strata, the Chuska Sandstone of Gregory (1917). **2.1**

26.8 The steep western flank of Pinyon Mesa is visible at 11:00 in the distance. **0.7**

27.5 Kline, Colorado. **4.5**

32.0 Red Mesa, Colorado. **2.0**

34.0 We are now within the outcrop belt of the Upper Cretaceous Lewis Shale. At 9:00, drab shale slopes of the Lewis are visible. The Lewis Shale of Cross et al. (1899) is primarily composed of dark-gray to greenish-gray shale with some sandy layers, limestone and calcareous nodules. It represents the last episode of marine deposition in the San Juan Basin. Together with the overlying Pictured Cliffs Sandstone, the Lewis represents the Late Campanian R-5 regression (Molenaar, 1983) of the Cretaceous epicontinental sea in the Colorado Plateau region. Ammonites from the Lewis Shale and Pictured Cliffs Sandstone (Cobban, 1973; Cobban et al., 1974; Lucas and Sealey, First-Day Road Log, this volume) thus provide important biostratigraphic data with which to determine a maximum age for the overlying Upper Cretaceous continental deposits of the Fruitland and Kirtland Formations. **0.8**

34.8 The road descends into the river valley. **0.5**

35.3 Bridge over Long Hollow Creek, a tributary of the La Plata River. The sandstone on both sides of the road is the Cliff House Sandstone (the upper formation of the Mesaverde Group) which underlies the Lewis Shale. **0.7**

36.0 On the left the roadcut exposes the Lewis Shale. **1.2**

37.2 More Lewis Shale is visible along both sides of the highway for about the next 2 mi. **1.8**

39.0 Welcome to New Mexico! **1.1**

40.1 The sandstone cliff on the left side of the highway is the Pictured Cliffs Sandstone. The Pictured Cliffs Sandstone of Holmes (1877) is generally a white to brown sandstone with some shale interbeds in its lower portion. It represents a regressive littoral marine unit composed of delta-front and barrier lithofacies (Flores and Erpenbeck, 1981). **0.3**

40.4 At 9:00 the red "clinker" is in the Fruitland Formation, the deltaic, coal-bearing strata that overlie the Pictured Cliffs Sandstone. **1.0**

41.4 Another bridge over the La Plata River. **0.8**

42.2 The low rolling hills from 9:00 to 11:00 are covered strata of the Fruitland Formation. **1.1**

43.3 At 9:30, past the low rolling hills and in the distance, are bluffs of the Nacimiento Formation on the western end of Bohannon Canyon and other canyons that drain eastward into the Animas River. The Nacimiento Formation in this area is unquestionably of Paleocene age based on the fossil mammals it contains (see, for example, Granger, 1917). **0.8**

44.1 La Plata, New Mexico. **1.6**

45.7 Cemetery on the left as highway crests the hill. The strata to the left belong to the Nacimiento Formation (originally "Nacimientan series" of Keyes, 1906 and "Nacimiento Group" of Gardner, 1910). Fossil mammals from the lower part of the Nacimiento Formation farther south in the San Juan Basin are of early Paleocene (Puercan) age (see, for example, Matthew, 1937). These fossil mammals thus constrain the minimum age of the Ojo Alamo Sandstone, which underlies the Nacimiento Formation throughout the San Juan Basin. **1.7**

47.4 Sharp bend in road. **0.6**

48.0 Badlands of the Nacimiento Formation are visible to the left. **0.5**

48.5 At 12:00 across the valley the eastern face of Pinyon Mesa is visible. **1.4**

49.9 On the right, the Kirtland Formation is exposed in a roadcut. Strata referred to here as Kirtland Formation and visible for the next 4 mi were mapped by Reeside (1924, pl. 1) as McDermott Formation. **0.5**

50.4 At 9:00 across the valley the Ojo Alamo Sandstone overlies the upper part of the Kirtland Formation. **1.5**

51.9 To the right, the Kirtland Formation, a variegated sequence of mudstone, sandstone and siltstone, is overlain by the Ojo Alamo Sandstone. The section exposed here is on the far eastern edge of Pinyon Mesa. **0.7**

52.6 At 12:00 across the valley of the Ojo Alamo Sandstone above the Kirtland Formation is visible again. **2.2**

54.8 Gate; **turn right** onto dirt road (San Juan County Road 391) and proceed westward. **0.1**

54.9 Cattle guard; stay left. **0.3**

55.2 Green and buff mudstones of the Kirtland Formation are visible to the right. **0.1**

55.3 The road forks; stay left. **0.3**

55.6 Well pad; stay left. We are now entering a bowl of badlands developed in the Kirtland Formation. As you look up the valley note the purple and blue strata high in the section. These strata, which immediately underlie the Ojo Alamo Sandstone, formed the primary basis for Reeside's (1924) identification of the McDermott Formation here, on the slopes of Pinyon Mesa. **0.7**

56.3 Road forks; **go right. 0.2**

56.5 At 1:00–3:00 note the badlands of the Kirtland Formation with purple-banded strata near the top of the section. **0.2**

56.7 Road forks; **stay right. 0.2**

56.9 The Ojo Alamo Sandstone is now very visible. Note, in particular, its irregular base. **0.3**

57.2 Road forks; **stay right. 0.1**

57.3 Elliott Oil Company well. **0.4**

57.7 The La Plata Mountains are visible at 1:00–2:00; the San Juan Mountains are visible at 3:00. **0.5**

58.2 Road forks; **stay left. 0.2**

58.4 The road forks three ways; **after the first left, bear left 0.2**

58.6 Road forks; **stay right 0.7**

59.3 Road forks; **bear right. 0.2**

59.5 Road forks; **bear right. 0.1**

59.6 Road forks; **stay left. 0.1**

59.7 Road forks at crest of hill; **stay left. 0.1**

59.8 **STOP 2.** Park around Dugan Production Corporation well located in sec. 15, T30N, R14W.

The purpose of Stop 2 is to examine the contact between the Kirtland Formation and the Ojo Alamo Sandstone on the western flank of Pinyon Mesa. It is also possible from this vantage point to see the Hogback monocline along the western edge of the San Juan Basin.

Reeside (1924, pl. 1) originally mapped only two stratigraphic units here, the McDermott Formation overlain by the Ojo Alamo Sandstone. As Reeside (1924, p. 25) noted, "beds of purely andesitic debris do not occur west of La Plata River in New Mexico, though sandstone, shale, and conglomerate with a notable amount of andesitic material in them mark the McDermott formation clearly in the region north of the San Juan River." Thus, at the location of Stop 2, Reeside (1924, p. 61) reported 40+ ft of McDermott Formation unconformably overlain by 190 ft of Ojo Alamo Sandstone. On the north side of Pinyon Mesa, Reeside reported as much as 165 ft of McDermott Formation.

Hayes and Zapp (1955), however, offered the following observations on the stratigraphy in this and adjoining areas:

> . . . at Pinon Mesa . . . the Kirtland Shale is succeeded by 60 to 100 ft of banded sandy shale and thin beds of sandstone that differ from the underlying Kirtland shale only in the presence of scattered chert pebbles in the sandstone and local lenses of tuffaceous sandstone. These beds are overlain with irregular contact by approximately 200 ft of cliff-forming conglomeratic sandstone. Reeside (1924) assigned the lower pebbly and tuffaceous beds to the McDermott formation and the overlying sandstone to the Ojo Alamo sandstone, which he considered genetically distinct from the McDermott formation and unconformable with it . . .
>
> Considerable effort was expended during this investigation in an attempt to establish and trace a precise upper contact of the Kirtland shale, to be drawn at the lowest occurrence of pebbles, or megascopically identifiable andesitic detritus. Careful tracing of beds in areas of continuous exposures revealed that the stratigraphic horizon at which these materials appear is not constant, that the beds are lenticular, and that lithologies common in the Kirtland shale recur above the lowest coarse clastics. The upper contact of the Kirtland shale is therefore transitional and arbitrary.

These observations, as well as the work of Barnes et al. (1954) and O'Sullivan et al. (1972) have supported assignment of the strata at Pinyon Mesa and adjacent areas north of the San Juan River in New Mexico that Reeside (1924, pl. 1) mapped as McDermott Formation to the Kirtland Formation (also see Lehman, 1985). As Fassett and Hinds (1973, p. 24) put it:

> In the Pinyon Mesa area, beds of tuff ranging in thickness from thin laminae to beds several feet thick and thicker sandstone beds which contain abundant andesitic debris occur in the uppermost Kirtland; these beds are in what Reeside (1924) originally called the McDermott Formation.

It is well worth considering how similar Reeside's McDermott at Pinyon Mesa is to the McDermott we saw at Stop 1.

At Pinyon Mesa, biostratigraphic control of the Cretaceous-Tertiary boundary is very poor. To our knowledge, the only biostratigraphic data relevant to placement of this boundary are dinosaur fossils reported by Kues et al. (1977, p. 146, 264). The fossils are indeterminate hadrosaur remains from the lower exposures of the Kirtland west of Pinyon Mesa in sec. 25, T30N, R5W.

Leave Stop 2 by turning around and retracing route back to New Mexico Highway 17 (New Mexico 17 = Colorado 140). **0.2**

60.0 Road forks; stay right. **0.1**
60.1 Road forks; stay right. **0.1**
60.2 Road forks; stay left. **0.1**
60.3 Road forks; stay left. **0.2**
60.5 Due south to southwest on the skyline are mesas and buttes capped by the San Jose Formation that are south of the San Juan River in the Kutz Canyon area. **0.6**
61.1 Road forks; stay left. **0.1**
61.2 Take the middle of the three roads, thus going to the right. **0.2**
61.4 Go straight. **0.3**
61.7 At 12:00 the bluff capped by Ojo Alamo Sandstone on the other side of the La Plata River is visible. **0.8**
62.5 Road forks; stay left. **0.4**
62.9 Road forks; stay left. **0.4**
63.3 Road forks; stay left. **0.7**
64.0 Road forks; stay right. **0.7**
64.7 Cattle guard; stay right. **0.1**
64.8 The dirt road meets the paved highway (NM-17). **Turn right** and proceed southward on the highway. **0.6**
65.4 At 9:00 note channel-scouring at the base of the Ojo Alamo Sandstone. **1.2**
66.6 At 3:00 the Kirtland Formation exposed up Cottonwood Arroyo is visible. **2.3**
68.9 Intersection of NM-17 and US-550; **turn left** and head east on US-550. The bluffs on the south bank of the San Juan River are visible to the south. The capping sandstone is the Ojo Alamo and it overlies the Kirtland Formation. **1.3**
70.2 **Turn right** onto the truck route (Murray Thruway). We have entered Farmington, New Mexico. Established in 1879, Farmington derived its name from "farming town" because of the prolific farming that then took place in the San Juan River valley. The Navajo Indians called the place where Farmington stands "tqo-tah," which means three waters, because it is here that the San Juan, La Plata and Animas Rivers merge. **1.1**
71.3 Intersection of the Murray Thruway and NM-371. **Turn right** onto NM-371 and proceed south toward Bisti. **0.2**
71.5 Bridge over the San Juan River. The San Juan River is the largest river in the San Juan Basin, and its tributaries (principally the Chaco River) drain most of the hydrographic San Juan Basin. In Spanish, "San Juan" means St. John the Baptist. The Spanish explorer Don Juan de Oñate originally conferred this name on an Indian pueblo in northern New Mexico, and the name was subsequently also applied to this river. **0.6**
72.1 **Turn right** onto paved road and proceed west. **0.5**
72.6 Green mudstone of the Kirtland Formation is exposed in the roadcuts on the left. **0.2**
72.8 The pavement ends; proceed ahead on the gravel road. **0.4**
73.2 On the right note the Quaternary gravels and cobbles exposed in a small pit. **0.5**
73.7 Take a sharp **left turn** onto a narrow dirt road. **0.2**
73.9 Navajo dwelling on the left. Watch out for sheep crossing the road. **0.2**
74.1 From 10:00–3:00 a broad panorama of the bluffs south of the San Juan River is visible. The Ojo Alamo Sandstone caps the bluffs and is immediately underlain by the Kirtland Formation. To the west, the Fruitland Formation underlies the Kirtland. **0.3**
74.4 Road forks; **stay right.** **0.4**
74.8 Green mudstone and sandstone of the Kirtland Formation is visible in the arroyo on the left. **0.2**
75.0 Road forks; **stay left.** **0.6**
75.6 Road forks; **stay left.** **0.3**
75.9 Road forks; **stay left** **0.3**
76.3 **STOP 3.** Park around well. Here, we will examine the stratigraphy at a locality where a large dinosaurian femur (Fig. S3.1) was discovered just within the Ojo Alamo Sandstone (Fassett et al., 1987). The strata exposed in the bluffs south of the San Juan River were originally described by Bauer (1916), Bauer and Reeside (1921) and Reeside (1924). About 7 mi northwest of Stop 3 is the town of Kirtland, namesake of the Kirtland Shale of Bauer (1916). Another 2 mi to the northwest is the town of Fruitland, for which Bauer (1916) named the Fruitland Formation. Both of these towns are along the San Juan River.

Bauer's (1916, pl. 65) type section of the Kirtland Shale is along the south bank of the San Juan River. Therefore, we are either looking at, or very close to, part of the type Kirtland Shale; Bauer's map (1916, pl. 64) is not detailed enough to allow determination of the exact location of the typical Kirtland section he measured. A medial sandstone member of the Kirtland Shale was named the Farmington Sandstone Member by Bauer (1916). It is exposed at Stop 3 at the bottom of the local section as a gray to buff, fine-grained sandstone. However, this is only the top of the Farmington Sandstone Member. Along the San Juan River, Reeside (1924, p. 62) reported a total thickness of 459 ft of interbedded sandstone and mudstone that he assigned to the Farmington Sandstone. Dilworth (1960), who studied the sedimentology of the Farmington Sandstone along the San Juan River, concluded it was derived from a metamorphic or volcanic terrain to the southwest. Marine foraminiferan fossils collected by Dilworth (1960) from the

FIGURE S3.1. Hadrosaur femur from Ojo Alamo Sandstone at Stop 3. Fossil is now on display in Geology Museum of the University of New Mexico. Scale bar is 20 cm long.

Farmington indicated to him that the Farmington represented a brief marine transgression into the San Juan Basin. However, as Fassett and Hinds (1971, p. 26) pointed out:

> It is the authors' opinion that the fossils described by Dilworth were reworked because (1) the total physical character of the Farmington clearly indicates a fluviatile origin, and (2) all the earlier fossil collections [especially dinosaur fossils reported by Gilmore (1935)] indicate a fluviatile-origin for the Farmington.

Above the Farmington Sandstone at Stop 3 are about 82 ft of drab (yellow-gray-olive) mudstone and shale with minor and usually lenticular beds of dark-brown, medium-grained sandstone. These strata unquestionably pertain to what is informally termed (after Bauer, 1916) the upper shale member of the Kirtland Formation. An approximately 40-ft-thick pale orange to dark yellowish orange, medium- to coarse-grained sandstone with some conglomerate lenses overlies these mudstones. This sandstone, in turn, is overlain by 6.5–10 ft of tuffaceous sandstone. It is clear from the measured stratigraphic section along the San Juan River reported by Reeside (1924, p. 62) that he assigned both of these sandstones to the McDermott Formation. Bauer (1916), however, had assigned these rocks to the upper shale member of the Kirtland Shale, an assignment subsequently upheld by Hayes and Zapp (1955), Beaumont and O'Sullivan (1955), O'Sullivan and Beaumont (1957), O'Sullivan and Beikman (1963), O'Sullivan et al. (1972) and Fassett and Hinds (1971). O'Sullivan et al. (1972, p. 54) provided a rationale for this decision as follows:

> Reeside (1924, p. 51) assumed that andesitic debris appeared suddenly in the succession of rocks only after deposition of the Kirtland Shale and that it was, therefore, a reliable criterion for identification of his McDermott Formation. Recent studies, however, have disclosed that andesitic debris at least 300 feet below the top of the Kirtland Shale is present in the area immediately north of the San Juan River, and that the McDermott Member of the Animas Formation, as now defined, is not present south of the San Juan River.

The coarse-grained and conglomeratic, pale orange to white, cliff-forming sandstone at the dinosaur bone locality is the Ojo Alamo Sandstone of all workers. The dinosaur bone (locality coordinates are SE$^1/_4$ NW$^1/_4$ NE$^1/_4$ sec. 36 [unsurveyed], T29N, R14W) was collected from tuffaceous, coarse-grained, pale olive to olive gray sandstone about 2.5 ft below the upper sandstone ledge of the Ojo Alamo Sandstone (Fig. S3.1). This bone is the right femur of a hadrosaur (Fassett et al., 1987).

There are a few conclusions that can be drawn from this dinosaur fossil. The bone is virtually complete and its cortical surface is not abraded, so it seems highly unlikely that it is reworked. Therefore, the stratum from which this bone was derived must be considered Cretaceous unless independent biostratigraphic evidence (like pollen) suggests otherwise. This is a very large bone of an advanced ornithopod dinosaur; clearly it is Late Cretaceous. The stratigraphically highest dinosaur occurrence elsewhere in the San Juan Basin that is *in situ* (not reworked) within the Kirtland Shale is 3 m below the base of the Ojo Alamo Sandstone. Therefore, this bone is the stratigraphically highest dinosaur found in the San Juan Basin, although by emphasizing this point we don't want to give the impression that it is necessarily the youngest dinosaur found in the San Juan Basin. We simply don't have the data needed to support such an assertion at present.

Leave Stop 3 and retrace route to Farmington.

End of Supplemental Road Log 3.