BRIGHAM YOUNG UNIVERSITY

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CONTENTS

Field Guide and Road Log to the Western Book Cliffs, Castle Valley, and Parts of the Wasatch Plateau

A Field Guide and Road Log prepared for the Coal Geology Division, Geological Society of America Field Trip, October 17-19, 1975, and for presentation at a Symposium at the Annual Meetings of the Geological Society of America at Salt Lake City, October 20, 1975.

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Brigham Young University Geology Studies

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Coal Geology Division
The Geological Society of America
Field Trip

October 17-19, 1975

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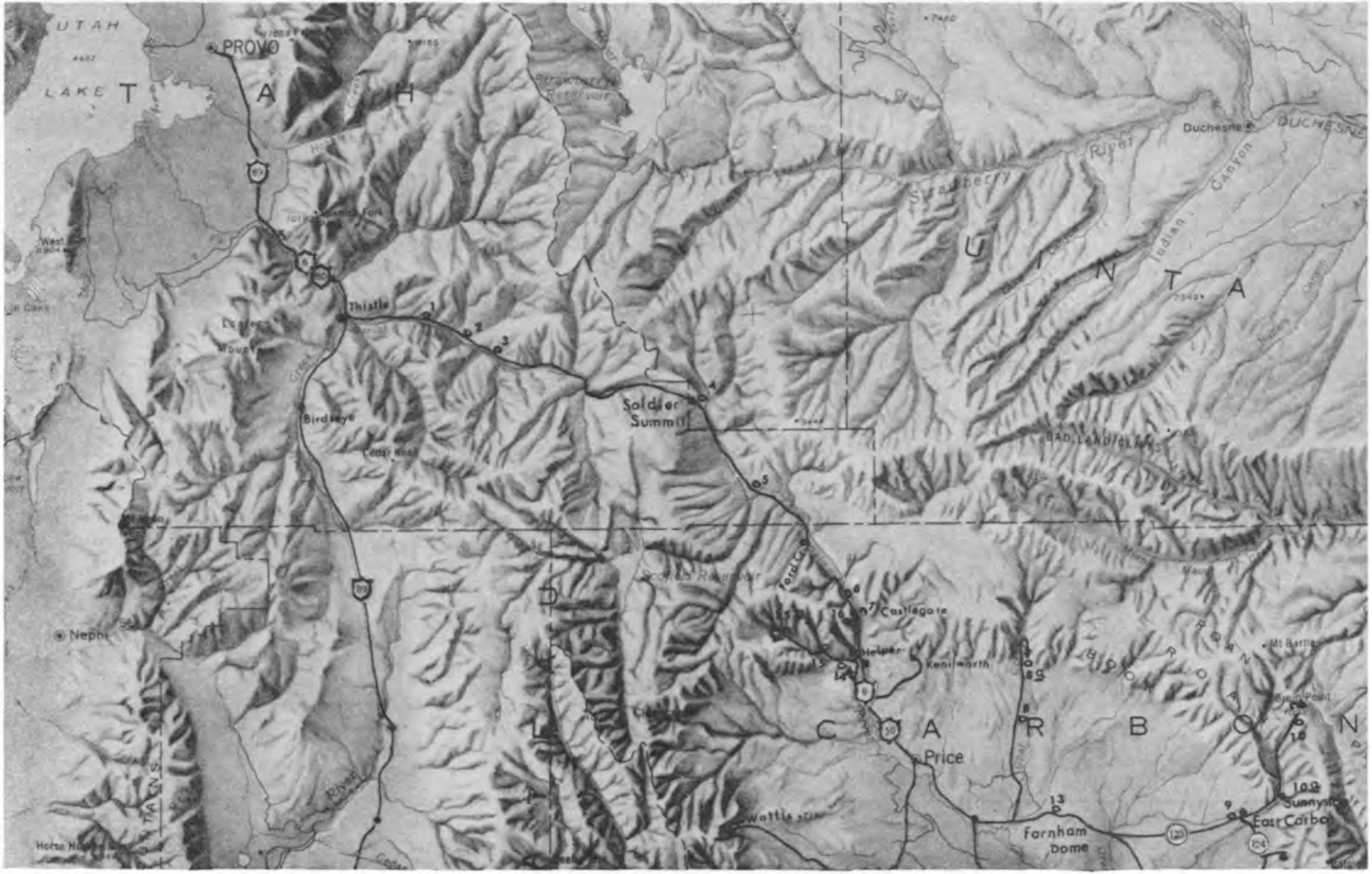
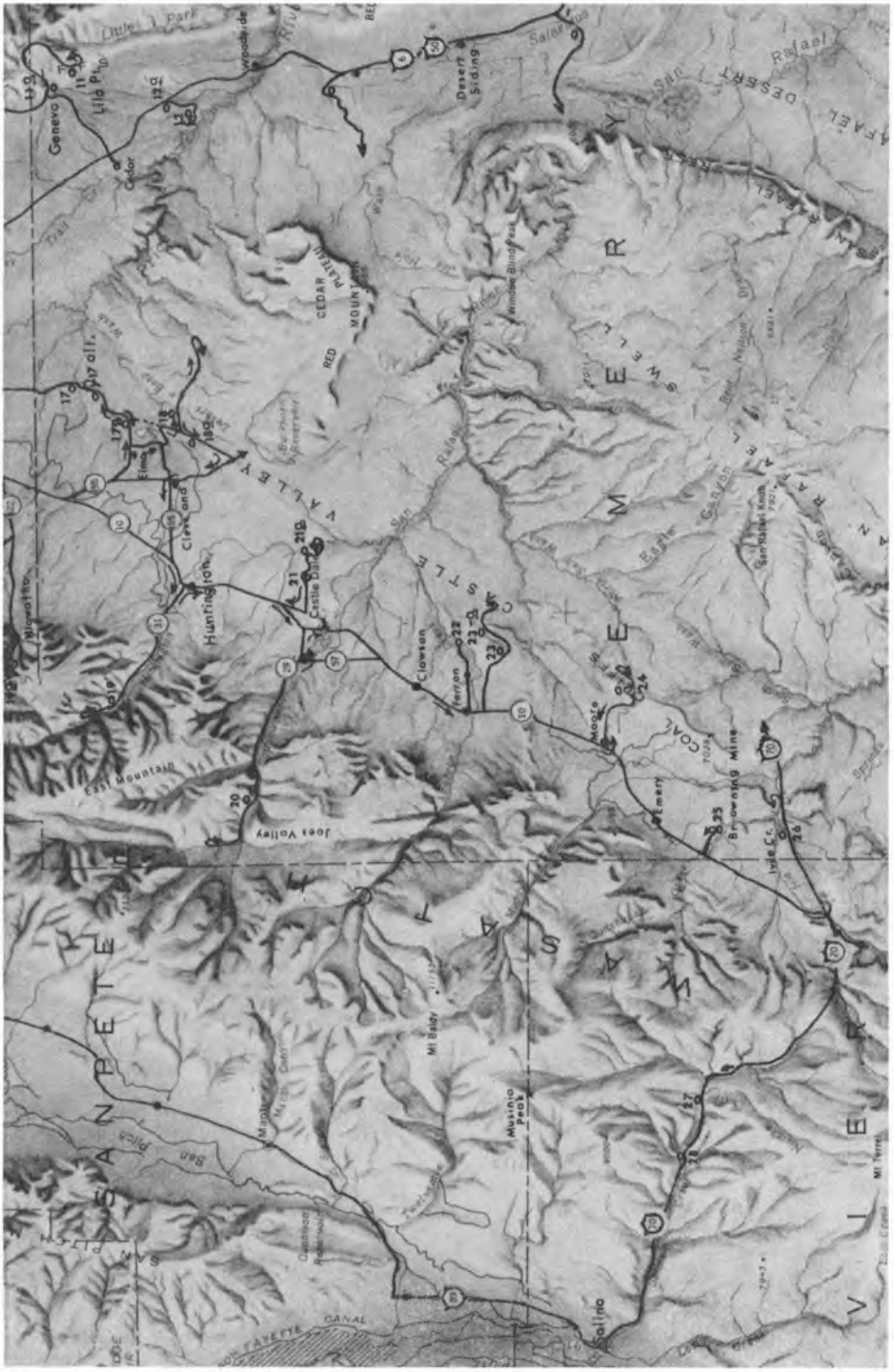
Index to Road Logs

Oct. 17-19, 1975

		STOP NOS.	Total Miles	Mileage GSA 1975 Log	Page Nos.	Mileage BYU 1974	Page Nos.
DAY 1 (OCT. 17, 1975)		1–13	162.7				
PART I-A	Provo to Thistle	—	21.2	0.0–21.2	7–10	—	
PART I-B	Thistle-Sunnyside Road	1–7,9	71.8	21.2–93.0	11–22	0.0—71.7	3–42
PART I-C	Sunnyside Road-Price	12,13	69.7	93.0–162.7	22–39	—	
SIDE TRIPS	Coal Canyon	8	22.8	85.9	39–41	—	
	Whitmore Canyon-Bruin Point	10	17.8	104.3	41–42	—	
	Horse Canyon-Lila Point	11	7.65	114.7	42–44	—	
DAY 2 (OCT. 18, 1975)		14–21	156.75				
PART II	Price-Spring Canyon-Price	14–16	32.1	0.0–32.1	44–49	—	
	Price-Castle Dale-Price	17,18,20	124.65	32.1–156.7	51-71	—	
SIDE TRIPS	Hiawatha-Wattis	19A	19.6	40.5	71–72	—	
	Huntington Canyon	19	21.5	84.5	72–76	—	
	E. of Castle Dale	21	9.6	126.8	76–80	—	
DAY 3 (OCT. 19, 1975)		22–28	128.9				
PART III-A	Price to Ivie Creek	24,26	87.7	0.0–87.7	80–112	—	
PART III-B	Ivie Creek to Salina	27,28	41.2	87.7–128.9	112–121	55.6–93.7	76–93
SIDE TRIPS	Ferron-Molen	22	10.6	43.0	121–122	—	
	Ferron Creek	23	15.3	43.6	122–128	—	
	Browning Mine	25	5.2	72.8	128–129	—	
TERMINAL (OCT. 19,1975) from Salina							
	Salt Lake City via Thistle	—	150.5	—		0.0–90.3	93–117
	Salt Lake City via Freeway	—	138.	—		—	


UTAH
LAKE
PROVO
Strawberry Reservoir
Duchesne
DUCHESNE
Strawberry
River
Indian
Canyon
Thistle
Birdseye
Soldier Summit
Scofield Reservoir
Castlegate
Helper
Kenilworth
Price
Nephi
Farnham Dome
East Carbon
Sunnyside
BAD LANDS CLIFFS
U I N T A
C A R B O N



Figures 1A, B, Mile 0.0, Day 1.
Relief map showing route of trip and field trip stops. (Modified from Shaded Relief Map of Utah, 1:500,000, 1959, U. S. Geol. Surv.)

Field Guide and Road Log to the Western Book Cliffs Castle Valley, and Parts of the Wasatch Plateau

ROAD LOG FIRST DAY (OCT. 17, 1975)
Day 1, Mile 0.0 SPANISH FORK CANYON, NORTH END WASATCH PLATEAU, PRICE RIVER CANYON AND WESTERN BOOK CLIFFS

From Provo through Thistle, Soldier Summit, Castlegate, Price, Wellington and Sunnyside area and back to Price.

GSA 1975 ROAD LOG, PART I-A
PROVO TO THISTLE

Note: Most of the information in this Road Log, Part I-A, has been partially revised from the log prepared for the 1966 Field Trip of the Coal Geology Division, Geological Society of America and affiliated societies, by J. Keith Rigby, William K. Hamblin and R. G. Young and published by the Utah Geological and Mineralogical Survey, p. 131-138, *Central Utah Coals: A guidebook prepared for the Geological Society of America and Associated Societies,* as Bulletin 80 (November, 1966, 164 pp). Additional material has been added by Aureal T. Cross, and the log was collated by Aureal T. Cross, Christopher C. Cross, and E. Blair Maxfield.

MILEAGE *Cumulative*	*Interval*	
0.0		Provo, Utah. Brigham Young University campus is located on a delta built by the Provo River when Lake Bonneville was at an elevation of 4800 feet (1485 m) (Provo level).
0.3	0.3	Junction of 9th East and 9th North Streets. Turn right; continue south on 9th East. The surface here is on prodelta clays. Higher levels of Lake Bonneville are visible against the mountain scarp to the east. The highest level is the Bonneville level at 5135 feet (1565 m). The bedrock exposed in the mountain front is principally late Precambrain and Cambrian clastics with Mississippian gray carbonates exposed at the mountain top. The high country, behind the front scarps, is Pennsylvanian Oquirrh Formation.
1.1	0.8	Traffic light at junction of 9th East and Center Streets; continue south across Center Street on 9th East.
1.7	0.6	Junction of 9th East with U.S. Highway 89 and 91. Gravel quarries at the mouth of Slate Canyon to the east are in Bonneville sediments. To the west of the road most of the low country represents Lake Bonneville prodelta clays. Utah Valley to the west is typical of the Basin and Range valleys with a great thickness of Late Tertiary

and Quaternary sediments filling fault-block basins. Paleozoic rocks are exposed in the ranges along the margin.

3.3	1.6	Rise off the prodelta clay plain onto pre-Bonneville alluvial fans. These alluvial fans are thinly veneered with lacustrine sediments.
3.9	0.6	Pacific States Cast Iron Pipe Co. to west. This site and the foreground are the former site of the Ironton Plant of U.S. Steel Co. Iron ore for that plant was obtained from magnetite deposits associated with intrusives in southwestern Utah and coal was shipped from Carbon County.
5.0	1.1	Prodelta clays of Lake Bonneville.
5.3	0.3	Entering Springville. Crumpled Cambrian to Mississippian carbonates well exposed on west scarp of Wasatch Mountains to east. Flexing represents early Laramide overturning to the southeast. The small rise as we enter Springville is the result of post-Bonneville antithetic faults related to the major Wasatch normal fault system. A series of springs outlines this fault in the valley to the west.
6.9	1.6	Junction of overpass. Keep right at the south edge of Springville and continue on U.S. Highway 89 and Alt. 50 toward Price.
7.9	1.0	Rise off prodelta clays onto the foreset slope of the delta built by Hobble Creek and Spanish Fork into Lake Bonneville. The upper surface of the delta is at the Provo level. Hobble Creek is the canyon at 9 o'clock; Spanish Fork Canyon ahead at about 1 o'clock. At 7 o'clock (to the left rear), crumpled Mississippian carbonates are well exposed.
9.0	1.1	Mapleton Flats. Surface of a delta built by Hobble Creek and Spanish Fork River at the Provo Level of Lake Bonneville. From here to the east we can see the large reentrant of the Wasatch fault, as expressed by the numerous faceted spurs along the mountain face. This is the locality where faceted spurs were first recognized as a criterion for faulting. The Bonneville shoreline, at an elevation of 5135 feet (1565 m), is well developed at the base of the facets and can be traced throughout the reentrant.
9.9	0.9	Junction at Mapleton, U.S. Highway 89 and Alt. 50.
11.0	1.1	Remnants of Bonneville delta at the base of Maple Mountain to the east, and ahead to the right. Junction Utah 147 to east.
12.3	1.3	Crossing small post-Bonneville fault with an associated sag pond developed east of the road. Ahead to the southeast is Hercules Powder Plant on the upfaulted Provo level. The Provo level has been displaced about 35 feet (10.7 m) by a small fault. To the east, the Bonneville

terrace is etched into Pennsylvanian Oquirrh rocks and can be traced to the mouth of Spanish Fork Canyon directly ahead. Small outcrops of Diamond Creek Sandstone (Permian) are faulted down against lower Oquirrh Formation (Pennsylvanian) to the south-southwest. (See stratigraphic section, Fig. 3, BYU 1974 Guidebook, p. 7.) At this point the Wasatch fault has a probable displacement of about 10,000 feet (3060 m). The reddish sandy outcrops behind the Hercules Powder Plant are postorogenic Tertiary deposits which are down-faulted against the uplifted topography of the Wasatch Mountains. Equivalent Tertiary beds to the east angularly overlie folded Mesozoic rocks.

The major Wasatch fault which bounds the western flank of the Wasatch Range can be traced into the mouth of Spanish Fork Canyon, where it makes an abrupt turn and continues to the west (right) around the base of the mountains. No branch of the Wasatch fault has been found up Spanish Fork Canyon.

12.4	0.1	Junction of U.S. Highway 89 with U.S. 6 and 50. Continue southeast on U.S. 6 and 50.
12.6	0.2	Hercules Powder Plant entrance.
13.1	0.5	Railroad overpass (siding to Powder Plant).
13.4	0.3	Mouth of Spanish Fork Canyon. Pennsylvanian Oquirrh deltaic rocks (Text-fig. 3., BYU Guidebook, 1974, p. 7), exposed east of highway immediately south and east of the Wasatch fault scarp as laminated sandstones and siltstones dipping about 15° east. Equivalent red beds deposited at margin of the land masses to the east. Shaly breaks, representing the most marine part of the sequence at this particular outcrop, contain isolated linguloid brachiopods.
14.8	1.4	On the southwest side of highway, across Spanish Fork, an outcrop of Pennsylvania coaly shale is exposed 12-14" (.31–.35 m) thick behind the irrigation dam.
15.0	0.2	Small outcrop of Oquirrh Formation on the north side of the road. Typical deltaic sequence with thin coals (coals not seen here).
15.3	0.3	Exposure of Pennsylvanian strata (no coal exposed).
15.7	0.4	Cold Springs. Approximate boundary Pennsylvanian-Permian portions of Oquirrh Formation.
16.1	0.4	Canyon to south cut in soluble Kirkman Limestone. Small sink holes developed on terraces south of ranch house.
17.2	1.1	Quarry on north side of highway is in westward-dipping

		Diamond Creek Sandstone folded in a sharp asymmetric anticline. Sulfur spring at crest of anticline.
17.6	0.4	Vertical Diamond Creek Sandstone (east limb of tight, asymmetric anticline).
18.2	0.6	The Diamond Creek Sandstone is overlain by cherty Kirkman Limestone (Permian), in the upper part of the hill, which may be faulted at about the road level. Red Woodside Shale (Triassic) is exposed to the northwest near the triple telephone poles. This nonresistant unit forms very poor outcrops and is overlain by the lower Triassic, Thaynes Limestone which outcrops along the north side of the road for the next half mile. Across the canyon to the south, flat-lying Flagstaff-North Horn rocks rest unconformably upon folded and beveled Triassic Thaynes Limestone. The entire Cretaceous interval exposed in Carbon County (Fig. 2) is represented here in Spanish Fork Canyon by this erosional surface. Sponges can be collected above the road at the top of this section.
18.6	0.4	Road to Forest Camps 3 miles to the northeast.
18.8	0.2	Cross Diamond Creek. Reddish outcrops to the southeast of the bridge are the basal part of the Ankareh Formation (Triassic).
19.7	0.9	Husky gasoline station. The base of the Jurassic Nugget (Navajo) sandstone is exposed in low ledges east of the highway. The Nugget Formation forms the abrupt cliffs to the south in the canyon and is overlain conformably by the Twin Creek (Carmel) Limestone Jurassic sequence.
20.5	0.8	A narrow part in Spanish Fork Canyon. A landslide mass of North Horn sediments has flowed down a small tributary canyon carved in the Nugget Sandstone, visible to the southwest. Remnants of the main highway, which formerly was on the west side of the canyon, can be seen on the landslide. Because of the lack of stability in the North Horn sediments on the west, the highway was moved to its present position on the east side of the canyon.
21.2	0.7	Junction of U.S. Highway 6 and 50 with U.S. Highway 89 at Thistle. Continue on U.S. Highway 6 and 50 past prominent cliffs of Nugget Formation. Contact between the Nugget Sandstone and the Twin Creek Formation at the base of the reddish zone on top of the cross-bedded sandstones. The upper part of the marine sequence in the Twin Creek is exposed in road cuts a short distance to the east (0.5 mi).

END ROAD LOG PART I-A,
CONTINUE EAST ON U.S. HIGHWAY 6 AND 50 ON

BYU 1974 ROAD LOG, PART I, P. 3 AND GSA 1975 ROAD LOG, PART I-B (following pages).

Supplemental field notes, road log points, and additional information will be intercalated here by mileages given in Part I, BYU 1974.

GSA 1975 ROAD LOG, PART I-B
SUPPLEMENT TO BYU 1974 GUIDEBOOK, PART I, PP. 3-42.
THISTLE TO SUNNYSIDE AREA

Miles 0.0 to 71.7 BYU 1974, Part I, pp. 3–42
Miles 21.2 to 93.0 GSA 1975, Part I-B

Note: Largely from field notes by Aureal T. Cross, Christopher C. Cross, E. Blair Maxfield and Robert G. Young, supplemented by information from the GSA 1966 Coal Division Guidebook (Bull. 80).

MILEAGE			
Cumulative		*Interval*	
GSA 1975	BYU 1974		
21.2	0.0		Thistle. Junction of U.S. Highway 89 from south and U.S. 6 and 50. Continue east on U.S. 6 and 50.
26.7	5.5	5.5	Entering Red Narrows. Massive conglomerate directly beside highway.
26.9	5.7	0.2	STOP 1, 1975—RED NARROWS (P. 9, BYU, 1974) (Vehicles pull across to north side of highway and park on wide pull-off just beyond NARROWS) The composition of the boulder and pebbles here has been approximately determined in one sample test as 65 percent limestone, 20 percent quartz, 10 percent chert and 5 percent metaquartzite. The source beds seem to be Precambrian and Pennsylvanian quartzite, Oquirrh and other Pennsylvanian-Permian limestones. The boulders range up to 3 feet in diameter and even in the coarser layers there is crude fluvial stratification.
29.1	7.9	2.2	STOP 2, 1975—(=Stop 4, BYU 1974, P. 11, Mile 7.9) Flagstaff limestone showing algal balls in one of the middle ledges exposed just west of the pull-off. Also freshwater carbonaceous shales and mollusc-bearing beds just east of pull-off (= Mile 8.1, BYU 1974 Guidebook, p. 11). Contact of North Horn below with the Flagstaff is about 0.3 mile west at about the position of the Strawberry Fault which is associated with the dipping rocks here. For detailed illustration see Supplement paper on "Algal Deposits in Cretaceous and Tertiary," *Geology Studies* 22, Part 3, December 1975.

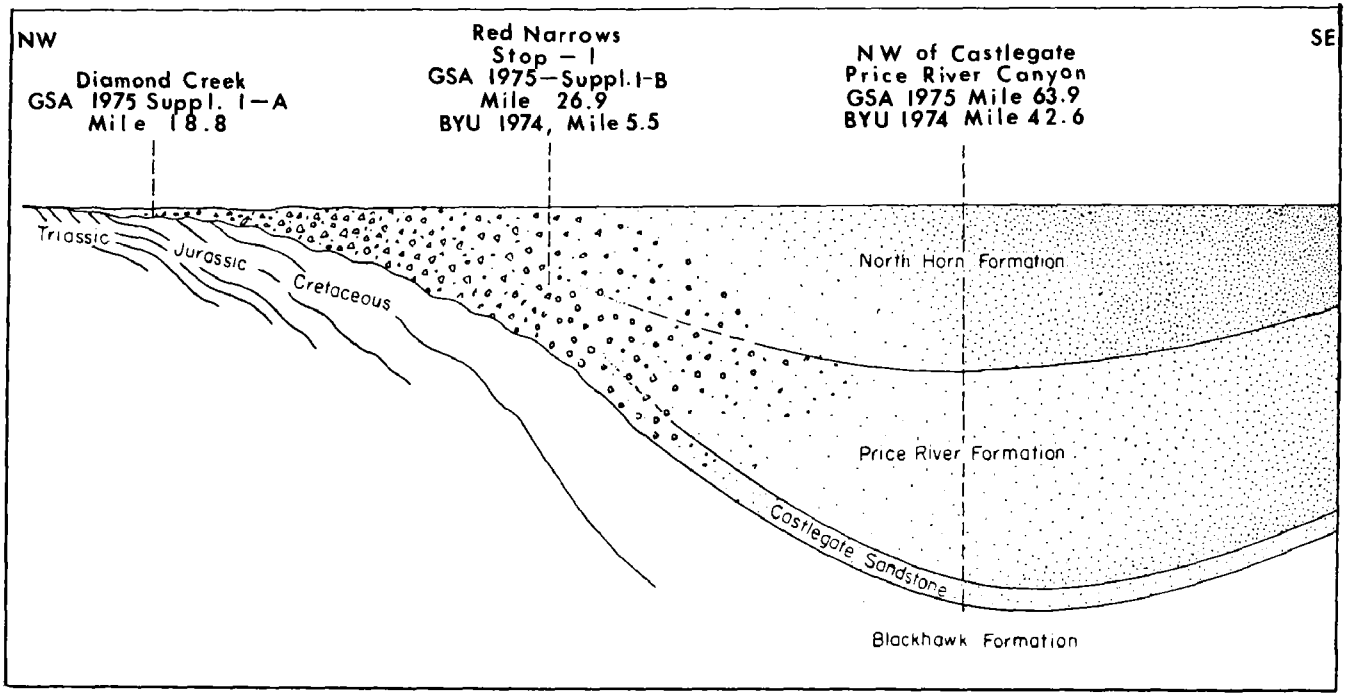
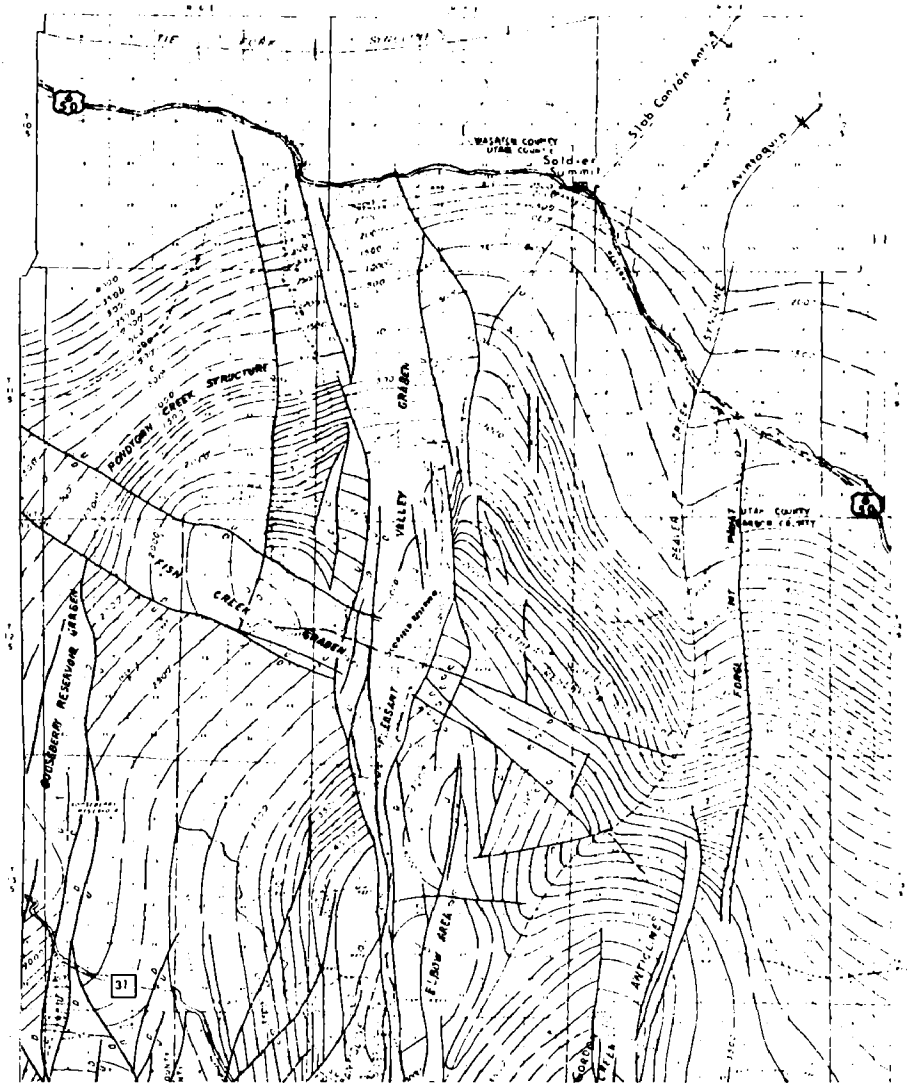


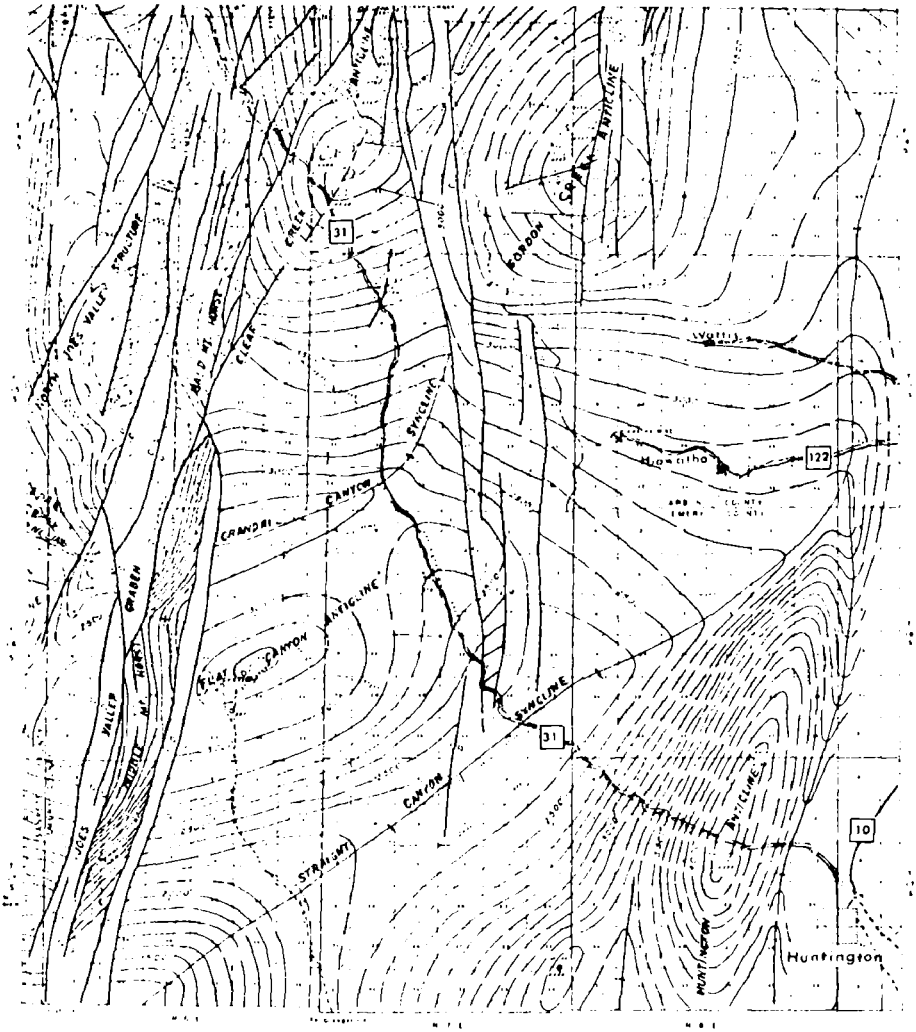
Figure 2, Miles 18.2 and 26.9, Day 1, Stop 1.
Idealized diagram showing unconformity at Diamond Creek and its relation to the Cretaceous-Tertiary clastic wedge to the east. (Modified from Rigby, Hamblin, and Young, 1966, Utah Geol. & Mineral. Survey Bull. 80, Fig. 3, p. 138.)

31.6	10.4	2.5	Faults in Green River Formation along Highway.
31.8	10.6	0.2	STOP 3, 1975—(=Stop 5, BYU 1974 Guidebook, p. 12, Mile 10.4) Small faults in Green River Fm. on north side of highway (See Text-fig. 7. BYU, 1974, p. 13). Bus pull-off on left (north) side of highway.
36.0	14.8	4.2	Railroad overpass.
45.8	24.8	10.0	Entering Wasatch Co. (Wasatch-Utah County line), west edge of Soldier Summit, Utah. The broad valley is cut in Colton Formation.
46.0	25.0	0.2	Soldier Summit center.
46.4	25.4	0.4	STOP 4, 1975—(=BYU 1975, Mile 25.4, p. 17) *Ozocerite Mines & Coffee Stop.* (Pull off onto gravel road junction on left (north) side of highway.) Abandoned mines on left. Two areas of dumps and mine on hill to north can be examined. See article by Cross and Wood.
49.0	27.7	2.6	Reentering Utah Co. (Utah-Wasatch Co. line). Major fault (Forge Mt. Fault) ahead.
52.0	30.7	3.0	Junction Utah State Road 96, to Scofield Reservoir and Clear Creek to the southwest, with U.S. Highway 6 and 50.
52.9	31.6	0.9	Junction minor road to old railroad siding of Colton on right (southwest). Old ozocerite test pit on near side of tracks. This is the type locality of the Colton Formation (Spieker, 1946, p. 139), tentatively dated as early Eocene, a fluviatile and lacustrine sequence which is transitional and intertonguing with the Green River Fm. The Formation is about 1500' (460 m) just north of Colton.
53.8	32.5	0.9	STOP 5, 1975 (OPTIONAL)—(=Stop 6, BYU 1974, p. 21, Mile 32.5) (Bus pull-off on right [S] side of road) Double road cuts through Colton Formation exposing cross-sections of stream channels, particularly near east end of cut on north side of road.
56.9	35.6	3.1	Junction Utah State Road east to Utah 33 (to Duchesne 48 miles to NE) with U.S. Highway 6 and 50. Excellent exposure of Flagstaff For-



Figures 3A, B, Mile 46.4, Day 1, Stop 4; Mile 84.75, Day 2, Stop 19. Geologic Structure, Wasatch Plateau. (Modified from Walton, Paul T., 1954, Wasatch Plateau gas fields, Utah: *in* Geology of portions of High Plateaus and adjacent Canyon Lands, central and south-central Utah: Intermountain Assoc. Petrol. Geol., 5th Ann. Field Conf., p. 78-85, Plate 6.)

mation limestone along road here both east and west of junction and in the railroad cuts to the north and east. The Green River lacustrine beds lie above the Colton red beds to the north across the subsequent valley carved on the Col-



ton. About midway to the skyline in the Green River is the Mahogany oil shale zone, a prominent ledge.

58.1	36.8	1.2	Utah-Carbon Co. line. Big curve to east. Interbedded fluvial sands and thin-bedded shales of North Horn exposed ahead below contact with overlying Flagstaff. This transitional Cretaceous-Tertiary unit is over 2000' (610 m) thick here, much of it reddish in color. There is a freshwater calcareous shale bed near the top, containing molluscs and gas-

tropods, and an occasional coaly zone such as the one ahead at Mile 38.3 at Ford Creek which contain some fossil plant leaves.

From some palynological analysis of this sequence, it is interesting to note there is a good transitional pollen and spore flora from late Cretaceous to early Tertiary and, associated with these indigenous fossils, there is a small suite of reworked (recycled) palynomorphs ranging in age from late to early Cretaceous, Jurassic and Pennsylvanian. The older fossils increase in relative importance to the younger recycled palynomorphs in successively younger beds, though the relative percent of recycled to indigenous forms remains about the same. This indicates an extension of erosion headward or deeper into older and older rocks in the headlands to the west as the North Horn sediments were accumulating on an easterly widening coastal plain.

59.6	38.3	1.5	Ford Creek Bridge. Coaly zone in North Horn to right above road. Fossil plants collected here for study.
60.4	39.1	0.8	Junction with Price River Canyon Recreational Area Road. Excellent exposures near base of North Horn Formation ahead for next 0.4 mile.
63.9	42.6	3.5	STOP 6, 1975—(=BYU 1974, Mile 42.6, p. 26) Base of Price River Formation—Top of Castlegate Sandstone. Bus pull-off on right (SW) on paved spur.

The Castlegate Sandstone here is about 500' (155 m) thick and overlies a coaly zone assigned to the Black Hawk Formation on an unconformable surface. The unconformity, however, actually occurs in or at the base of the coaly zone. Note the close parallel relationship of the upper coals in this zone with the unconformable base of the Castlegate. It is probable that a channel developed here which first filled with interbedded swamp peat and overbank muds before being buried by the coarser channel deposits of the main Castlegate flood.

A comparison of the character of these Castlegate sediments with the coarser conglomerates at the Narrows (Stop 2, 1975, Mile 29.1; BYU 1974, Mile 7.9) and with Figure 2 (p. 8).

64.4	43.1	0.5	Southeast end of big road cut to southwest.

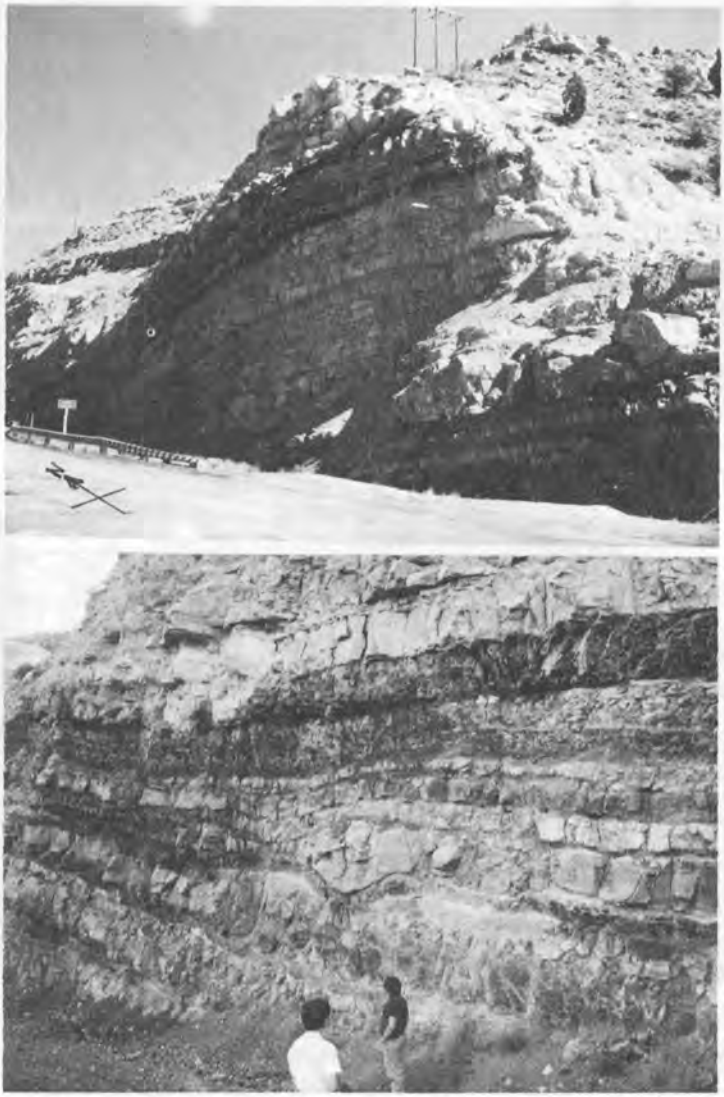


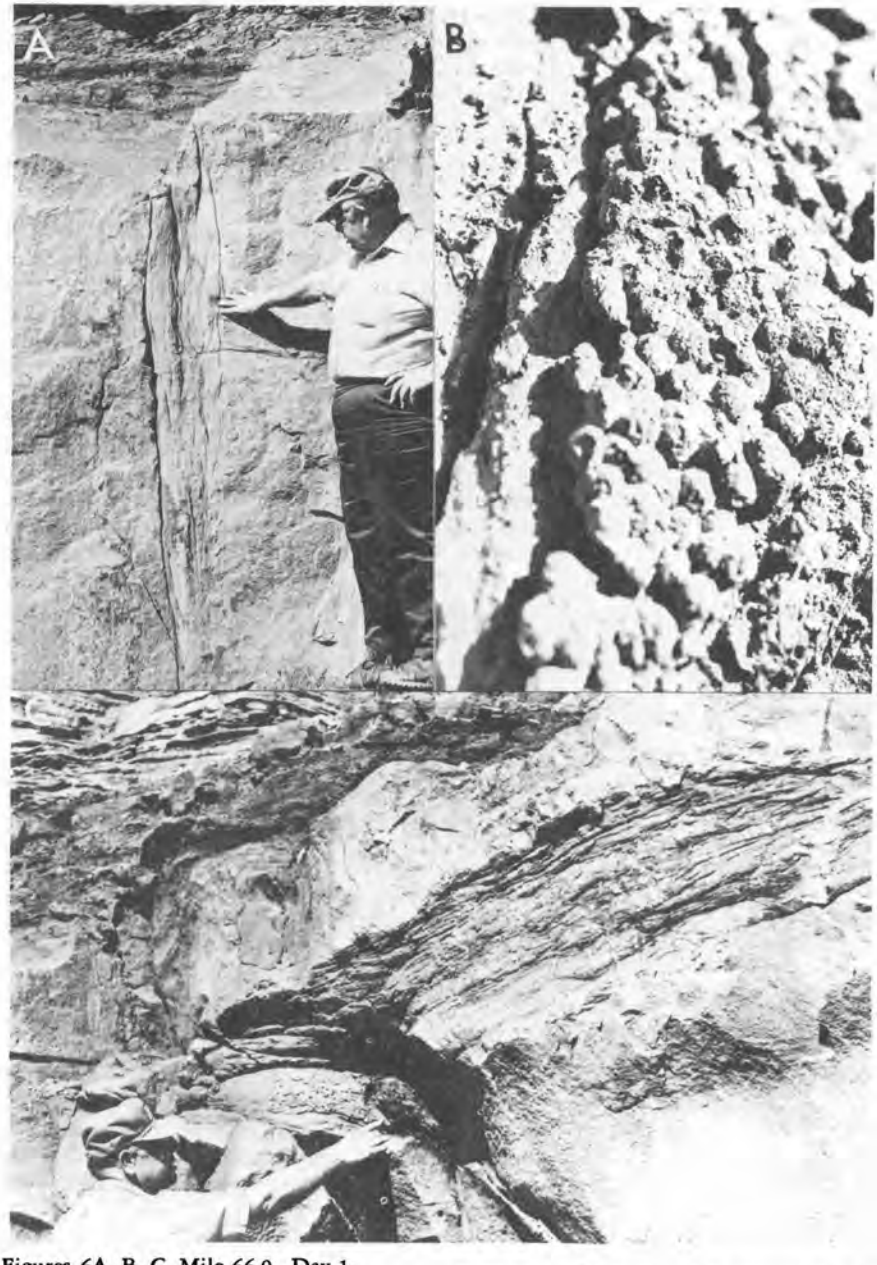
Figure 4A, Mile 59.6, Day 1 (BYU 1974 mi 38.3, Part 1), Ford Creek. Two fluvial swamp coal zones, North Horn Formation, Price River Canyon.
Figure 4B, Mile 65.0, Day 1 (BYU 1974 mi 43.7, Part 1) Kenilworth coal zone (Blackhawk Fm). Baked shales and sandstones overlying burned-out Kenilworth Coal. Note irregular small alluvial channel fills and effect of their lack of compaction on overlying beds.

Figure 5A, Mile 63.9, Day 1, Stop 6 (BYU 1974, mi 42.6, Part 1), Castlegate Sandstone.

Base of Castlegate Sandstone at right overlying upper Blackhawk (?) fluvial, double coal zone.

Figure 5B, Mile 65.75 and 66.0, Day 1 (BYU 1974 mi 44.45, Part 1), Castlegate area. Deep road cut south of Castlegate with Aberdeen Ss ("A") at top, and Spring Canyon Ss at very base at left and on far bluff, and visible through the notch across Price River Canyon ahead. Fossil logs in top of Spring Canyon Ss (SC) with thin irregular coal at that level and double coal (SCC) above. A thin veneer of Mancos Shale (M) spread westward to here on top of the Spring Canyon Ss.

			Thick interbedded fluvial and swamp sequence with good fossil leaves and amber and gastropods in dark shales. Leaf and invertibrate collections made here by Cross.
65.0	43.7	0.6	Baked shales overlying burned-out Kenilworth coal zone. Fossil leaves collected from low-grade ceramic product above coal beds.
65.75	44.45	0.75	STOP 7, 1975—(=Stop 8, BYU 1974, Mile 44.4, p. 28) Bus pull-off on wide parking area across highway toward southeast end of area across from tipple of North American Coal Corporation at Castlegate and discharge participants and then proceed ahead through big cut and wait there. Participants will have opportunity to examine Aberdeen coaly lagoonal sequence across road to the SW (compare with Figure 23 A, p. 33, BYU 1974) and then proceed down the northeast side of highway into the big double cut ahead to examine a thin minor Mancos Shale transgressive deposit, between the base of the massive Aberdeen Sandstone and the underlying Spring Canyon Member, and the coals and logs in the Spring Canyon at the southeast end of the cut. *Watch for traffic here.*
66.0	44.7	0.25	Reboard buses at southeast end of big cut.
66.2	44.9	0.2	Junction Utah State Road 33 to Duchesne.
66.8	45.5	0.6	Utah Port of Entry; truck weighing station.
67.3	46.0	0.5	STOP 16, 1975 (DAY 2, Mile 22.8) (=Stop 9, BYU 1974, Mile 46.0, p. 34-35) We will return to this stop Saturday morning (Oct. 18) Gentile Wash and Panther Hollow.
67.4	46.1	0.1	Utah Railway Line crossing highway.
68.0	(46.7)	0.6	Private road to Carbon Fuel Co. Mine.
68.2	(46.9)	0.2	Good view of basal portion of the Mesaverde Group at 10:00, intertonguing with the upper parts of the Masuk Shale member of the Mancos Shale. At 11:00 are some beheaded or inactive pediment remnants sweeping away from the cliffs.
68.7	(47.4)	0.5	Road to Spring Canyon STOP 15 & 15A, 1975 (OPTIONAL) (DAY 2). We will return here Saturday, October 18.
68.9	47.6	0.2	Helper, Utah (North Main Street).



Figures 6A, B, C, Mile 66.0, Day 1.
6A,C. Southeast end of deep cut near Castlegate. Vertical and horizontal logs in the upper part of Spring Canyon Sandstone just below lowermost Spring Canyon Coal zone.
6B. Teredo borings in one of several logs.

70.9	(49.6)	2.0	Two benches of Emery Sandstone form palisades-like cliffs at narrow gulch to west. This eastward tongue of the Emery is in the foreshore facies off the beaches. Emery forms big cliffs to the east below the pediment caps on the Mancos slopes.
72.0	50.7	1.1	Upper bench of Garley Canyon Sandstone; Price River bridge.
72.4	51.1	0.4	Lower bench of Garley Canyon Sandstone exposed at stream level behind country club greens. The Garley Canyon Sandstone forms a double cuesta in the Blue Gate (middle Mancos) Shale to the south.
74.7	(53.4)	2.3	Excellent view of Garley Canyon Sandstone cuestas in Blue Gate Shale to southwest and a lower sandstone near the base of a pinnacle south of Gordon Creek.
76.8	55.5	2.1	Price, Utah. Junction of Utah State Highway 10 in center of Price.
76.9	(55.6)	0.1	LUNCH STOP. Museum, Court House, Price.
77.0	(55.7)	0.1	Crest of hill near east edge of Price. Mission Motel below crest to west and Green Well Motel just beyond crest to east. Overnight here Friday and Saturday, Oct. 17-18.
83.8	62.5	6.8	Wellington Community Park.
85.6	64.3	1.8	Bridge over Coal Creek.
85.9	64.6	0.3	Secondary road up Coal Creek Junction at service station, about halfway between Coal Creek Bridge and Utah State Road 53 to Myton. SIDE TRIP, COAL CANYON, STOPS 8 and 8 A (OPTIONAL). This road log will be found at end of *First Day Log* after Mile 162.7, GSA 1975, p. 35).
86.1	(64.8)	0.2	Junction Utah State Road 53 northeast to Myton via Soldier Creek, Minnie Maud Creek, Gate Canyon & Wells Draw.
88.3	67.0	2.2	Farnham Dome. Ferron Sandstone—west end of main exposure.
88.5	67.2	0.2	Base of Ferron Sandstone at east end of cut on west flank of Farnham Dome,
88.6	67.3	0.1	STOP 13, 1975—(=Stop 10, BYU 1974, Mile 67, p. 39) No stop at this time. STOP 13

			will be made later in first day in sequence of Ferron Sandstone study. (Bus will park on short pull-off on north side of road 0.1 mile east of base of cut on return trip.)
89.2	67.9	0.6	Broad valley at crest of Farnham Dome (Anticline) with 385' (118 m) of Tununk Shale Member of Mancos Shale exposed between dipping Dakota Ss. (17° N 80° W) and base of lower bench of Ferron marine sand. Measured and sampled here for palynologic analysis of environment.
89.5	68.2	0.3	Milepost 253. Trail junction south into center of Farnham Dome to one of the producing CO_2 wells drilled into the Navajo Sandstone. The Cedar Mountain Shale Formation of Early Cretaceous age crops out in the center of the dome. The dome is actually interpreted by some as the overturned lip of the hanging wall of a thrust fault which moved southeast.
93.0	71.7	3.5	Junction Utah State Road 123 on east side of Grassy Creek Trail. Leave BYU 1974 Guidebook, Part I.

END ROAD LOG PART I-B, GSA 1975
CONTINUE TO SUNNYSIDE, EAST CARBON CITY, HORSE CANYON, WOODSIDE AREA, FARNHAM DOME TO PRICE ON GSA 1975 ROAD LOG, PART I-C

GSA 1975 ROAD LOG PART I-C.
SUNNYSIDE, HORSE CANYON, WOODSIDE AREA

This section of Road Log in part composited from GSA 1966 Coal Geology Division Road Log (Bull. 80, Utah Geol. & Mineral Survey; p. 161-164), and from field notes of Aureal T. Cross, Edward Cotter, and Robert G. Young and collated by Aureal T. Cross, Christopher C. Cross, and E. Blair Maxfield.

Miles 93.0 - 162.7, GSA 1975, Part I-C.

MILEAGE		
Cumulative	*Interval*	
93.0	0.0	Junction Utah State Road 123 with U.S. Highway 6 and 50. Continue east on Utah 123 to East Carbon City and Sunnyside. Road traverses old pediment surfaces of as much as 50' (15 m) thickness. Note assortment of boulders in some cuts, some up to several feet in diameter.
96.1	3.1	Blackhawk coal-bearing sequence capped by Castlegate Sandstone makes up cliffs ahead. Above the Castlegate are Price River and North Horn (darker) overlain by Colton (variegated) and Green River Formations (light white) on the Roan Cliffs beyond the Book Cliffs.

98.7	2.6	Large transported blocks of sandstone on pediments along road.
100.4	1.7	Outdoor theater.
101.0	0.6	STOP 9, 1975 (OPTIONAL) — GENERAL VIEW WESTERN BOOK CLIFFS. Castlegate forms massive bed midway on cliff at 10 o'clock. It is much thinner here than at its type locality in Price Canyon. The lower part of the escarpment is soft, grey Mancos Shale. Between the Castlegate and Mancos, the Kenilworth and Sunnyside Members can be recognized, representing the eastward thinning, near-shore, marine sands and siltstones of the Blackhawk Group. The Aberdeen Member has graded into silty and slightly sandy units in the top of the Mancos Shale. Price River and North Horn equivalents occur in the Book Cliffs escarpment. Directly ahead the Blackhawk Formation forms the lowest outcrops, overlain by Castlegate Sandstone which forms a key horizon in the foothills as the high prominent ledge. A soft, relatively nonresistant equivalent of the Colton beds seen near Soldier Summit forms a subsequent valley about midway up the escarpment and separates the Book Cliffs from the Roan Cliffs behind. The skyline to the east is capped by basal beds of the Green River Formation. To the southeast at 2 o'clock the prominent Castlegate Sandstone forms the major cliff in the escarpment.
101.5	0.5	East Carbon, Utah, P.O. (formerly Dragerton).
101.7	0.2	Junction Utah State Road 124 to Horse Canyon and the Columbia and Geneva mines. Continue straight ahead into Sunnyside.
102.3	0.6	Cross Grassy Trail Creek Bridge.
102.8	0.5	Sunnyside, Utah. Sandstone beds above the main Mancos slope include, from base up, two weak Aberdeen Member tongues, three Kenilworth Member sandstone tongues interbedded by Mancos Shale trangressive units, and these are overlain by another Mancos tongue below the basal Sunnyside Member. The Castlegate Sandstone forms the main cliff and this is overlain by the Price River Formation. Burned zone is in the Sunnyside Member.
103.5	0.7	Abandoned beehive coke ovens which supplied coke for the old Ironton Steel operation in Provo.
103.9	0.4	Good view to the left and ahead of Aberdeen, Kenilworth, and Sunnyside Members of Blackhawk Formation.
104.3	0.4	Tipple and coal preparation plant of Sunnyside Mines on right. Castlegate Sandstone cliffs ahead.

Figures 7A, B, Mile 104.3, Day 1, Stop 10 (optional), (Mile 10.7, Side Trip to Whitmore Canyon-Bruin Point).

7A. Sunnyside bituminous sandstone deposits at about 9200' (2860 m) el. on road up Whitmore Canyon to Bruin Point, el. 10,285' (3140 m). Arrow pointing to layer of upper Wasatch (or possibly lower Green River) beds which are "bleeding" tarry bitumen from porous sandstone.

7B, Looking down toward Whitmore Canyon showing rugged nature of area; abandoned 3-mile aerial tramway (2 arrows near center and upper center); and road winding down through Wasatch Formation.

The following is quoted from the 1966 GSA Guidebook, p. 163-164.

Stop 12. Kaiser Steel Corporation installed modern longwall mining equipment in their no. 3 mine in 1961. The equipment consisted of an Anderton shearer-loader, panzer-type conveyors, and a self-advancing hydraulic roof-support system. The longwall method of mining, using this type of equipment, is readily adaptable to the Lower Sunnyside bed, which is 5 to 6 feet thick with poor roof conditions and bouncing problems.

The recently developed hydraulic roof support system is a significant contribution to longwall mining. Longwall mining has been used in Europe, but prior to the development of hydraulic roof support, production per man shift was relatively low because timber support was required.

The coal-retrieving machine is an Anderton shearer-loader using a 60-inch drum with a cutting width of 27 inches. Coal cut by the drum is removed from the mine by the face conveyor. The drum cuts in one direction only and after each cut the drum is returned to start another cut. The conveyor and roof support system are moved up to the face before the new cut begins.

Coal recovery along the longwall approaches 100 percent. The only coal lost is the two or three inches not reached by the cutter bits on the drum.

Caving of the roof rock closely follows advance of the roof support system. This relieves pressure on the roof and essentially eliminates roof bounces, which are a problem of room and pillar mining.

Park bus if STOP 10, 1975 (OPTIONAL) to Bituminous Tar Sands near Bruin Point is to be made.

SIDE TRIP. STOP 10, 1975 (OPTIONAL) UP WHITMORE CANYON TO BRUIN POINT AND SUNNYSIDE TAR SANDS

This road log will be found at end of *First Day Log* after Mile 162.7 GSA 1975, p. 39, and following *Coal Canyon Log*.

104.3		Kaiser No. 3 Mine tipple, Sunnyside. Go southwest toward East Carbon City.
105.2	0.9	Sunnyside, Utah, P.O. and Trading Post.
106.8	1.6	Junction Utah State Roads 123 and 124. Turn left (south) on 124.
107.0	0.2	Descend through pediment cap. Note angular discordance of Mancos (Masuk) Shale beneath.
107.2	0.2	Cross spur line D.&R.G.W.R.R.
109.2	2.0	Turn right (south) on Horse Canyon road. Road straight ahead goes to Columbia Mine, U.S. Steel. Road traverses lower and middle pediment surfaces. Note thickness, size, and assortment of material making up these caps and the large caliche buildups within these alluvial sediments. Ahead in the distance, across the Mancos

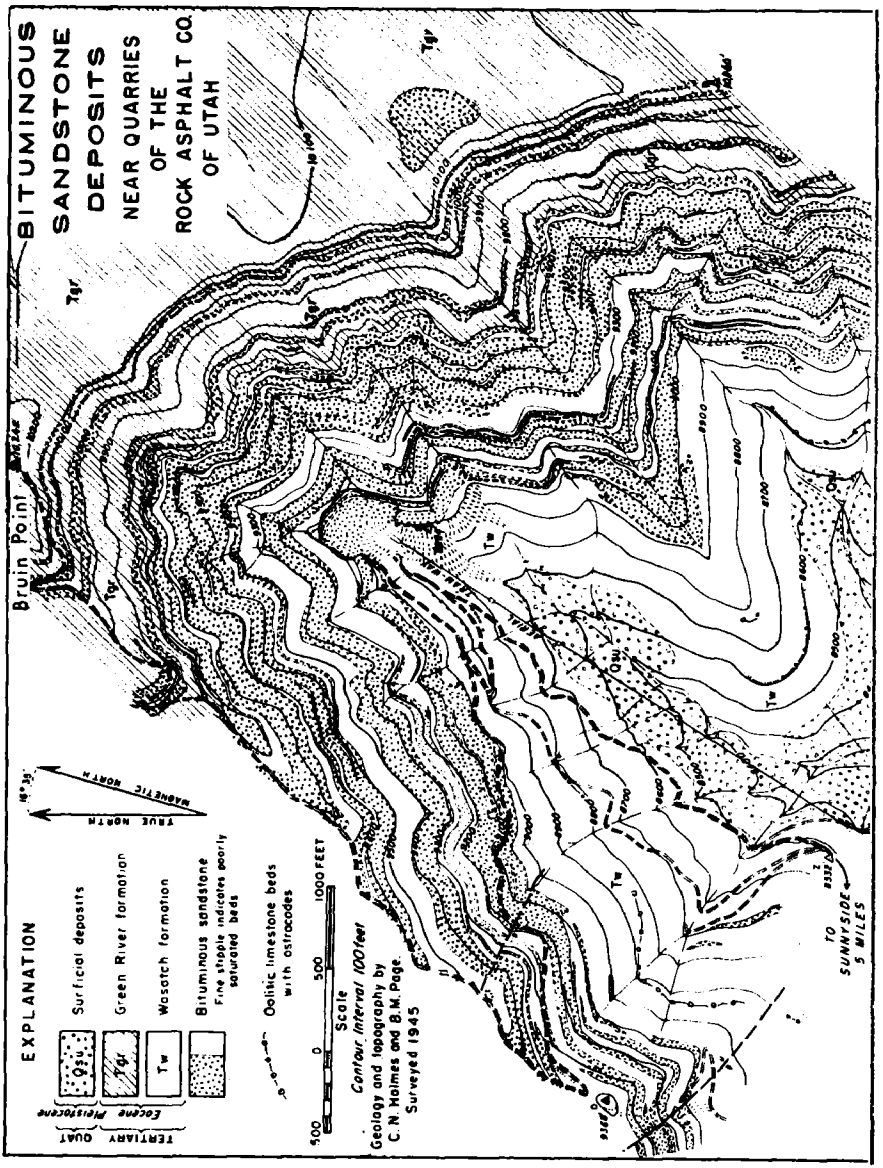


Figure 8, Mile 104.3, Day 1, Stop 10 (optional), (Mile 10.7, Side Trip to Whitmore Canyon-Bruin Point).

Stratigraphy and distribution of Sunnyside tar sands below Bruin Point. (Map reproduced from Holmes and Page, 1956, fig. 1, p. 172, I.A.P.G. 7th Ann. Field Conf. Guidebook; originally published as fig. 1, U.S.G.S. Oil and Gas Inv. Prel. Map. 86, 1948).

Shale Valley, features of the east side of the San Rafael Swell are evident with Cedar Mountain, about 20 miles away, dominating to the SSW. Further west, about 35-45 miles, the Wasatch Plateau is visible in the distance facing the Castle Valley (2 to 4 o'clock).

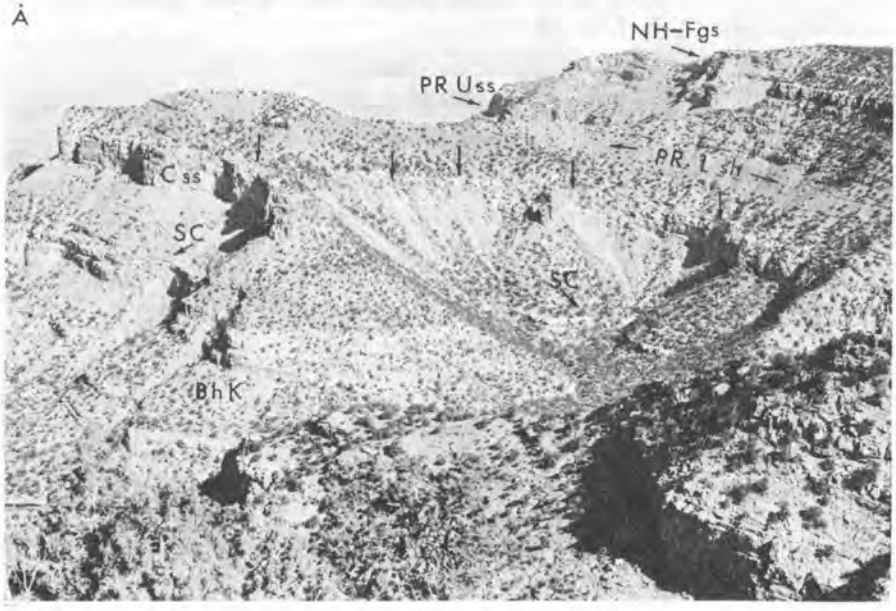
113.8	4.6	Junction with Horse Canyon and Geneva Mine road ahead. Continue straight ahead into Horse Canyon. Thick coal on cliff at 2 o'clock is Sunnyside seam. We return to this junction after visiting Horse Canyon and Lila Point.
114.7	0.9	Geneva Mine, U.S. Steel, Western District Coal. *Park Bus.* STOP 11, 1975, HORSE CANYON AND LILA POINT. Participants board shuttle vehicles for trip up Horse Canyon to Lila Point. For this, see log page 38, for SIDE TRIP TO HORSE CANYON & LILA POINT following end of First Day Road Log (Mile 162.7, page 35) and following logs of COAL CREEK and WHITMORE CANYON SIDE TRIPS.
		Reboard bus to continue south.
114.9	0.2	Steel bridge across creek.
115.1	0.2	Tipple.
115.5	0.4	Junction with Utah State Road 124 southwest to U.S. Highway 6 and 50 and north to East Carbon City and Sunnyside. Turn left (south) across coal-dump fill and continue up onto pediment surface.
115.9	0.4	High point on road. Start down long pediment surface which descends 900' (270 m) from about 6200' (1880 m) el. in a graceful flattening curve from the Book Cliffs, through juniper scrub, out onto and even across the Mancos (Blue Gate Shale) valley as a broad, alluvial fan. Lila Point above to left; Sunnyside Coal shows in cliffs to left.
116.2	0.3	Cattle guard.
117.7	1.5	View across the Mancos Shale subsequent valley around amphitheater-like reentrant in the Book Cliffs caused by the San Rafael Swell. The green Curtis Fm. (Jurassic) is at the base of the cliffs in the distance east of Cedar Mountain. The overlying red sequence is Jurassic age Summerville Fm. capped by a gypsum conglomerate and this is overlain by variegated Morrison Fm. which is capped by the early Cretaceous Buckhorn Conglomerate.
120.0	2.3	Junction Utah State Road 124 with U.S. Highway 6 and 50. Turn left (east).
121.1	1.1	Deep cuts through alluvial fan; descend into Mancos valley.

122.35	1.25	Milepost 270. Road built on Mancos Shale here (Blue Gate Member). Good view across valley ahead about 6.5 miles at 11-12 o'clock to faulted (graben) cliffs at Williams Draw. The highway at this point crosses faults trending about N 20° W. These are quite isolated examples of cross-faults to the more east-west orientation.
123.35	1.0	Milepost 271.
123.70	0.35	Bridge.
123.8	0.1	Trail to NNE and to RR. A major fault crosses here, part of the system trending about N 72° W which is exposed on the Book Cliffs as horst-graben structures to the ESE and as a series of parallel faults from 1 to 4 miles WNW of here.
124.4	0.6	Milepost 272.
125.3	0.9	Turn right (southwest) off U.S. 6 and 50 (0.1 mile north of Milepost 273). Low Mancos knob on right. Cross cattle guard. A major fault crosses the highway at this point. It is probably an extension of the main fault seen about 4 miles east and 1.5 miles south on the Book Cliffs scarp. Compare your USGS Map I-798, Woodside Quadrangle (near NE Cor., NE ¼, Sec. 18, R. 14 E, T. 17 S). Compare also with faults across center of Secs. 1-2-3, R.

Figures 9A, B, Mile 114.7, Day 1, Stop 11 (Mile 3.9, Side Trip to Lila Point).

9A. View from promontory below Lila Point looking NW across Horse Canyon at cliffs above Geneva Mine. Five unmarked arrows pointing down at top margin of Castlegate Ss ("Css") indicate location of some subsidence fractures through the Castlegate Sandstone from mine workings in Sunnyside Coal ("SC") 300 feet (91 m) below. Arrows marked "SC" point to two outcrops of Sunnyside Coal rather clearly exposed above whitecap of Middle Sandstone (Sunnyside) Member of Blackhawk Fm ("SM"). The Kenilworth Member ("Bn K"), below, is comprised of both shale (Middle Shale Member) above, and sandstone (Kenilworth) below. "PR L sh"—Price River Fm, Lower Shale Member of Fisher, Erdmann, and Reeside (1960); "PR Uss"—Price River Fm., Upper Sandstone Member; "NH-Fgs"—North Horn—Flagstaff undivided.

9B. View WNW across mouth of Horse Canyon showing profile of Book Cliffs from promontory west of road, about 500' (150 m) below Lila Point. Tipple of Geneva Mine at bend in Carbon County RR in left center. Conveyer belt below "M." The 160' (48 m) thick Castlegate Sandstone Member ("Css") of the Price River Fm. caps the cliff at right The Sunnyside Coal ("SC") is near the base of the Blackhawk Upper Shale Member ("Bh U sh") and lies almost directly upon the 100' (30 m) Middle Sandstone Member ("Bh M ss") (Young's Sunnyside Member) which has a conspicuous white-cap and forms a very prominent cliff. Below this cliff is the Middle Shale Member (upper part of Kenilworth sequence) overlying a 200' (60 m) zone of cliff-forming sandstones and some shale beds of the Lower Sandstone Member (lower part of Kenilworth sequence). The thin sandstone near the base ("A") may be equivalent to the Aberdeen Member further west. It appears to be separated from the Kenilworth by a thin tongue of Mancos Shale as well as overlying the main Mancos Shale exposed in the slopes below and in "The Cove" to the SW of Lila Point.


A
NH–Fgs
PR Uss
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B
W
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124
A
M

		13 E, T. 17 S and across center of Secs. 10-11-12, R. 14 E, T. 17 S.
125.4	0.1	Cross old highway segment.
125.8	0.4	Cross D.&R.G.W.R.R. double track and turn left. (High clearance required as east track is about one foot higher than west track.) Bus may park on east side of tracks and participants will be shuttled to STOP 12, 1975, SILVAGNI RANCH. Small wooden bridge 1 mile ahead will not support bus.
126.8	1.0	Turn right across small wooden bridge up dip-slope towards scarp of upper bench of Ferron Sandstone.
126.9	0.1	Electric transmission line. Some concretions showing on surface of dip-slope here. Keep in mind the position of these concretions as we proceed west and south through the Castle Valley the next two days and see the bench in which they occur gradually becomes the lowermost conspicuous sandstone or siltstone bench of the Ferron.
127.3	0.4	Curve to right (north) down through seaward silty zone of Ferron.
127.6	0.3	Lower part of main bench and thick middle bench making cuesta low in valley.
127.7	0.1	STOP 12, 1975. SILVAGNI RANCH SECTION.

STOP 12, 1975. Woodside Unit of Ferron Sandstone at Silvagni Ranch. SE 1/4, Sec. 24, T. 17 S, R. 13 E, Emery Co., Utah, Woodside Quad (15'), 1948.

DISCUSSION OF SEDIMENTARY FEATURES AND PALEOENVIRONMENTS.

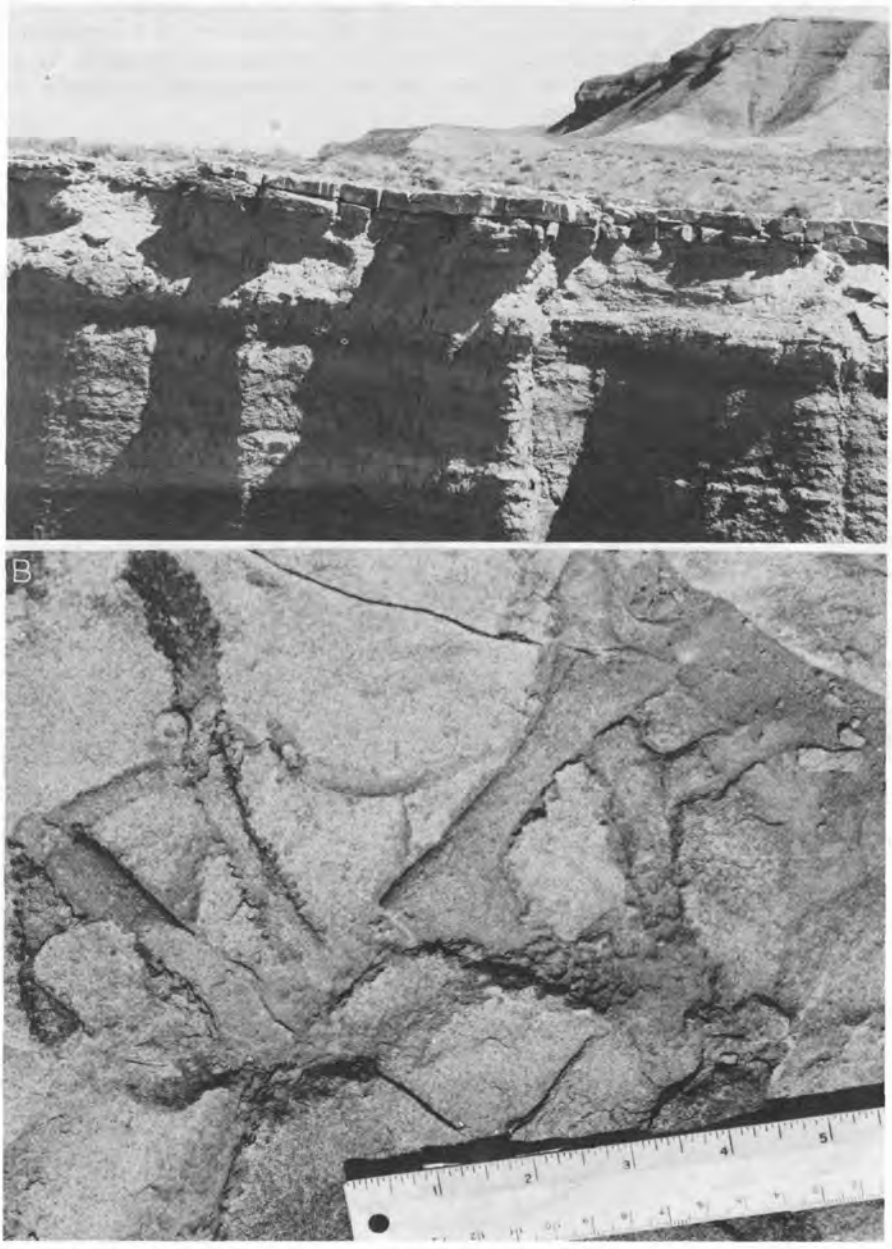
Edward Cotter

General orientation

This exposure of the Woodside unit near the Price River exhibits most of the typical characteristics of a remarkable sandstone. This unit is stratigraphically the oldest of the Castle Valley Ferron Sandstone units. Around the corner to the west the Dakota Sandstone can be seen to be several hundred feet below the Woodside unit, and toward the top of the dark slopes to the north are the remnants of the Washboard unit of the Ferron. The Woodside unit can be followed northwestward (approximately landward) below the Washboard unit to the vicinity of Grassy Trail Creek, about 10 miles (16.2 km) away, where the Woodside unit pinches out in typical bioturbated, dark gray Mancos Shale, such as is seen here above and below the sandstone. It can also be traced more than 15 miles (22 km) to the south.

Woodside unit characteristics

This sandstone is different from all other Ferron sandstones. It is medium- to coarse-grained quartz arenite that is moderately well sorted and has

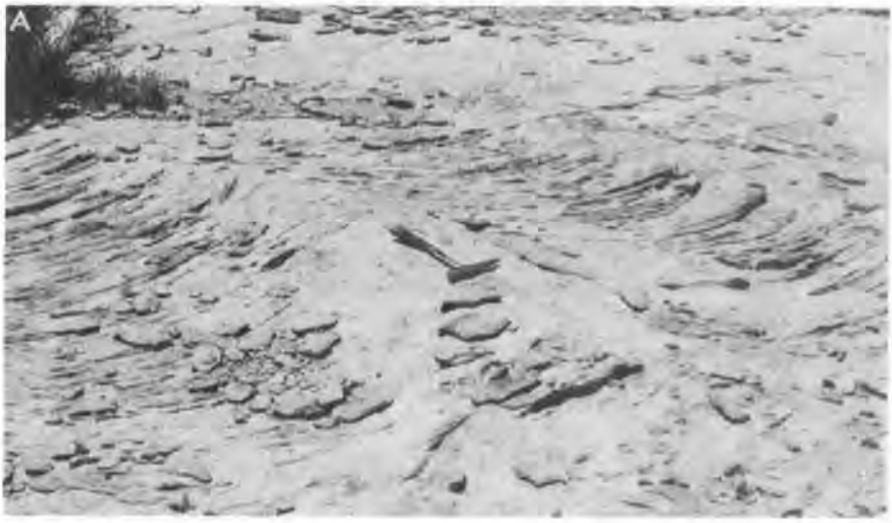


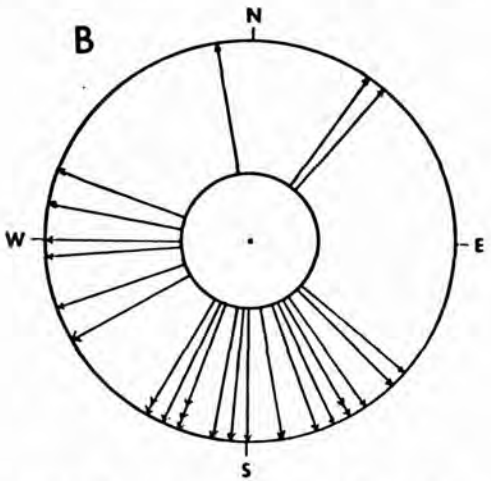
Figures 10A, B, Mile 127.7, Day 1, Stop 12, Silvagni Ranch Section.
10A. Lower Ferron Sandstone unit in foreground; main bench in background with Tununk Shale between. Lower sandstone shows a broad trough in laminated, coarse-grained sandstone surrounded by bioturbated sandstone (Cotter).
10B. *Thallassinoides* in the Woodside unit; exposed on dip surface (Cotter).

subrounded grains. Much of the unit is bioturbated by the activities of filter feeders, such as *Ophiomorpha* and *Thalassinoides,* but there is a significant amount of planar and trough cross lamination with bipolar, coast-parallel transport directions dominant. Parts of the unit have numerous mollusk shells in various stages of fragmentation.

Interpretation of depositional environment

During times of deposition of the dark gray Mancos Shale, the environment was seaward of and separated from the shoreface, and it was the site





Figures 11A, B, Mile 127.7, Day 1, Stop 12, Silvagni Ranch Section.
11A. Typical trough cross lamination expressed on dip surface of the Woodside unit; hammer handle points in direction of flow (Cotter).
11B. Axes of sediment transport directions (Cotter).

of low-energy mud sedimentation and the postdepositional activity of deposit feeders. For the accumulation of the sandstone there developed higher energy conditions such that medium to coarse sand could be moved as dune bed forms by traction currents that reached even to the transition with the upper flow regime. During much of the time of sand accumulation, robust filter-feeding organisms found the environment hospitable, so there must have been sufficient current activity to bring nutrients and to prevent mud deposition.

The Woodside unit must have been formed in submerged offshore marine sandbars in a shallow shelf sea. Source of the sediment is conjectural, but most likely it came from the Vernal Delta complex to the north and northeast. Transportation energy probably came from storms, but the influence of tides cannot be ruled out.

Features at this location

In addition to the general compositional and textural characteristics, one can see the typical physical and biogenic structures of the Woodside unit. South of the road there are various examples of cross lamination and the burrows of filter feeders. North of the road the extensive dip surface on the sandstone shows numerous arcuate patterns of laminae filling troughs (Fig. 11A). The axes of these patterns are significant indicators of sediment transport directions. A number of transverse cross sections of troughs can be seen in the small outcrop reentrants north of the road. In the small reentrant west of the parking site are numerous mollusks in place and in darker brown blocks littering the slope.

129.7	2.0	Return to buses at R.R. crossing via shuttle.
130.2	0.5	Jct. Silvagni Ranch road with U.S. Highway 6 and 50. STOP 12-A (OPTIONAL). FAULTS IN BOOK CLIFFS. (See note concerning faults Mile 125.3 & 122.35.) If time permits we will stop briefly for discussion of this fault system and its relation to coal near outcrop. Refer to Map I-798. *Expected Mining Conditions Based on Geologic Parameters.* As we proceed northwestward, follow the U.S.G.S. Map I-798 and observe horst-graben structures and fault cluster reentrants in west facing scarp of Book Cliffs.
131.1	0.9	Milepost 272.
131.7	0.6	Trails to NE and SW to R.R. Major fault system crosses Mancos valley here. It is well displayed in the Ferron and Lower Cretaceous Buckhorn Conglomerate 1.5-3.0 miles west.
131.8	0.1	Bridge.
132.15	0.35	Milepost 271. Approaching major pediment scarp capping Blue Gate Shale.
134.30	2.15	Face of Mancos (Blue Gate Shale) scarp below Pediment.
135.6	1.3	Junction, Horse Canyon Road, Utah 124, to northeast

and short spur (1.9 miles) going southwest to D.&R.G. W.R.R. watering station at Cedar. Ferron Sandstone and lower Mancos (Tununk) shale not as well exposed in continuous profile sections at outcrops around Cedar.

136.1 0.5 Sign "Price 25 miles."
Approximately at this place the trace of a major fault extending eastward from its good exposure about 1.3 mi WSW, where lateral displacement of Ferron Sandstone, Dakota, Cedar Mountain, and Buckhorn Conglomerate Formations (Cretaceous) may exceed 2000' (610 m). This may be an extension westward of the graben north of Williams Draw in the Book Cliffs, 6.5-7.5 miles east, or even the major fault at Williams Draw (through center Secs. 34, 35, 36 and eastward, T. 16 S, R. 14 E, Woodside 1/48,000 Quadrangle).

This could also curve to the north but this is less likely.

140.8 4.7 Bridge over a west branch of Icelander Wash.

142.1 1.3 Cross Emery-Carbon Co. line into Carbon County.

147.2 5.1 Cross D.&R.G.W.R.R. spur to Sunnyside.
Good view point to Farnham Dome to the northwest.

147.8 0.6 Junction of Utah State Road 123 to Sunnyside to east. Continue principally west on U.S. Highway 6 and 50.

147.9 0.1 Bridge over Grassy Trail Creek.

149.6 1.7 Junction road to north into Clark Valley across broad flats of Mancos shale. Book Cliffs and the Roan Cliffs, of Tertiary ages, behind them, well exposed to north.

149.9 0.3 Road cuts in Mancos Shale.

150.4 0.5 Milepost 254. Escarpment of Ferron Sandstone on right (north).

150.9 0.5 Trail to south. This road leads to "Mounds Junction" on the D.&R.G.W.R.R. and crosses the Ferron Ss. escarpment to the south from 6.9-7.3 miles from U.S. Highway 6 and 50. The road extends along the rim of this cuesta for nearly 2 miles, passing through fields of densely scattered concretions in the upper surface of the main bench of the Ferron Sandstone. Some of these concretions 10' (3 m) in diameter.

Two miles south of the highway, along this road, is the Equity Oil Co. Mounds #3 well, which is one of 4 wells here on the Farnham Dome producing CO_2 from the Navajo Sandstone at about 2700' (825 m). This carbon dioxide gas is piped to Wellington for manufacturing dry ice and carbonic gas. (See BYU 1974, Mile 62.5, p. 38-39, and Mile 67.9 and Text-fig. 27, p. 40-41.)

151.4 0.5 Milepost 253. Junction of jeep trail to south into center of Cedar Mountain Fm. exposures (oldest exposed rocks).

151.7 0.3 Broad Tununk Shale valley to south with Dakota bordering on east and Ferron Sandstone (lower bench) forming cliff at top of 385' (112 m) shale section.

152.2 0.5 STOP 13, 1975. FARNHAM DOME SECTION. Pull off on short gravel flat on right (north) about 0.1 mile east of bold east facing scarp of Ferron Sandstone above the Mancos (Tununk Member) Shale.

We will walk through this section uphill to the west, 0.4 mile, and board the bus at the top of this section, at the contact of the Blue Gate above the sandstone.

STOP 13, 1975, FARNHAM DOME SECTION

Day 1, Mile 152.2

Farnham Unit of Ferron Sandstone, West Side Farnham Dome at U.S. Highway 6 and 50. NW cor., SW ¼, Sec. 1 and across E Center, Sec. 2., T. 15 S, R. 11 E, Carbon Co., Utah, Wellington 15' Quadrangle.

Edward Cotter and Aureal Cross

General orientation

In the northern part of the Castle Valley the Ferron Sandstone Member of the Mancos Shale is a composite of several very thin sandstone units whose sediment was derived from the Vernal Delta system located generally north and northwest of Castle Valley. This faulted highwayside outcrop of the Ferron exhibits two of these units: the Farnham unit (above) and the Washboard unit. The Washboard unit will be examined tomorrow (Saturday, October 18, 1975) in its more typical expression at Stop 17, near the Washboard Wash locality which is 7.8 miles S of Wellington but is inaccessible by bus. It is the Farnham unit that will be closely examined here. The Farnham unit crops out over only a limited part of the Ferron Sandstone outcrop belt on the west side of the Farnham Dome. It is enclosed within parts of the laterally much more exensive Washboard unit.

Farnham unit characteristics

Above a sharp base, the Farnham unit consists of less than 25 feet of very fine to fine-grained sandstone that has moderately sorted, subangular grains. Mollusk shells are very abundant, most of them fragmented, but with some whole valves in clusters. The unit is cross laminated throughout. Many bases of the sets and some of the laminae are lined by shell fragments. Current transport directions were bipolar, with a moderate spread in the NW and SE quadrants. Some outcrops exhibit a subtle lateral inclination of major bedding surfaces to the southwest. The only common biogenic structure is protrusive *Teichichnus,* seen in most outcrops, although the uppermost foot of the unit might have *Ophiomorpha, Thalassinoides,* and/or retrusive *Teichichnus.*

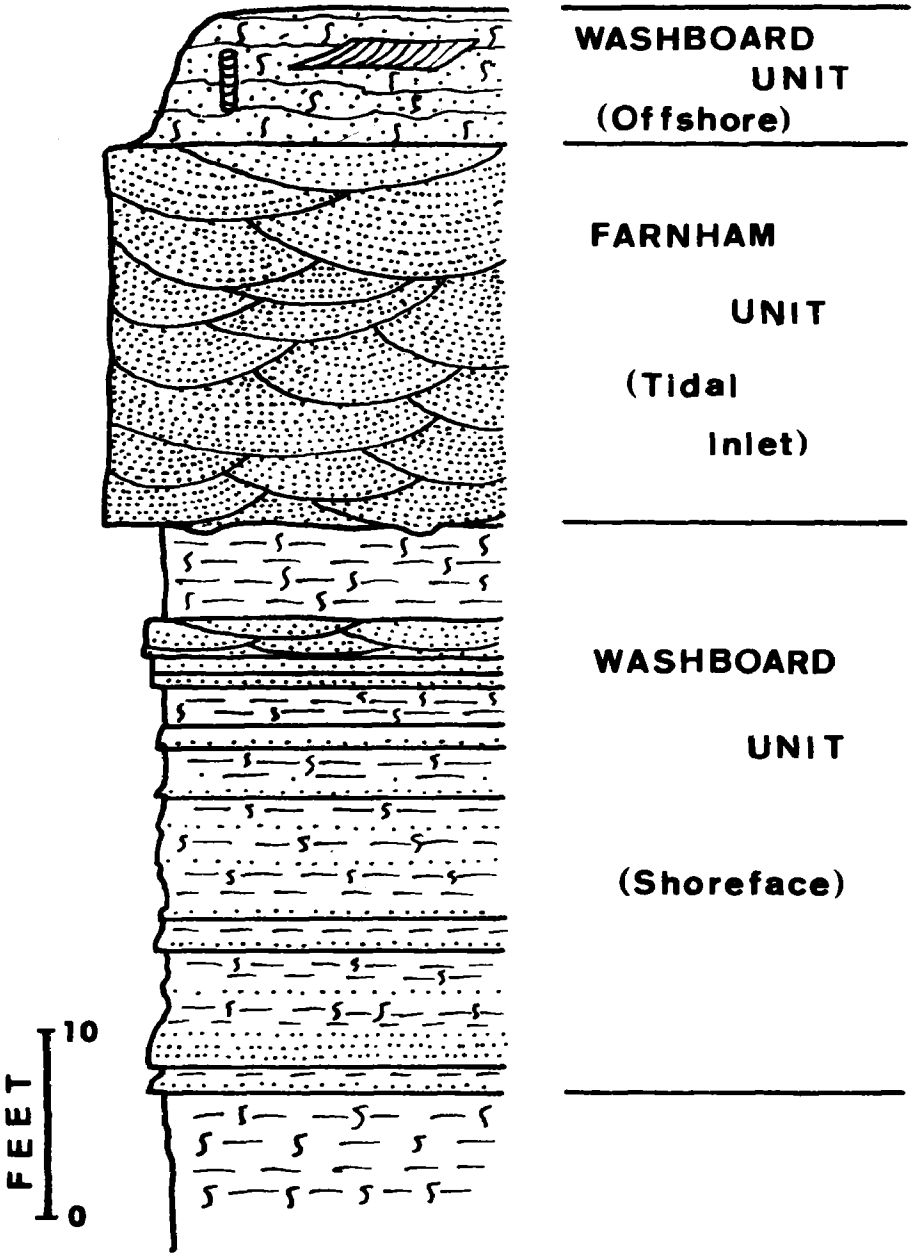
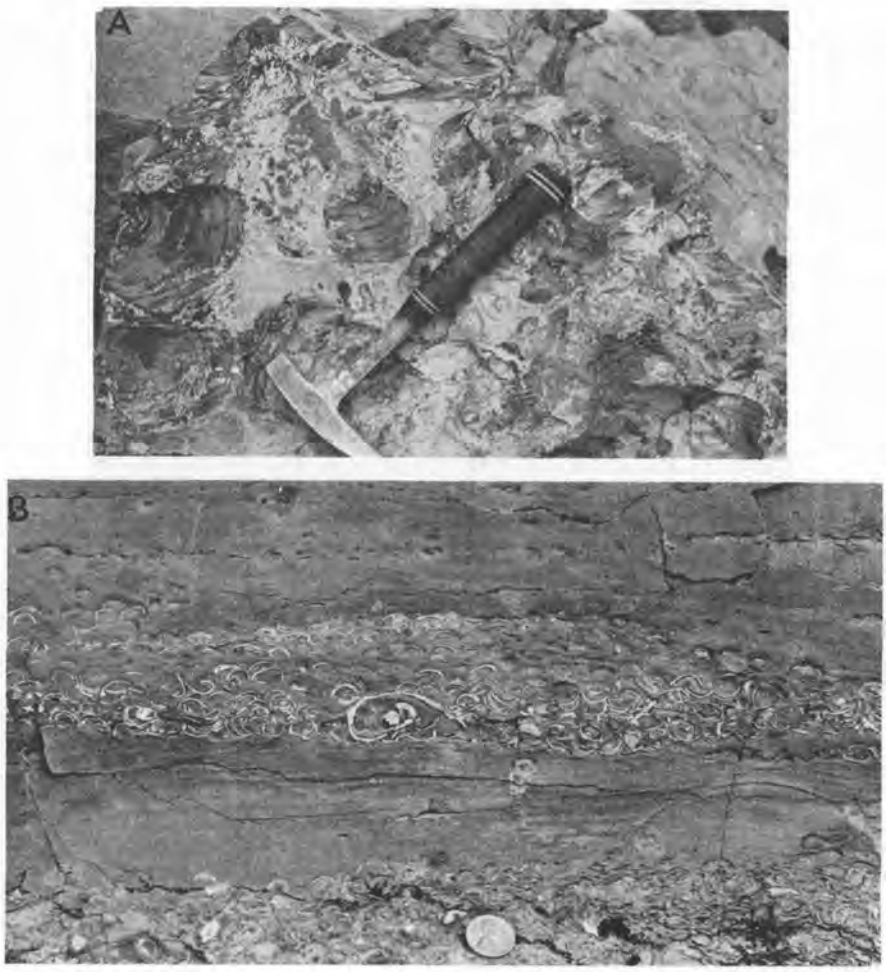


Figure 12, Mile 152.2, Day 1, Stop 13, Farnham Dome Section.
Diagrammatic representation of sedimentary features of three units of Ferron sequence at Farnham Dome (Cotter).



Figures 13A, B, Mile 152.2, Day 1, Stop 13, Farnham Dome Section.
13A. Large mollusks on surface of slab at western end of exposure along north side of U.S. Highway 6 and 50 (Cotter).
13B. Mollusks in various sages of fragmentation concentrated by current flow in Farnham unit of Ferron Sandstone (Cotter).

Interpretation of depositional environment

The Farnham unit has all the essential features of a tidal inlet deposit that cuts down partway into the shoreface deposits of the Washboard unit. It is covered by offshore to shoreface deposits developed during subsequent transgression.

Others have interpreted the sandstones in the Farnham Unit here as barrier beach deposits. Both the invertebrates and the dinoflagellates indicate nearshore marine conditions.

The top seems to be relatively abrupt or truncated by later transgression. This should be examined.

Features at this location

Most of the features typical of the Farnham unit can be seen at this stop, except that biogenic structures are less common, and lateral inclination of major bedding surfaces cannot be seen. The best place to start is at the west end of the outcrop on the north side of the highway, where large and small shells, trough cross lamination, and the sharp base of the unit are well displayed. A cluster of mollucs occurs in the Farnham unit on the south side of the road opposite; examples of these can be seen in the large fallen blocks. About two-thirds of the way from west to east in the outcrop, small side canyon drainage has exposed trough cross lamination and clusters of fossils, whole and fragmented. The Washboard unit below the Farnham unit exhibits lower shoreface characteristics, particularly the parallel-to-burrowed structures of Howard.

Structure

The Farnham Dome is a surface structure that has been shown by Peterson (Peterson, V. E., 1954, I.A.P.G. Guidebook, pp. 86-88) to be located on the northward-plunging axis of the San Rafael Swell. Several relatively large faults traverse the structure in a NNE-SSW direction. Two closely spaced faults are evident in the section which we are studying exposed along U.S. Highway 6-50 resulting in the Ferron Sandstone Member, Farnham Unit, being repeated there. There are also at least two smaller faults that cut the structure more or less transversely, east and west. One of these is conspicuous on the north side of the highway nearly directly opposite the trail to south at Mile 150.9. There the Ferron is offset several hundred feet in an east-west direction.

Peterson showed the main NNE-SSW faults to be low-angle thrust faults with the hade in at least one place to be as much as 60°. These are part of the system of faults occurring on the northwest side of the San Rafael Anticline. The part of the structure generally referred to as the "Dome" is interpreted as "a tightly-folded and overturned lip of the hanging wall of an overthrust up on the true anticlinal portion of the structure to the southeast."

Test wells drilled into the crest of the "dome" intersect the sole plate of the overthrust at about 1,100' (335 m) and penetrate the Buckhorn Conglomerate in a normal anticlinal section below.

The Tununk and Lower Blue Gate Shale Members

The Tununk Shale is 385' (112 m) thick and has many siltstone stringers and a number of calcareous silty fossiliferous layers.

The *Gryphaea newberryi* zone is at 39-42' (about 12 m) above the base and there are additional concretionary limestone or siltstone zones at 120' (37 m), at 165' (50 m), and 171' (52 m). There are conspicuous, thin, weak, bench-forming layers of siltstones or fine sandstone, usually several beds in 10' to 30' (3-9 m) as at 25-30' (7-9 m), 47-55' (14-17 m), 200-240' (60-72 m), and 258-275' (78-82 m). This indicates offshore storm current sweeping of sands and silts in an area of long shore currents with adequate supply, probably from a delta system. They very likely are simply advance sweeps of sediment from a prograding delta to the north or northwest

which eventually reached within a few miles of this locality as the Ferron sands.

The number of layers of limestone concretions is probably not significant; 93-95' (29 m), 99-100' (30 m), 120' (37 m), 160' (49 m), 172' (52 m), and an especially good layer 197-199' (60 m).

In the Blue Gate Shale overlying the Ferron Sandstone Member there are some excellent concretion zones, some concretions as large as 4' (1.2 m) in diameter; some relatively pure limestone, e.g., at 199-202' (160 m) above the base of the Ferron Sandstone; and some more sandy, e.g., at 247-255' (75 m). One particularly noteworthy layer is the algal biscuit zone at 170-178' (51-52 m) above the base of the Ferron Sandstone northwest of the exposures along the highway. One of these is illustrated in the paper on "Algae in the Cretaceous and Tertiary of the Northwestern Colorado Plateau," *Geology Studies* 22, Part 3, December 1975.

152.6	0.4	West end of road cuts at top of Farnham Unit of Ferron Sandstone. Blue Gate Shale above. Bus may not be able to pull completely off highway here onto wide area so we may be required to board in a hurry!
153.1	0.5	Blue Gate Shale has some very sandy zones, including a strong bench at about 250' above the base of the Ferron. These show up in the highway cuts as we descend the hill on the west flank of the Farnham Dome.
154.3	1.2	Soldier Creek bridge.
154.5	0.2	Junction Utah State Road 53 to Myton, one of the important Gilsonite areas.
154.8	0.3	Road junction, Coal Creek road to north.
155.1	0.3	Coal Creek bridge.
156.8	1.7	Wellington City Park.
162.6	5.8	Crest of hill at east edge of Price. Green Well Motel.
162.7	0.1	Mission Motel.

END. PART I. GSA 1975 ROAD LOG.

SIDE TRIP. STOPS 8 AND 8 A (OPTIONAL)

Day 1, Mile 85.9

(BYU 1974, MILE 64.5) UP COAL CANYON (EAST OF WELLINGTON) FOR REGIONAL VIEW OF BOOK CLIFFS AND BARRIER BEACHES IN ABERDEEN MEMBER, BLACKHAWK FM.

(Bridges will not support bus.)

Coal Creek road to north junctions with U.S. Highway 6 and 50, 2 miles east of Wellington City Park, and 0.2 mile east of Coal Creek bridge, and 0.2 mile west of junction of Utah secondary road 53 to Myton (between Mile 64.3 [Coal Creek bridge] and Mile 64.65 in BYU

1974 Guidebook, p. 39). Hardsurfaced road is not in good repair beyond mile 3.2 north of highway. Road goes to Book Cliffs across west center of T. 14 and 13 S, R. 11 E, Carbon Co., Utah, Wellington 15' Quadrangle.

Cumulative	*Interval*	
0.0	.0	Junction of U.S. 6 and 50 with Coal Creek Road at service station.
1.3	1.3	Wash.
2.5	1.2	Cross narrow steel bridge over Coal Creek.
3.2	0.7	Junction. Take the less improved road to the right (north).
3.4	0.2	Cattle guard.
4.9	1.5	Small wooden bridge.
5.7	0.8	Excellent view of the Book Cliffs to the north. These cliffs trend nearly east-west. Units exposed are essentially the same as those to be seen along Book Cliffs scarp northwest of Helper except that two higher members can now be separated from the undivided Blackhawk. Four or five levels of gravel-covered pediments are developed in the Mancos Shale.
7.3	1.6	Section of the Mancos Shale. The Mancos dips four or five degrees to the north so that we proceed upsection. The total thickness of the Mancos in this region is nearly 5000' (1510 m).
7.5	0.2	Cattle guard.
7.8	0.3	STOP 8, 1975 (OPTIONAL)—Regional view of the Book Cliffs Sequence exposed in the cliffs includes the upper part of the Mancos Shale, the Star Point Formation and the Blackhawk Formation, with Castlegate Sandstone capping the higher promontories. The lowest sand stringer is the Panther Member of the Star Point Formation which grades laterally into and is not lithologically distinctive from the Mancos Shale a mile to the east. The Storrs Tongue still is represented by a thin, silty, hard layer recognizable from the Mancos only in fresh exposures. The first prominent sandstone ledges are those of the Spring Canyon Member of the Blackhawk. The Aberdeen Member is represented by a barrier beach facies completely replacing the coal facies of the member. The lowest very conspicuous white-capped sandstone on the cliffs is the uppermost sandstone bed of the Aberdeen. The second very conspicuous white-capped ledge (next above) is the basal Kenilworth Member. Locally the lower member of the Sunnyside Sandstone can be recognized. The burned zone is composed of Kenilworth and Sunnyside Members. Castlegate Sandstone remnants can be seen on the skyline.

8.0	0.2	Cross natural gas pipeline. Good view of the cliffs with the upsweeping pediments, 2 o'clock.
11.4	3.4	STOP 8A, 1975 (OPTIONAL)—View of the barrier beaches of the Aberdeen Member. Most of the units seen at the previous STOP 8 are visible from here. The massive-appearing siltstone near the road is the Panther Tongue. The overlying Storrs Tongue is not prominent. The first three sandstones are those of the Spring Canyon Member, and are poorly exposed. The Aberdeen Member, above a shale break, is composed of a thin, lower, brown sandstone and at least two, and in places three, thicker, white-capped sandstones interpreted to be a barrier beach complex. A fourth barrier beach sequence is exposed on the east side of the canyon, so that in this area there are four white-capped sands within the Aberdeen Member. A small shale break separates the basal sandstone of the Kenilworth from the barrier sequence. The coal-bearing sequence of the Aberdeen and Kenilworth seen in Price Canyon at Stop 7, mile 44.4, BYU 1974 Guidebook, is entirely replaced by sandstones of a barrier beach sequence.
22.8	11.4	Turn around. Return to U.S. Highway 6 and 50. Proceed east.

END SIDE TRIP COAL CANYON.

SIDE TRIP. STOP 10, 1975 (OPTIONAL)
UP WHITMORE CANYON TO BRUIN POINT ABOVE SUNNYSIDE
SUNNYSIDE TAR SANDS

Day 1, Mile 104.3

North and northeast from Sunnyside through the western half of T. 14 S, R. 14 E, Carbon Co., Utah. (Truck or 4-wheel drive vehicles only.)

MILEAGE		
Cumulative	*Interval*	
0.0	0.0	Kaiser Steel Co., Mine No. 3.
0.5	0.5	Junction. Continue straight ahead (north) between Castlegate Sandstone cliffs.
0.8	0.3	Bridge over Whitmore Creek. Price River sandstone ahead at 12 o'clock with North Horn (tree-covered slopes) above and capped by red fluvial Colton Fm. sands at top of cliffs.
1.1	0.3	Rodeo grounds on right. Canyon to east.
1.7	0.6	Top of Price River Fm. (low cliff to right).
1.8	0.1	Air intake for mine (right).
2.0	0.2	Vent for return air from mine.

2.5	0.5	Junction. Keep left. Approximate position of contact between the top of the Price River Fm. and base of North Horn Fm. Wasatch (Colton) above (red beds).
2.9	0.4	Base of tramway from Sunnyside tar sand quarries.
3.0	0.1	Junction: bear right up through North Horn Fm.
5.2	2.2	View of bituminous sandstones at 12 o'clock near skyline.
6.6	1.4	Quarries in Bituminous Tar Sands (Wasatch). Head of tramway.
8.8	2.2	Summit of Bruin Point. Looking west across Castle Valley from Bruin Point, Cedar Mountain is at midleft and San Rafael Swell is toward the south. Whitmore Canyon is in foreground and West Ridge lies across the canyon with variegated Wasatch (Colton) rocks exposed. The communication tower is at 10,285' (3140 m), the highest point in the Uinta Basin. Microwave tower belongs to Mountain Fuel Supply Co. Turn around and start descent toward Whitmore Canyon.
9.0	0.2	Bituminous sand on left. Road traverses contact of basal Green River and upper Wasatch (Colton). Several exposures of tar sands here.
9.9	0.9	Viewpoint of Sunnyside Tar Sands across canyon as you go around turn.
10.7	0.8	STOP 10, 1975 (OPTIONAL). SUNNYSIDE TAR SANDS. This is one of the largest deposits of bituminous sandstone in the United States. The bitumen-bearing sandstones are in the upper Wasatch (fluvial) and lower Green River (lacustrine). The lenticularity and extremely porous nature of the Wasatch fluvial sandstones has allowed high percentage of bitumen accumulation by weight. Most commercial grades of bituminous sandstone contain greater than 9 percent bitumen, by weight. The source beds are thought to be the Green River Shales.
14.7	3.7	Junction of road in Whitmore Canyon; bear left. New mine intake across Whitmore Canyon on right.
17.8	3.1	Kaiser No. 3 mine, Sunnyside.

END SIDE TRIP UP WHITMORE CANYON TO BRUIN POINT.

Day 1, Mile 114.7

SIDE TRIP. STOP 11, 1975
UP HORSE CANYON TO LILA POINT
ENGINEERING GEOLOGY, FAULTING, SUBSIDENCE OF SUNNYSIDE COAL AND OVERLYING ROCKS.

Eastward from Center, W side, Sec. 4 across Sec. 3, into W Center Sec. 2, thence WSW to S Center, Sec. 3 to

Lila Point in SE ¼, SW ¼, Sec. 3, T. 16 S, R. 14 E, Emery Co. Utah, Woodside Quad., 1/48000.

Note: Road log prepared from field notes by Aureal T. Cross and E. Blair Maxfield.

MILEAGE *Cumulative*	*Interval*	
0.0	0.0	Office & yard of Geneva Mine, U.S. Steel Co. Keep left between buildings and creek.
0.2	0.2	Junction. Keep left along lower road.
0.35	0.15	Portal. Overhead tram. Sunnyside coal seam exposed up on cliff at mouth of portal across creek (NW).
0.4	0.05	Exposure of upper part of main bench and a small roof seam on right. This coal sampled as part of Cross' palynology report.
0.5	0.1	*Historical Tree* (enclosed by fence across creek). Carving on blaze "Sam Gilson by God 1878." Ninety-seven years growth and still not much larger than when carved by the early explorer of Uinta hydrocarbons and coals.
0.95	0.45	Junction. Take road to right (Little Park, 7 mi; Williams Draw, 10 mi; Lower Range Creek, 23 mi)
1.0	0.05	Cattleguard.
3.55	2.55	Excellent view to SW toward San Rafael Swell and Cedar Mt., with broad pediment sloping at decreasing angle in distance away from cliffs below Lila Point. Headward erosion of valley into Mancos Shale below pediment cap exposes several hundred feet of Mancos Shale. Road to SW to U.S. Highway 6 and 50 winds down pediment through juniper-pinyon forest.
3.9	0.35	STOP 11, 1975. LILA POINT. SUBSIDENCE FEATURES AND FAULTING El. 8034 feet (2425 m). View to W and NW down to tipple, conveyor belt, and mine in Horse Canyon. Observation of subsidence cracks in cliffs above mine workings. Comparison of regional fault patterns of San Rafael Swell and Book Cliffs escarpment with faulting, tension cracks, etc., in mines. Use U.S.G.S. Map I-704, by Richard Dunrud and Barton Barnes (1972), and U.S.G.S. Map I-798, by Frank Osterwald and John Maberry (1974). Turn around and descend hill to Horse Canyon.
6.7	2.8	Cattleguard at base of hill.
6.75	0.05	Junction. Keep left.
7.20	0.45	Historic tree.

7.3	0.1	Top of Sunnyside Coal on left. Good view of coal at portal and down canyon.
7.35	0.05	Overhead tram to portal.
7.65	0.3	Cross RR track into mine yard.

END SIDE TRIP TO HORSE CANYON-LILA POINT.

SECOND DAY ROAD LOG
PART II
WESTERN BOOK CLIFFS - CASTLE VALLEY
PRICE, HELPER, SPRING CANYON, GENTILE WASH, CLEVELAND-ELMO AREA, HUNTINGTON CANYON, CASTLE DALE, STRAIGHT CANYON AND RETURN TO PRICE

Note: Log prepared from field notes by Aureal T. Cross, Christopher C. Cross, Edward Cotter, and E. Blair Maxfield and from writeups in Spring Canyon area from Bulletin 80, Utah Geol. & Min. Sur. 1966.

0.0	0.0	Price, Utah. Junction U.S. Highway 6 and 50 and Utah State Road 10 southwest through Castle Valley. Continue west to Helper on 6 and 50. For interval to Helper use Road Log BYU 1974, miles 55.4 to 47.6, p. 37-35, and GSA 1975 Part I-B, miles 76.8 to 68.9, p. 21, in reverse.
7.9	7.9	Turn left (west) onto North Main Street into north Helper from U.S. Highway 6 and 50 at stoplight. Continue on North Main Street about 2 blocks.
8.1	0.2	Roosevelt Street. Turn left, south, off North Main Street onto Roosevelt and continue south to Canyon Street.
8.3	0.2	Canyon Street. Turn left (east) one block to Duchesne Street.
8.35	0.05	Duchesne Street. Turn right and continue south (*uphill*). Duchesne becomes Reservoir Street. Continue on up to top of pediment.

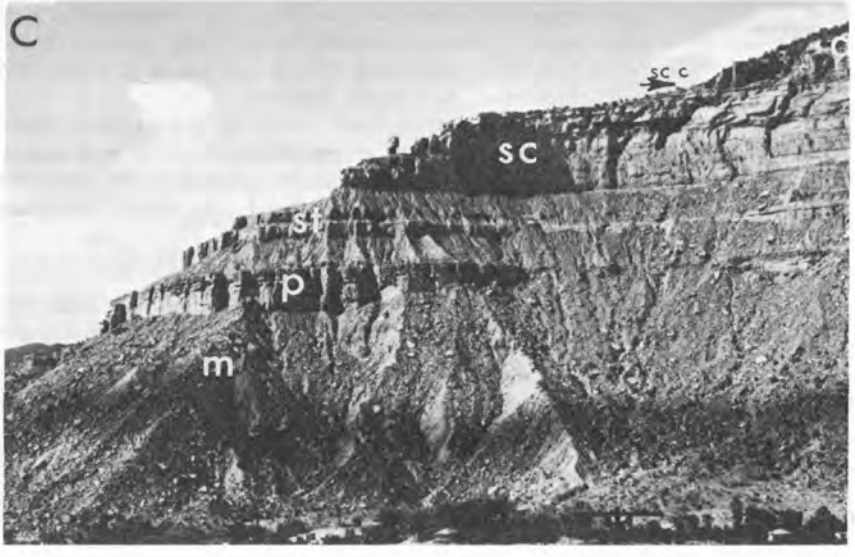
Figure 14A, Mile 12.3, Day 2, Spring Canyon, Storrs Jct., Sowbelly Gulch (Stop 15 ahead).
Panther Sandstone Tongue ("P") channel or bar. First conspicuous white-cap ss above is Spring Canyon ("SC"). The massive sandstone capping the sequence (left center) is Aberdeen.

Figure 14B, Mile 13.1, Day 2, Stop 15, Sowbelly Gulch.
Panther Ss Tongue ("P") is massive bar (or channel) sandstone here.

Figure 14C, Mile 8.95, Day 2, Helper Face.
Western Book Cliffs—NE Wasatch Plateau exposed above Helper as viewed from Reservoir Hill SE of Helper. "m"—Mancos (Masuk Member) Shale; "p"—Panther Ss. Tongue (Star Point Fm.); "St"—Storrs Ss Tongue (Star Point Fm.); "sc"—Spring Canyon Ss Member of Star Point Formation (Blackhawk Fm. of Young); "scc"—Spring Canyon Coal at top of Sc Ss, more coal here than to the NW where we saw it; see Figure 5B; "a"—Aberdeen Ss. Price River Canyon is at left.


A
SC
P


B
SC
P


C
SC C
SC
S
P
m

8.9 0.55 End of pavement (at private drive) turn right on gravel street and pull up onto gravel flat on right to park. (This will be a one-block loop to get back to Reservoir Street.)

8.95 0.05 STOP 14, 1975. HELPER FACE OF WESTERN BOOK CLIFFS. Walk up onto promontory near reservoir.

Panorama of Star Point and Blackhawk Formations. Panther Sandstone forms the basal cliff around the amphitheater. To the north directly above Helper, the thin stratified eastern facies of the Panther, similar to that seen in the type locality, can be seen above the gray Mancos slopes. As the unit is traced eastward along the Helper face, the sandstones near the top become thinner until finally, to the northeast where the Panther disappears over the skyline, only a few thin sandstone units are present and the member is dominantly a silt facies. The Storrs Sandstone, which is the upper member of the Star Point Formation,[1] forms prominent stratified sandstone exposures in Spring Canyon, similar to the type of the Panther Member. As the Storrs is traced across the Helper face, the siltiness becomes evident, so that ultimately in eastern exposures, the Storrs is almost entirely silty shale, with poor expression on the cliff face.

Some of the most prominent and rapid facies changes are seen in sandstones of the Spring Canyon Member. In the type locality, the Spring Canyon Sandstone is easily divisible into units which, when traced eastward, become more massive and appear to merge into one or two major units at the western edge of the Helper face. When these units are traced eastward along the face, however, they pass laterally into several stratified units interbedded with shale until in the easternmost exposure the massive character is lost. The coalescing Spring Canyon sandstones have been interpreted as a beach complex.

The Aberdeen Sandstone shows the same type of facies pattern as that observed in the Spring Canyon unit further to the west. As the Aberdeen Member is traced eastward, it passes into a beach complex, much like that in the Spring Canyon Member in the Helper face.

Reboard bus. Bus pull-on around small block.

9.0 0.05 Turn left down Reservoir Street (which becomes Duchesne Street), cross Hill Street and turn left on Canyon Street.

9.55 0.55 Canyon Street. Continue west about 3 short blocks to Bryner Street, just beyond small bridge over creek.

9.7 0.15 Bryner Street. Bear left onto road up *Spring Canyon.*

[1]Young (1955) redefined the Blackhawk to include the Spring Canyon; others still include Spring Canyon Sandstone in the Star Point Fm.

10.0 0.3 New housing community. Most of the houses were moved here this past year from the old town of Castlegate, which has been completely dismantled.

10.7 0.7 Underpass beneath Utah Railroad. The high bluff to the southwest is capped by the Panther Sandstone which also forms the first major sandstone in the cliffs on the north side of the canyon. To the north, Mancos Shale is exposed at the base of the bluff capped by the Panther Sandstone. Above this the Blackhawk sequence is well exposed, particularly the massive sandstones of the Spring Canyon Member and the overlying Aberdeen Member. In both of these units the white-capped sandstones are prominent.

11.8 1.1 Old stone buildings on right.

12.3 0.5 Panther Sandstone conspicuous on right (north) about 100' above and ahead on left side.

Cross railroad tracks. The sand immediately above is the Panther Sandstone Tongue overlain by the Storrs Sandstone, both in the Star Point Formation. The Blackhawk Formation forms the cliff, in which are developed two prominent white sandstones: the lower is the Spring Canyon Sandstone; the upper is the massive Aberdeen Sandstone.

12.5 0.2 Canyon to right (NW).

12.7 0.2 Mancos Shale (Masuk Member) on right for 0.1 mile.

13.1 0.4 STOP 15, 1975. SOWBELLY GULCH: BARS OR CHANNELS? Junction Sowbelly Gulch to right. Spring Canyon Road turns left across small bridge. NO TRESPASSING sign recently put up by Braztah Corporation.

Abandoned tipple at the townsite of Storrs. At this stop the Panther Sandstone shows two strikingly different facies. The easternmost exposure consists of stratified units dipping gently to the east, similar to those to be examined at the next stop at the type section in Price River Canyon. Directly to the north, the Panther Sandstone consists of a massive sand with little stratification. The stratified eastern facies has been interpreted as a beach slope. The massive western facies may be channel or bar sands. Above the Panther Sandstone there is a small outcrop where the Storrs can be seen in the profile to the east, followed by the entire Spring Canyon sequence and the massive white-capped basal Aberdeen Sandstone of the Blackhawk Formation.

This massive sandstone has more recently been interpreted as a channel cutting into foreset beds.

14.0 0.9 STOP 15A, 1975 (OPTIONAL). TYPE AREA SPRING

CANYON MEMBER. Site of abandoned loading yard and tipple for Spring Canyon No. 7 mine.

The Panther Sandstone at this stop shows two distinct facies. The eastern exposure consists of a rather massive unit with thick undulatory bedding, which grades laterally to the west into the typical, well-stratified, gently inclined layers of the Panther. The stratification in the Panther in this particular section, however, is inclined to the west, or what has been interpreted as toward the lagoon. Within Spring Canyon at STOPS 15 and 15A the Panther Sandstone consists of the three distinct facies. The easternmost facies seen at STOP 15 consists of stratified units dipping to the east. This complex has been interpreted as a barrier bar trending northeast-southwest, with beach-slope stratification dipping towards the deeper parts of the offshore region to the east and lagoonal-face stratification dipping to the west. There is some suggestion that the overlying units in the Blackhawk Formation follow this same basic sedimentary pattern of a central bar, an offshore facies, and a lagoonal facies, although the sedimentary structures in the overlying Blackhawk units are not as well expressed as in the Panther sand. No coal occurs above the Panther at this locality, but it is possible that coal may be found to the west, on the basis of patterns of sedimentation which are found in the Blackhawk units higher in the section. Emphasis has been placed on the Panther Sandstone here, since greater knowledge of details of stratification and facies trends obtained from careful study of this unit permit a more accurate interpretation of paleogeography and locations of coal formation.

The coal is trucked into this region for loading and sizing. The coals mined here were the Spring Canyon and Aberdeen units higher in the section to the north. The prominent cliff or butte seen to the northwest, up the canyon beyond the coal tipple, is a remnant of the Castlegate Sandstone.

14.7	0.7	Typical pattern of the massive sands of the Blackhawk Group. The massive unit here is the Spring Canyon Sandstone which becomes thin-bedded and grades into silty sequence to the east. In contrast to this, the overlying Aberdeen Sandstone was massive in the vicinity of Castlegate, but it is becoming less well developed toward the west. Both of these sandstones maintain the prominent white cap, but the lower Spring Canyon Sandstone is the more massive.
15.0	0.3	Upper sands of the Storrs Tongue in the creek to the north, with facies pattern much like the Panther Sandstone at its type locality. Well-stratified units dipping to the

east develop gradually, as do the fore-beach deposits in the Panther Sandstone east of Price Canyon. This is probably the same pattern of development that we would see if we could trace individual sand-tongues of the Blackhawk Group eastward in the marine shale section as well. This is the type section of Spring Canyon Member of Young.

15.4	0.4	Liberty Fuel Company mine to southwest of road in Spring Canyon. Coal mined here is from Spring Canyon Member. The massive white sand to the north, and on the promontory up-canyon is the Aberdeen Sandstone above the white-capped Spring Canyon Sandstone. Turn around and return to U.S. Highway 6 and 50.
16.7	1.3	Site of abandoned Spring Canyon No. 7 Mine.
17.6	0.9	Sowbelly Gulch on left. Excellent view of Panther Sandstone down canyon ahead.
21.1	3.5	Bryner and Canyon Streets in north Helper. Continue down Bryner Street 3 blocks to North Main Street.
21.3	0.2	North Main Street intersection. Bear left then right and on north to junction with Highway.
21.4	0.1	Junction with 6 and 50. Turn left up Price River Canyon on 6 and 50.
21.6	0.2	Milepost 233.
22.0	0.4	Road to Carbon Fuel Company mine on left.
22.8	0.8	STOP 16, 1975. GENTILE WASH & PANTHER HOLLOW. We will hike up Gentile Wash. The bus will turn around up the road at a convenient place. See BYU 1974 Guidbook, Mile 46.0, p. 34-35, Stop 9, for extensive writeup. Return to Price. Follow BYU 1974 log, Miles 46.1 to 55.5 and GSA 1975 log, Miles 67.4 to 76.8, Part I-B.
22.9	0.1	Cross Utah railway line.
24.2	1.3	Road into Helper to Spring Canyon Road.
24.3	0.1	Railroad crossing at edge of Helper.
27.5	3.2	Cross Price River at exposures of Garley Canyon Sandstone.
32.3	4.8	Center of Price. Junction with Utah Road 10. Continue on to Museum.
32.1	0.1	LUNCH STOP. Return to Junction.

Figure 15A, Mile 8.95 and 22.0, Day 2, Book Cliffs near Helper.
View of same section as in Figure 14C except looking from mouth of Price River Canyon to NE (same symbols as in 14C).

Figure 15B, Mile 22.8, Day 2, Panther Hollow from U.S. Highway 6 and 50.
Excellent display of a beach face stratification. Thin, well-defined beds dipping at low angle to east with successively younger beds accumulating on beach prograding to east. The uppermost bed at the left (one of the thicker units) is about 2/5 of the thickness down in the pile at the right as at least 5 more layers have accumulated on it, each a little further east (seaward). These thin units of sand are truncated rather uniformly at the top by the next transgressive phase with attendant gradation from marine shales to coarser sands upward.

32.2	0.1	Junction Utah State Road 10 with U.S. Highway 6 and 50 in Price. Turn south toward Castle Valley.
32.4	0.2	Cross D.&R.G.W.R.R. tracks.
33.1	0.7	Cross Price River Bridge.
33.45	0.35	County Fairgrounds. Double escarpment and cuestas to west in distance (in foreground in front of cliffs) is Garley Canyon Sandstone. Note pinnacle of Blue Gate shale at 3 to 4 o'clock. This is below level of Garley Canyon. An unnamed sandstone tongue makes a small bench near the base of the pinnacle.
33.7	0.25	Milepost 68.
33.8	0.1	Deep wash (stream).
35.65	1.85	Milepost 66. Approaching terraces cut on Mancos (Blue Gate) Shale for some distance right and left (east-west). The Blue Gate Member is somewhat silty here, with some flat lenses of siltstone. One such lens extends from west to east a little above the road level about one-half way through the cut. Other thin lenses appear to be at about the same level which indicates minor current channels flowing along (down?) the foreshore slope.
36.05	0.4	Top of hill just below top of terrace.
36.35	0.3	Road junction. Paved road to east (left). Excellent view toward SE (10-11 o'clock) of Cedar Mtn., capped by Buckhorn Conglomerate (Lower Cretaceous) and the San Rafael Swell. Pediments stretching in low curves upwards to west toward Book Cliffs (Wasatch Plateau east escarpment). First cliff above Mancos Shale in middle distance is Garley Canyon Sandstone.
36.65	0.3	Milepost 65. Excellent view of continuous pediment surface from SE to SW (11-12 o'clock) showing very low slope at left and increasing slope toward Wasatch escarpment to west.
37.65	1.0	Crossing Miller Creek.
38.25	0.6	Gravel road to left. Good view of pediment cutting across Blue Gate Shale toward Wasatch scarp. From 3 to 4:30 o'clock is an excellent view of the northwest dipping double Garley Canyon cuesta. The first prominent cliff on main scarp in distance is Panther Tongue of Star Point Formation above several hundred feet of gray Mancos Shale (Masuk Member).
38.65	0.4	Milepost 63. If you look back to northwest at about 4 o'clock, the pinnacle referred to at 33.45 (County Fairgrounds road) SW of Price is visible several hundred feet below Garley Canyon Sandstone.
39.45	0.8	Gravel road to right (west).

40.05	0.6	Junction Utah State Road 122 west to Hiawatha and Wattis. See separate log at end of Second Day for *side trip to Hiawatha and Wattis*. Log for this *side trip* follows Day 2 Log after Mile 156.75, p. 71.
41.35	1.3	Two road cuts in Blue Gate Member of Mancos Shale here with the upper level being quite sandy.
41.7	0.35	Carbon-Emery County line. Continue southwest into Emery County.
41.8	0.1	Steep road cuts in very sandy Blue Gate Member of Mancos Shale on both sides with flat sandstone lenses 1' (plus-minus) thick and 20' to 40' wide.
42.4	0.6	Crossing wash in broad valley. Small "mounds" toward 10 o'clock are remnants of Blue Gate Shale after pediment cap has been removed. The westward extension of the old pediment surface toward the Wasatch escarpment shows truncation of west-dipping Mancos Shale beds.
42.65	0.25	Milepost 59 and ranch road to east.
43.15	0.5	"Mounds" to east (9 o'clock) ("Twin Peaks" on 7.5' quadrangle).
43.35	0.2	Double road cuts in Blue Gate Shale.
43.65	0.3	Milepost 58. Paved road to east (left).
43.85	0.2	Washboard Wash (main headwater branch). Blue Gate Shale cuts ahead.
43.95	0.1	Clay dike in Mancos Shale at south end of road cuts.
44.25	0.3	Junction Utah State Road 155 southeast to Elmo and Cleveland area. Road marked "Dinosaur Quarry Road." Mancos Shale capped by pediment surface 1 to 3 o'clock. *Leave Highway 10. Continue on 155.* NOTE: Road log for Sunday, October 19 continues southwest on State Road 10 toward Castle Dale. This log rejoins State Road 10 7.15 miles SSW (19.25 miles SSW of Price; 2.2 miles NNE of Huntington) after the Elmo-Cleveland area side trip. The intervening road log for this 7.15 mile distance is given in Log for *Day 3* (Sunday), Miles 12.05 to 19.2.

SIDE TRIP STOPS 17 & 18, 1975
ELMO AND CLEVELAND AREA, WASHBOARD WASH FERRON SANDSTONE; SOURCES OF SEDIMENT; CARBONACEOUS ZONES

Day 2, Mile 44.25

Across south side of Elmo 7.5' Quadrangle into west side of Olsen Reservoir 7.5' Quadrangle

then back through north half of Cleveland 7.5 minute Quadrangle, Emery Co., Utah.

Note: Prepared from field notes Aureal T. Cross and Edward Cotter; log collated by Aureal T. Cross, Christopher C. Cross and E. Blair Maxfield. Discussion of Washboard Wash area by Edward Cotter.

MILEAGE			
Cumulative		*Interval*	
GSA 1975	*Side Trip*		
44.25	0.0	0.0	Junction Utah State Road 155 to the south and east to Cleveland and Elmo, 12 miles south of Price, Utah.
46.65	2.4	2.4	Junction. Elmo Road to east. Take Utah State Road 92 east to Elmo.
47.15	2.9	0.5	Road begins curve to due east.
48.40	4.15	1.25	Water tanks on left (north) at top of rise.
48.5	4.25	0.1	Curve to south into Elmo.
48.65	4.4	0.15	Turn left (east) through Elmo at Nina's Market.
49.25	5.0	0.6	Junction road to south to cemetery.
49.65	5.4	0.4	Junction (5369). Gravel road to south (marked "Dinosaur Quarry 11 mi") past west side of Desert Lake (because of a weak bridge we will return to this corner and take the road south after visiting the Elmo and Washboard Wash Sections of the Ferron Sandstone). Continue west past Desert Lake at 2 o'clock and Cedar Mt. ahead at 1 o'clock.
50.15	5.9	0.5	Junction (5617). Main road to north across Washboard Wash 1.1 miles north.
50.45	6.2	0.3	Pavement ends.
51.45	7.2	1.0	Ranch on north side of road (Sec. 35).
51.85	7.6	0.4	Cattleguard.
52.35	8.1	0.5	Curve at top of hill (boundary 110° 45') between Elmo and Olsen Reservoir Quadrangles. Continue to SE downhill through Ferron Sandstone into Olsen Reservoir Quad.
52.45	8.2	0.1	Descend through Ferron. Note cuesta and scarp to NNE.
52.55	8.3	0.1	Big concretions at top of main bench in Ferron.
52.65	8.4	0.1	Junction at base of shale slope of Tununk Member of Mancos Shale; bear left (ENE).

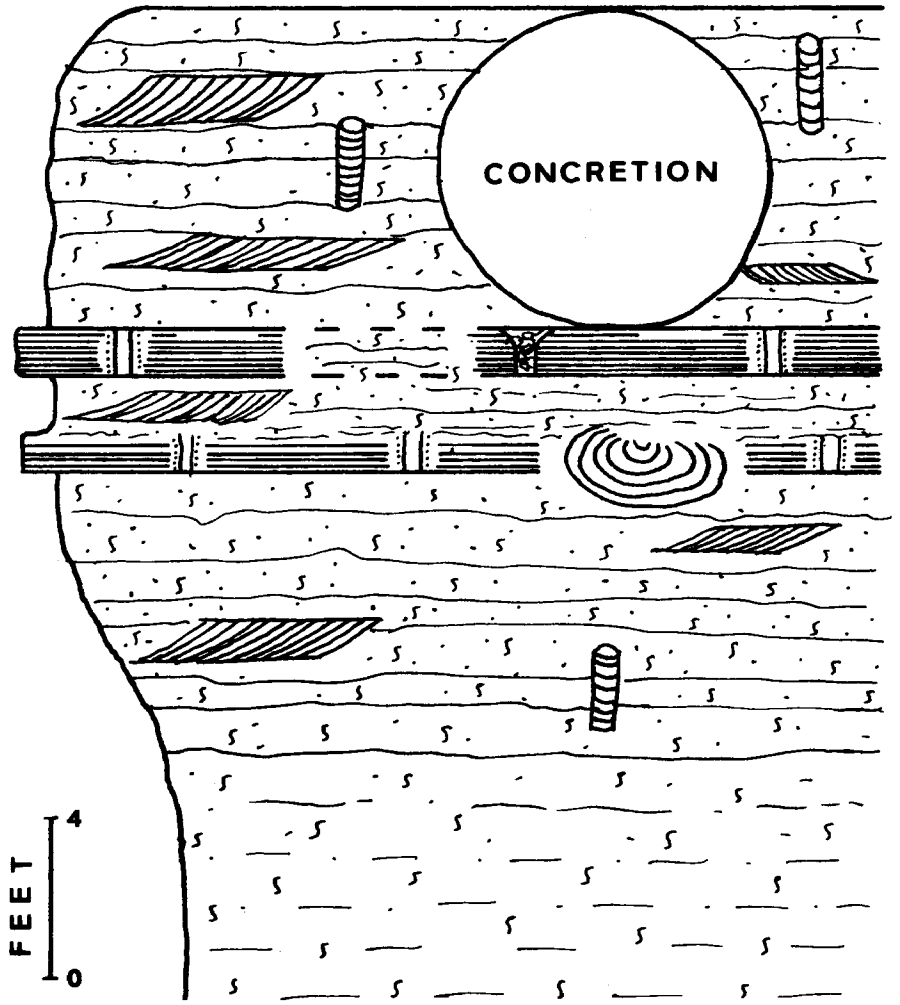


Figure 16, Mile 55.35, Day 2, Stop 17, Washboard Wash Section.
Diagrammatic section indicating position and type of sedimentary structures in Washboard Unit, Ferron Sandstone (Cotter).

52.95	8.7	0.3	Junction (5578) valley road; bear left (NE) toward Wellington (two bridges ahead with load limits below safe level for the bus, Washboard Wash—8 ton limit, and Price River—10 ton limit, prevented us from coming south from Wellington and will prevent us from visiting the actual Washboard Wash locality). Continue north along the east facing escarpment of the Ferron cuesta. Note concretions in sparse to dense array on upper surface of main bench.

Figure 17A, Mile 55.35, Day 2, Stop 17, Washboard Wash Section.
Ball-and-pillow structures in Washboard Unit at top of first bench of Ferron Sandstone near Washboard Wash (Cotter).
Figure 17B, Mile 52.55 and 58.05, Day 2, Stop 17A, Elmo Road Section.
Concretions up to 10′ (3 m) diameter weathering out at top of Washboard unit of Ferron which is comprised of relatively even-bedded thin sandstones and siltstones, extensively bioturbated.

54.05	9.8	1.1	Abundant concretions on west (left).
54.45	10.2	0.4	Stone house in field on right (east). Site of "Victor." Big slope of Tununk shale below.
55.35	11.1	0.9	Ferron promontory close to road. STOP 17, 1975. WASHBOARD WASH SECTION. Bus can go down to farm road one mile ahead on left and return to pick up participants (originally planned stop was just across Washboard Wash at Junction 1.8 miles north at S Center, Sec. 17, N Center, Sec. 20, T. 16 S, R. 11 E).

STOP 17. WASHBOARD UNIT OF FERRON SANDSTONE, NEAR WASHBOARD WASH

9.6 miles S. of Wellington, near Center, *Sec. 20,* T. 16 S, R. 11 E, Emery Co., Utah, Olsen Reservoir 7.5' Quad.

Edward Cotter

General orientation

The Washboard unit is the most widespread laterally of the thin, sheet-like sandstone units that comprise the Ferron sandstone in northern Castle Valley. These units are older than, and genetically unrelated to, the Last Chance Delta of the Ferron that will be examined in the southern part of the valley (*STOP 26*).

The Vernal Delta, from which these units were derived, is not exposed in Castle Valley, but in the subsurface not more than 10 miles west of this outcrop the Vernal Delta is well-developed. Information in Gray, Patalski, and Schapiro, 1966; Doelling, 1972, and Hale, 1972, shows the extensive coal zones in the terminal part of the Vernal Delta at nearby locations to the west.

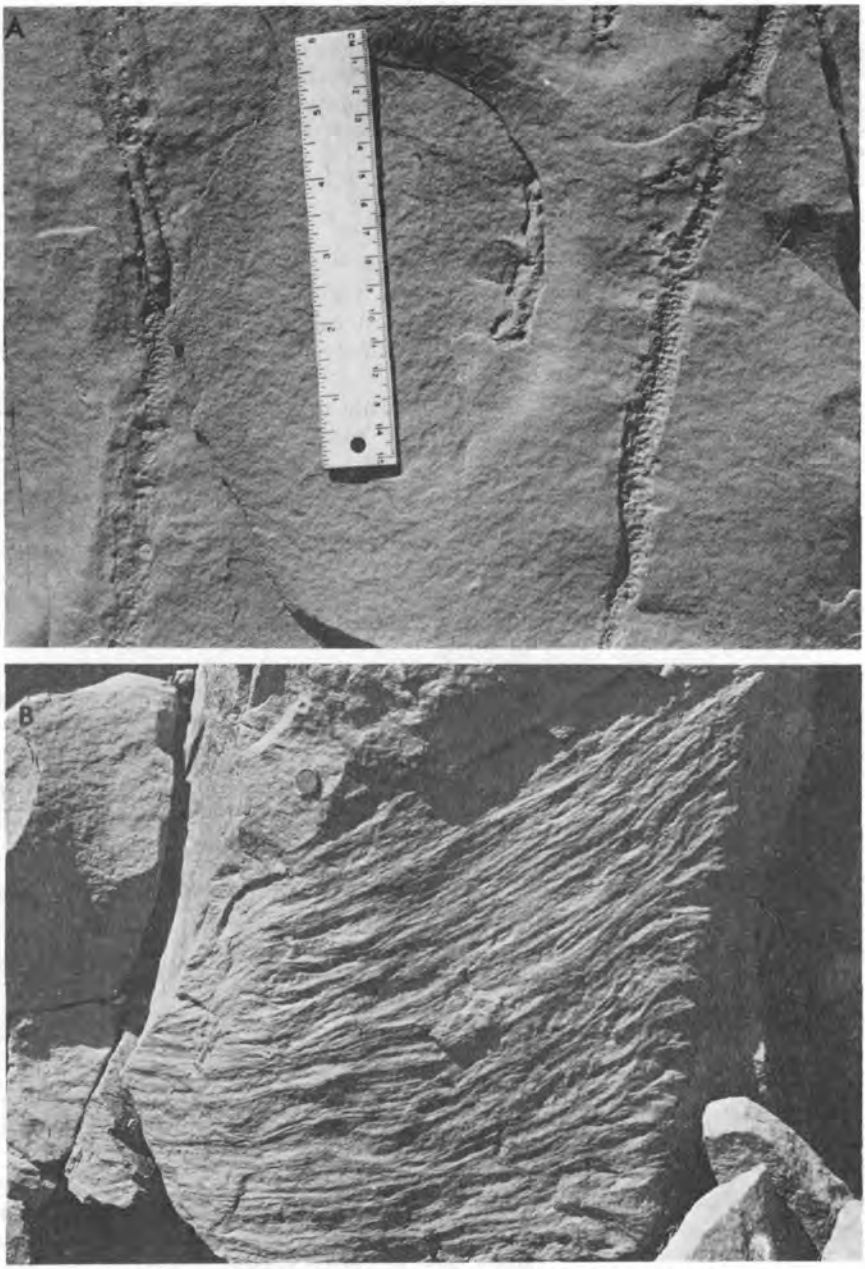
Washboard unit characteristics

At almost all localities the Washboard unit consists of a mixture of concretion-rich, bioturbated silt, sandstone and intercalated thin beds of laminated sandstone. The proportion of laminated sandstone is highest in the northernmost part of the outcrop belt. Ball-and-pillow structures are also present chiefly in this northern region. To the south along both limbs of the outcrop belt the Washboard unit thins and fines to a gradual merger with the typical shale of the Mancos Shale.

The intense bioturbation was done primarily by the deposit-feeder, retrusive *Teichichnus,* a biogenic structure seen commonly on fracture surfaces. Sedimentary structures in the laminated beds most commonly are even parallel lamination and, less commonly, broad shallow trough cross lamination. In many cases the tops of the laminated beds are burrowed, producing the sequence named "parallel to burrowed" beds by Howard. Burrowing in the laminated beds was accomplished by suspension feeders, such as *Ophiomorpha, Thalassinoides,* and, less commonly, *Rosselia.*

Interpretation of depositional environment

The two basic rock types, thoroughly bioturbated and laminated, record an alternation of depositional conditions. Bioturbated silty sandstone, charac-



Figures 18A, B, Mile 55.35, Day 2, Stop 17, Washboard Wash Section.
18A. *Ophiomorpha* in Washboard unit (Cotter).
18B. Retrusive *Teichichnus* in longitudinal section, Washboard Unit between Washboard Wash and Elmo Road Section (Coin is 2 cm diam.) (Cotter).

teristic of offshore zone, seaward of the shoreface, is the "normal" sediment type. Periodically there was introduced slightly coarser sand that settled out from the water to produce even, parallel lamination. The most likely agent of such semicatastrophic deposition is storm activity, flushing sediment from nearer shore and depositing it more seaward. The environment of the coastal zone in which such an alternation of conditions occur is the lower part of the shoreface zone.

Features of this location

1. General style of Washboard unit, well shown just west of the road.
2. Bioturbated beds. Retrusive *Teichichnus* occurs on some fracture surfaces.
3. Laminated beds, most easily observed just east of the road. Even parallel laminae, broad troughs, and "parallel to burrowed" beds. *Ophiomorpha* and *Thalassinoides*. These are also present in the draw west of the road.
4. Ball-and-pillow structures. Seen most easily just down the road a few tens of feet. Fine examples visible west of road. It is clear that it was the laminated beds that foundered.
5. Concretions. Found throughout the vicinity.

MILEAGE *Cumulative* *GSA 1975 Side Trip*		*Interval*	
			Return to Junction of valley road with road to Elmo.
57.75	13.5	2.4	Junction (5578). Bear right (road ahead blocked by bad bridge).
58.05	13.8	0.3	STOP 17-A, 1975 (OPTIONAL). ELMO ROAD SECTION. Junction at base of cliff. Walk up through to top of Ferron concretion zone.
58.25	14.0	0.2	Top of Ferron. Re-board bus. Continue west toward Elmo past Desert Lake.
61.05	16.8	2.8	Junction (5369). Turn left on road marked "Dinosaur Quarry 11 mi."
62.30	18.05	1.25	Curve left (east), then south across Desert Lake Waterfowl Management Area.
63.25	19.00	0.95	Junction with road to right (west) to Cleveland. Continue straight 0.25 mi then curve left.
63.50	19.25	0.25	Curve left to ENE.
64.6	20.35	1.1	Junction (5668). Road to south marked "Dinosaur Quarry." Turn right (south). Road runs along crest of Ferron cuesta.
65.0	21.05	0.4	Note strong carbonaceous zone above main sandstone along valley wall east of road here. This is about the farthest north this shows. We

			will observe this as it increases in intensity and finally becomes coal beds to the south near Moore.
65.8	21.85	0.8	Junction (5772) Road to east. Marked "Dinosaur Quarry 6 mi." Turn left for short side trip over Ferron cuesta. We will return to this corner.

Day 2, Mile 65.8

STOP 18, 1975 (OPTIONAL)
SIDE TRIP CLEVELAND-LLOYD DINOSAUR QUARRY ROAD
FERRON TO DAKOTA SECTION, DESERT LAKE AREA

The main section here is across the S side, SE ¼ Sec. 14 and into Sec. 13, T. 17 S, R. 10 E, Emery Co., Utah, Cleveland and Cow Flats 7.5' Quads.

65.8	21.85	0.0	Junction (5772). Go ENE up dip slope of Ferron cuesta.
65.95	22.00	0.15	Crest of hill. Carbonaceous zone above main bench of Ferron well-marked here. This zone is capped by a thin near shore or fluvial sandy zone with a few 1"-3" (2.5-1.5 cm) hard sandstone layers.
66.1	22.15	0.15	Edge of Ferron sandstone main bench. Concretions at this level as seen at Elmo Section (3.85 mi [6 km] NNE). Start down through regressive, marine offshore sand (Washboard Unit). Two benches aggregating about 15' (4.5 m) thickness.
66.15	22.2	0.05	Ball-and-pillow structure well-developed below concretion zone. Mancos Shale (Tununk Member) slope into valley below is interrupted by two weak benches. Note the zone of concretions along upper bench about 200' (60 m) apart.
66.35	22.4	0.2	Cattle guard at low bench. Upper of two weak benches in Tununk Shale slope. This is 80' (24 m) below base of lower bench of Ferron. These sandstone "lenses" do not seem to have lateral continuity but they look like offshore channel sands in the shales. As we go along the outcrops to the southwest to *Stop 18-A* and beyond, we will see these distributed at this level about 150 to 300' (50-100 m) apart for several miles.
66.6	22.65	0.25	Calcareous siltstone bench. Weak bench 45' (13.5 m) below upper bench and 130' (39 m)

			below base of Ferron Sandstone. (This part of the section is occasionally well exposed in the north road ditch where a steep gully has developed.)
67.0	23.05	0.4	Dry Wash at base of main Tununk Shale Valley.
67.2	23.25	0.2	Low crest developed on thin sandstone 10-12' (3-4 m) thick, in lower part of Tununk about 22' (7 m) above top of Dakota sandstone. This might be considered as an upper bench of Dakota sandstone except the fossils including *Pycnodonte Gryphaea Newberryi* indicate Mancos Fm.
67.25	23.3	0.05	Top of Dakota sandstone in small wash. Road follows up dip-slope of cuesta to east.
67.5	23.55	0.25	East edge of Dakota cuesta.
67.6	23.65	0.1	Contact of base of Dakota with upper part of Cedar Mt. Fm., red and green shales and sandstones. The Cleveland-Lloyd Dinosaur Quarry is 4.5 miles ESE. The visitor center is at NW ¼, NE ¼, Sec. 28, T. 17 S, R. 11 E, and the quarry itself is located nearly at the center, SW ¼, SE ¼, SE ¼, Sec. 21, T. 17 S, R. 11 E, Emery Co., Utah, Cow Flats 7.5' Quad. Turn around. Retrace route to top of Ferron cuesta.
68.0	24.05	0.4	Top of Dakota base of Tununk Shale.
69.15	25.2	1.15	Top of main bench Ferron Ss. at concretion zone.
69.25	25.3	0.1	Carbonaceous siltstone zone well developed on right above main bench of Ferron.
69.3	25.35	0.05	Siltstone zone with 1" layers of tan sandstone above carbonaceous zone.
69.45	25.5	0.15	Junction 5772 with road to Elmo. Same as at mile 65.8 END STOP 18, 1975 (OPTIONAL). SIDE TRIP ON CLEVELAND-LLOYD DINOSAUR QUARRY ROAD.
69.45	25.5	—	Junction 5772. Continue south along back slope of Ferron cuesta.
69.65	25.7	0.2	Good view east across Tununk Shale Valley to juniper-covered dip-slope of Dakota and into Cedar Mt. beyond.
70.05	26.1	0.4	Road goes along between the upper sandy bench on the right (west) and the main concretion-bearing zone at the top of the Ferron

			main bench here at left (east). The upper zone has also developed an occasional concretion. Above that lies the carbonaceous zone. Excellent overlook here over the scarp of the Ferron cuesta.
71.5	27.2		STOP 18-A, 1975. NEW SANDSTONE AND CARBONACEOUS ACCUMULATION OF FERRON FROM SOUTH. Well-developed zone of upper layer of concretions forms a row on the right of the road and the concretions, which we have been observing on top of the main bench of the Ferron Sandstone here, form a row on the left side of the road for nearly one-half mile. Note the carbonaceous zone is just above the upper concretion layer, as we will see well-developed on the Ferron Creek Road, STOP 23, 1975 (OPTIONAL). The question to be answered here is, "Is the upper sand zone, and the carbonaceous shale above it, a deposit accumulating in front of or at the edge of the Ferron Delta from the southwest, or is this carbonaceous zone accumulating at the southern or southeastern extreme (delta or lagoons behind off-shore bars) of the Vernal Delta to the north?" If the latter is true then this is the only area of exposure of a coaly zone at the southern edge of the Ferron coal field tested near Price about 21 miles north. Note the section below the main bench of the Ferron here and the weak sandy benches in the Tununk shale slope below.
71.15	27.8	0.6	Road crosses down through main layer of Ferron concretions.
71.35	28.0	0.2	Cattle guard. Road travels along on Tununk shale with concretions west of road (right).
71.95	28.6	0.6	Wire gate. Road on Tununk below the level of the Ferron main bench.
72.75	29.4	0.8	Junction (5893). Turn right (west) back toward Cleveland. Road straight ahead to south goes into San Rafael Swell and Buckhorn Reservoir; road to left, east, goes to Cedar Mountain.
73.95	30.6	1.2	Long curve to NNW.
76.25	32.9	2.3	Short curve to east (5784).
76.45	33.1	0.2	Junction. Continue on road north to Cleveland. (Road to SW goes to Lawrence.)

78.0	34.65	1.55	Stop sign at Junction with Utah Road 155 in Cleveland. Turn left through Cleveland.
82.6	39.25	4.6	Junction Utah 155 with Utah 10 (Price, Huntington Road). END. SIDE TRIP TO ELMO-CLEVELAND AREA AND STOPS 17 AND 18, 1975.

Day 2, Mile 82.6

CONTINUE SOUTH TOWARD HUNTINGTON AND CASTLE DALE.

MILEAGE *Cumulative*	*Interval*	
82.6	—	Jct. Utah State Road 155 and Utah 10, 19.25 miles SSW of Price, Utah (7.15 miles SSW of point where we took side trip to Elmo-Cleveland area). Huntington Lake ahead, El. 5839' (1775 m).
82.75	0.15	Milepost 50. Excellent view of Masuk Shale and Star Point Fm. ahead over Huntington.
83.25	0.5	As you round the curve to the west, going down off the pediment surface, "Red Point" is well-displayed. The Panther Tongue of the Star Point Formation is the first cliff at the top of the Mancos Shale (Masuk Member). The Spring Canyon Member of the Star Point is the massive ss. overlain next above the burned-out Hiawatha coal sequence. This burn, which oxidized the iron in the sands and clays above, imparts the red color to the rocks.
83.65	0.4	N-S crossroad.
84.45	0.8	Huntington Creek ("River") bridge. Curve to left into north edge of Huntington.
84.75	0.3	Road Junction of Utah Road 31 with Utah Road 10. Utah 31 goes up Huntington Canyon and across the Wasatch Plateau into the San Pete Valley to Fairview. See Road Log for SIDE TRIP UP HUNTINGTON CANYON and STOP 19, 1975 (OPTIONAL) at end of road log for Day 2 (Mile 156.75, p. 72). (If this Side Trip up Huntington Canyon is taken, add 21.5 miles to the road log at this point.)
85.2	0.45	Traffic light at center of Huntington. Note the big burned zone on the upper cliff (Aberdeen) south of Huntington at 3 o'clock.
86.15	0.95	Drive-in theater.
86.2	0.05	Milepost 47. Good view of pediment slope.
86.75	0.55	Road to Lawrence to ESE (Junction 5695).
87.05	0.3	Big wash (McElprang Wash).

87.15	0.1	Milepost 46.
87.35	0.2	Bridge over Guymon Wash.
88.15	0.8	Milepost 45. "Red Point" due west. This is an excellent profile for showing the three benches of Star Point Sandstone above the Masuk Shale Member of Mancos Shale: Panther, Storrs and Spring Canyon, respectively. On the cliff face, the Storrs is very inconspicuous. The Spring Canyon Ss. near the top of the cliff is accentuated by the burned (baked) shales above. At 4 o'clock the pediment surface dips away in a low curve and on the lower hill in the middle distance toward the right, the upper bench of the Emery Sandstone rises at a low angle to intersect the pediment surface at an angular erosional unconformity.
89.15	1.0	Bridge over north branch of Five Mile Wash.
90.1	0.95	Milepost 43.
90.4	0.3	South end of loop road to Lawrence to NE and bridge.
90.95	0.55	Junction Utah 29 to Orangeville. Leave Utah 10, turn west on Utah 29 to Orangeville.
		SIDE TRIP STRAIGHT CANYON—JOES CANYON. STOP 20, 1975.

Day 2, Mile 90.95

SIDE TRIP. STOP 20, 1975
UP COTTONWOOD CREEK AND STRAIGHT CANYON TO JOE'S VALLEY. SEQUENCE OF COAL AND CARBONACEOUS ACCUMULATIONS; FOSSIL PLANTS AS INDICATORS OF DEPOSITIONAL ENVIRONMENTS

Beginning at center, SW ¼, T. 18 S, R. 8 E, diagonally across the N ½ T. 18 S, R. 7 E and through the north side T. 18 S, R. 6 E, Emery Co., Utah

Note: Text and collation from field notes by Aureal T. Cross, Christopher C. Cross, E. Blair Maxfield and Lee R. Parker.

MILEAGE

Cumulative		*Interval*	
GSA 1975	*Side Trip*		
90.9	0.0	0.0	Junction Utah 29 and Utah 10. Go west toward Orangeville on Utah 29.
93.0	2.1	2.1	Emery County High School. Panorama of Wasatch Scarp ahead. First sandstone above Mancos Shale (gray slopes) is thin Panther Ss., overlain by additional Mancos-type shale including

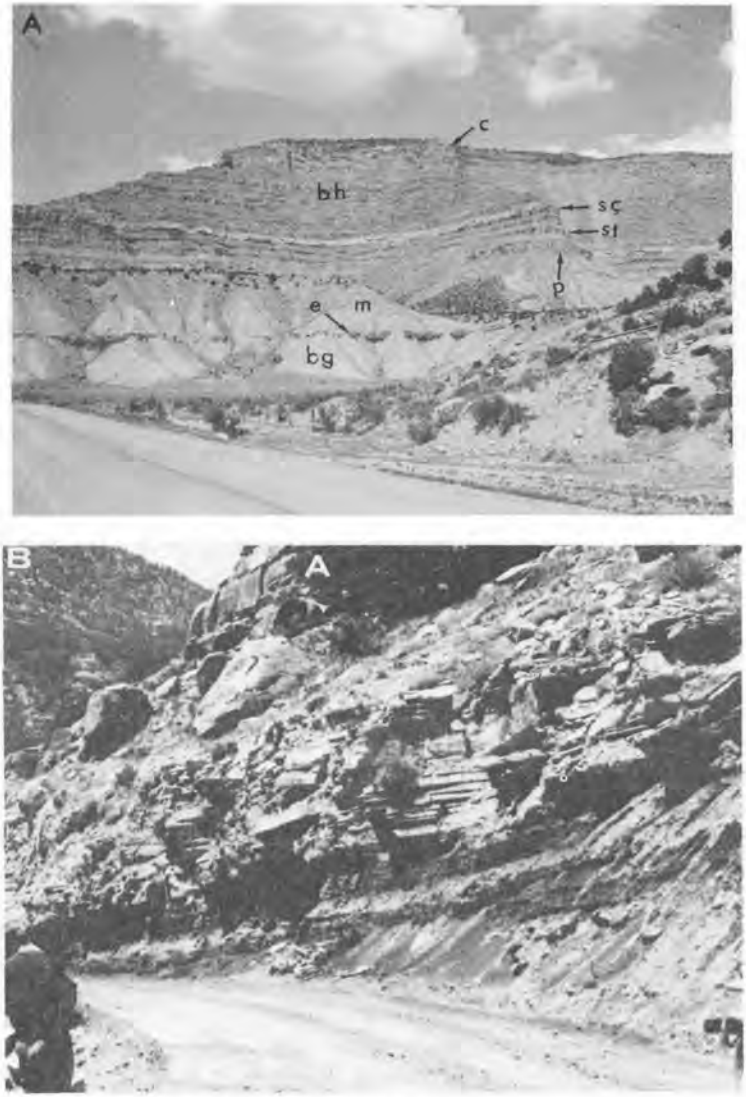


Figure 19A, Mile 93, Day 2, Wasatch escarpment.
Emery ("e") Ss breaks the Mancos Shale slopes into the Bluegate ("bg") below and the Masuk ("m") above. The Panther Tongue ("p") forms the first sandstone cliff above the Masuk. The Storrs Tongue ("s"), also of the Star Point Fm, is inconspicuous between the Panther and the conspicuous, white-capped, Spring Canyon Member ("sc"), which is the top of the Star Point (base of Blackhawk Fm. of Young). The Blackhawk ("bh") is capped by the Castlegate Ss Member of the Price River Formation.

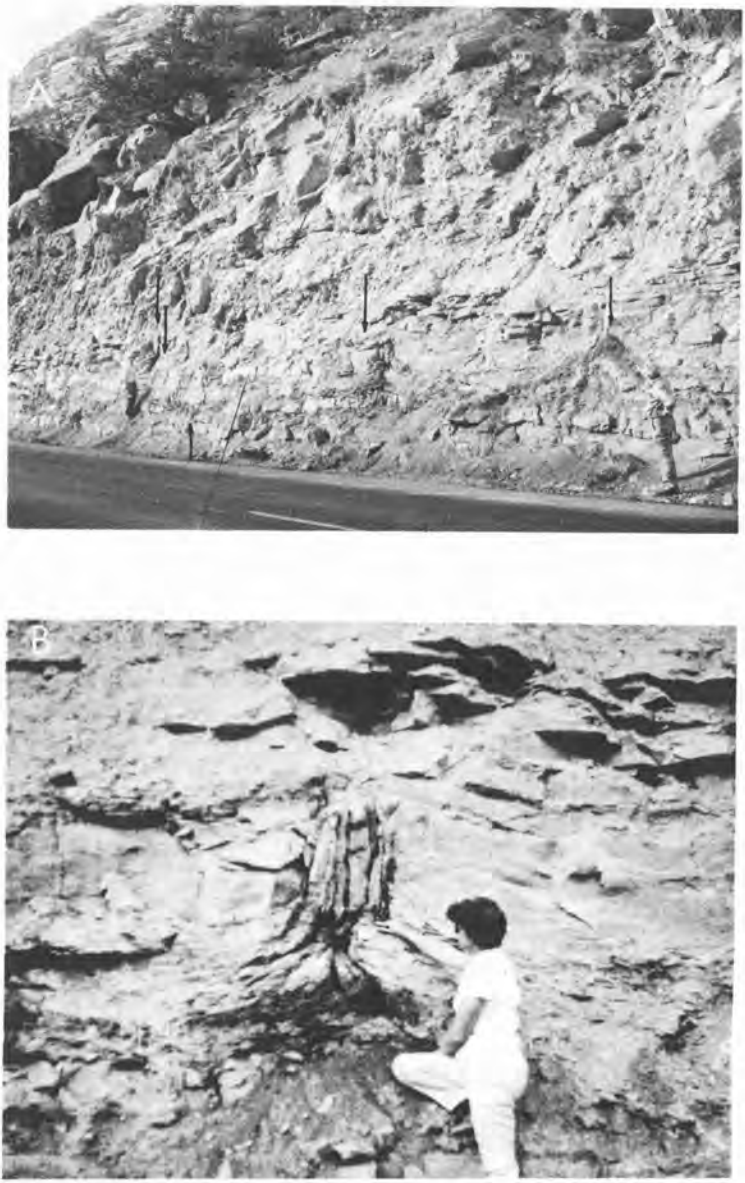
Figure 19B, Mile 104.85, Day 2 (Mile 13.95 of Straight Canyon Side Trip).
Hiawatha (Spring Canyon) coal with 8"-14" (20-35 cm) clay parting overlain by additional Spring Canyon swamp and fluvial beds and capped here by base of massive Aberdeen Ss Member ("A").

			the Storrs Tongue of the Star Point Formation. Above this is the massive Spring Canyon Sandstone overlain by a conspicuous burned zone representing the baked zones above the burned-out seams of one or more of the Spring Canyon Member coals (Hiawatha seams). The remainder of the Black Hawk Formation lies between this and the Castlegate Sandstone, which caps the cliffs. Near the base of the Mancos slopes the multiple Emery Sandstone can be seen. Below the Emery Sandstone, and blending in with the top of the tree-covered pediment, is the multiple Garley Canyon Sandstone Tongue (see Text-figure 21, p. 31, BYU 1974 Guidebook, mile 50.9-51.1, p. 36-37).
94.1	3.2	1.1	Junction of local road to SE to Castle Dale. Continue on Utah 29.
94.9	4.0	0.8	Junction Utah 57 and Utah 29 at Orangeville. Turn right (N) on Utah 29. (Steel bridge over Cottonwood Creek to left [S] not safe for bus.)
95.0	4.1	0.1	Milepost 18.
95.2	4.3	0.2	Curve to NW at edge of town.
95.6	4.7	0.4	First exposure of Mancos Shale (Blue Gate Member), near top pinnacle on right.
95.9	5.0	0.3	Garley Canyon Sandstone in wash at right.
96.0	5.1	0.1	Garley Canyon Sandstone promontory to north at 2 o'clock and 2 thin sandstone layers in Blue Gate Shale below.
96.05	5.15	0.05	Bridge.
96.8	5.9	0.75	Road to south to Garley Canyon Ss. promontory.
97.0	6.1	0.2	Milepost 16; Garley Canyon Ss. exposed nearly at road level.
97.2	6.3	0.2	Garley Canyon Ss. exposed to right and left. A thin ss. stringer (Upper Garley Canyon) about 100' above.
97.4	6.5	0.2	Canal crossing.
97.7	6.8	0.3	Excellent exposure of 2 benches of Emery Sandstone to SSW.
97.8	6.9	0.1	Bridge.
98.0	7.1	0.2	Milepost 15. "Castles" are formed by the 2 benches of the Emery Ss.

98.05	7.15	0.05	Road to Wilburg Mine, 5 miles (Peabody Coal Co.).
98.6	7.7	0.55	Good castles of Emery Ss. to north and south for 0.4 mi.
98.8	7.9	0.2	Swasey diversion dam.
99.0	8.1	0.2	Milepost 14.
100.0	9.1	1.0	Good exposure of main three-bench Emery Ss. on S side of creek.
100.4	9.5	0.4	Top of 2nd bench of Emery going under cover upstream.
100.7	9.8	0.3	Bridge.
101.0	10.1	0.3	Milepost 12.
101.3	10.4	0.3	Excellent exposure of upper (3rd) bench of Emery Ss.
101.95	11.05	0.65	Weak ss. in gray Mancos Shale 200' above Emery Sandstone upper bench to north and ahead toward curve.
102.2	11.3	0.25	Unnamed sandstone forms 2 thin benches in Masuk Shale 200 yds. N of road.
102.4	11.5	0.2	Another weak ss. in gray Mancos Shale 150'-250' above first tongue and 150'-250' below Panther Sandstone (see Text-figure 21, p. 31, BYU 1974 Guidebook).
102.7	11.8	0.3	Road Junction 6344. Road to right (NW) goes to East Mountain and Upper Joe's Valley. Continue on *left* fork up Straight Canyon to Joe's Valley and Ephraim. Cross bridge ahead. About 200' of Masuk Shale below Panther Ss. in promontory on N side with two sandstone or siltstone streaks.
103.0	12.1	0.3	Milepost 10.
103.4	12.5	0.4	Manti-LaSal National Forest Boundary; cattle guard.
104.0	13.1	0.6	Milepost 9.
104.2	13.3	0.2	Clay Banks Swale across Creek to south (N-S Valley).
104.3	13.4	0.1	1st coal dump. Coal seam overlies massive Spring Canyon Sandstone above.
104.4	13.5	0.1	Abandoned coal mine above ss.

Figures 20A, B, Mile 104.95, Day 2 (Mile 14.05 of Straight Canyon Side Trip).
20A. Profile of north side of Straight Canyon looking NE. Castlegate ("C") is the massive sandstone capping the Blackhawk sequence which includes the Aberdeen Ss member ("A"). "FP" is a good fossil leaf locality where the leaf of *Manihotites* shown in Figure 20B was collected.
20B. *Manihotites* leaf (obverse and reverse) and miscellaneous dicot leaves. Fossil fruits, thought to belong to *Manihotites*, were also collected from another site nearby.

104.5	13.6	0.1	Tipple of abandoned Black Diamond Coal Mine, 6727' el. Lowest coal in sequence (Hiawatha) on top of massive Spring Canyon sandstone. Old mine opening about 150' above road.
104.7	13.8	0.2	Two old mine openings above road on right including Oliphant Mine (abandoned) 6620' el.
104.85	13.95	0.15	Hiawatha coal crosses road and is somewhat changed from condition in mine with 8"-14" parting in lower portion.
104.9	14.0	0.05	Gully to north of road. Plant fossils, several layers. 2nd coal crosses road just west of north-heading gully.
104.95	14.05	0.05	3rd coal crosses road (2nd conspicuous coal zone).
105.0	14.1	0.05	Milepost 8 across creek from steep S heading canyon.
105.05	14.15	0.05	Series of 5 or 6 pull-offs in the next .6 miles.
105.3	14.4	0.25	Thin coal below cliff; very weathered.
105.35	14.45	0.05	Thick coal below big sandstone at road.
105.4	14.5	0.05	Cox Swale. This small tributary canyon across the canyon heads to the SW. Several coals are exposed about halfway up to Castlegate Ss. above Cox Swale.
105.5	14.6	0.1	Thin coal.
105.55	14.65	0.05	Thin coal.
105.65	14.75	0.1	STOP 20, 1975. PLANT FOSSILS & PALEO-ENVIRONMENTS. Coal exposure with fossil stumps in upright position in sandstones above coaly beds. A fossil plant bed lies between coaly zone and stump bed. (See article by Lee R. Parker).
105.7	14.8	0.05	Gully to north, with coaly zone at about 10' and a 1' coal at 20' above road (gulley is at Ponderosa pine). *Metasequoia* and *Araucaria* fossils here.
105.8	14.9	0.1	Coal below channels of sandstone at pine tree.
105.9	15.0	0.1	3' coal bed with shale parting near base.
106.0	15.1	0.1	Milepost 7.
106.1	15.2	0.1	Very massive sandstone crosses road.
106.3	15.4	0.2	Gully.



Figures 21A, B, Mile 105.65, Day 2, Stop 20, Plant fossils and paleoenvironments.
21A. Several stumps, at different levels, indicated below or above vertical arrows. Note deformation of bedding where stumps, acting as pillars, modify uniformity of compaction of shales and siltstones.
21B. Close up of one stump showing carbonized residue remaining in mud-cast. Note deformation of overlying beds (draped over stumps as compaction took place).

106.4	15.5	0.1	Thin coal zone beneath massive sandstone crosses road here.
106.45	15.55	0.05	Coal zone.
106.6	15.7	0.15	1' thick coal zone crosses road.
106.7	15.8	0.1	Big ravine to right. Valley has "Y" shape with streams shown on map.
106.8	15.9	0.1	Coal zone.
106.9	16.0	0.1	2 coal zones crossing road. Fairly thick dark shale zone.
107.1	16.2	0.2	Very massive sandstone with unconformity in gully about 20' above road.
107.35	16.45	0.25	Very massive sandstone with coal zone near base.
107.45	16.55	0.1	Coal zone (interbedded).
107.55	16.65	0.1	Ravine to north with excellent exposure of base of Castlegate Sandstone showing about 50' above road. Gray, Mancos-type shale, probably nonmarine, just above road; shale 10' below Castlegate; 3 coal seams exposed up to Castlegate.
107.65	16.75	0.1	Coal seam.
108.0	17.1	0.35	Milepost 5. Base of Castlegate; top of Blackhawk. Thick shale zone with several siltstones and sandstone layers.
108.2	17.3	0.2	Joe's Valley Dam. Foundation in Castlegate Ss. with several dark shale and coal zones.
108.3	17.4	0.1	Massive sandstone base crosses road here.
108.4	17.5	0.1	More interbedded coaly shale in massive sandstone.
109.9	19.0	1.5	Junction road in Lower Joe's Valley at N end of lake. Ranger station. Grocery at Joe's Lake. Turn around and return to Junction in Orangeville.
124.9	34.0	15.0	Utah 29 with Utah 57 at Orangeville. Turn left on Utah 29. (Bridge on Utah 57 into center of Orangeville 10 ton limit.)
125.7	34.8	0.8	Junction diagonal road SE into Castle Dale.
125.75	33.85	0.05	Road cuts at top of Mancos upward through pediment cover to terrace.
126.2	34.3	0.45	Junction. Coal mine road N to L.D.S. church mine in Hiawatha Coal.

126.8	35.9	0.6	Junction crossroad at Emery County High School (on SW corner of intersection). OPTIONAL STOP 21, 1975 SIDE TRIP TO FERRON SANDSTONE 4 miles E of Castle Dale. TO SEE PROGRESSIVE SOUTHWARD COAL DEVELOPMENT IN UPPER FERRON SANDSTONES. If this side trip, STOP 21, 1975 (OPTIONAL) is taken, add 12.45 miles between 126.8 and 128.9 where we will rejoin DAY 2 Road Log. Continue NE to Utah Road 10 on Utah 29.
128.9	38.0	2.1	Junction with Utah 10, 3.8 miles NE of Castle Dale. END. SIDE TRIP UP COTTONWOOD CREEK & STRAIGHT CANYON TO JOE'S VALLEY. STOP 20, 1975.
156.7		27.8	Return to Price. END. PART II. END. DAY 2, (Oct. 18, 1975).

Day 2, Mile 40.05

SIDE TRIP. STOP 19A, 1975 (OPTIONAL)
HIAWATHA AND WATTIS - TWO ACTIVE MINES IN SPRING CANYON COALS
HIAWATHA COALS - MAXIMUM SWAMP DEVELOPMENT

MILEAGE *Cumulative*	*Interval*	
0.0	0.0	Junction 5828. Utah Road 122 to Hiawatha. 7.9 mi SSW of Price.
2.7	2.7	Milepost 7.
3.05	0.35	Junction 6093. Road to Wattis, 8.2 miles. Continue straight ahead on Utah 122.
3.7	0.7	Milepost 6. Pediment rising about 150' per mile here (el. 6200'—1880 m). Hiawatha is 7200' (2100 m). Edge of juniper-pinyon forest; altitudinal control (about 6000'). Good view of Emery Sandstones below cliffs ahead and to NW. Garley Canyon Sandstones, in two main benches, form conspicuous cuestas extending northeastward about 2-3 miles in front of Emery Ss. benches.
5.7	2.0	Milepost 4. Mancos Blue Gate Shale exposed below pediment. Emery cliffs with castellated erosion of Blue Gate Shales below, ahead and to northwest.
8.7	3.0	Milepost 1. Tailings pond on left (S).
9.1	0.4	RR crossing.

9.5	0.4	Cross mine tramway from Blackhawk Mine (el. 7977') 1.1 miles SSW.
9.8	0.3	Center of Hiawatha. U.S. Fuel Co. King Mine 2.3 miles WSW in South Fork Canyon, NW ¼ Sec. 32, T. 15 S, R. 8 E, Carbon Co., is mining *Hiawath Seam* which is 10' thick at portal. 26'7" above is *Seam "A,"* 5'3" thick, lying directly between two massive bar-type sandstones. *Seam "B,"* also known as the *Wattis Seam*, because it is the principal seam at Wattis Mine (3.3 miles NNW at head of south fork of Serviceberry Canyon), is over 5'6" thick here and lies on a massive sandstone 76' thick. Both sandstones have a white-cap top of 10'-15'. 27' above the top of the *"B" coal,* the *"C" coal* is present as thin (1'5") irregular coal. *Seam "C"* is also overlain by a thick sandstone, with an irregular bottom. Between this and the top of *"B" seam* roof shale is a 17' interval of shale of lagoonal mud type, in places with organic rich layers, and occasionally (as here) with irregular broad lenses of massive sandstone (channels?) which, when absent, bring the two seams nearly together. Samples from these three seams are part of the palynology study by Cross and Singh. Retrace route to Highway 10. As we descend we have a remarkable view of the re-entrant to the left (north and east) of the conjunction of the Wasatch Plateau and Book Cliffs from the north-heading Price River Canyon eastward to near Sunnyside. Also, at about 2 o'clock, 30 miles to SE, Cedar Mountain (el. 7665'), capped by Buckhorn (L. Cretaceous) conglomerate, is the conspicuous point in the San Rafael Swell.
19.6	9.8	Junction Utah 122 with Utah 10. Turn right (SSW) towards Huntington, 13.6 miles.

END. SIDE TRIP TO HIAWATHA-WATTIS

Day 2. Mile 84.75

SIDE TRIP. STOP 19, 1975 (OPTIONAL)
UP HUNTINGTON CANYON
OBSERVE FAULTING OF COAL-BEARING SEQUENCES

Follow Utah Road 31 NW from the Center of the E Side to the NW Cor., T. 17 S, R. 8 E, into the SE Cor. of T. 16 S, R. 7 E, Emery Co. Utah, Huntington 7.5' Quad. and Hiawatha 15' Quad.

Note: Prepared from field notes by Aureal T. Cross, Christopher C. Cross and E. Blair Maxfield.

MILEAGE

Cumulative	*Interval*	
0.0	0.0	Junction Utah 10 & 31 at N edge of Huntington. Go NW on 31.

0.45	0.45	Rodeo grounds on right (N). Pediment gravels capping Blue Gate Shale.
1.45	1.0	Canal: Cottonwood Creek-Huntington Canal.
1.55	0.1	Blue Gate Shale on north (right) with 12-18" ss. ledge in lower part.
1.65	0.1	Bridge over Huntington Creek. A very sandy zone low in the Blue Gate Member of Mancos Shale. This is somewhat lower than any of the benches of Garley Canyon Ss. but is thought to be above the Ferron ss. here. This may be a top thin bench of the Ferron appearing over the east flank of the Huntington anticline. Or it might be equivalent to the sandy tongue near the base of the pinnacle SW of Price near Gordon Creek (See DAY 2, Mile 33.45 and 38.65).
1.9	0.25	Canal (North Ditch). Ranch to south. El. 5880' (1790 m).
2.1	0.2	Gravel road to north in grove. Pediment gravels conspicuous along road for 0.3 mile.
2.4	0.3	Historical marker #105.
2.7	0.3	Low cliff of Mancos Shale (Blue Gate) behind ranch buildings south of road is capped by a gray Ss. somewhat below the Garley Canyon.
2.95	0.25	Axis of Huntington Anticline. This structure, as based on the Ferron Sandstone top, has a closure of over 1250' (380 m). Phillips #1 Huntington well, which tested to Mississippian (?) at 11,250' (3,420 m) was drilled in 1954 on the low sandstone ledge to the south here which is probably Garley Canyon Sandstone. (see I.A.P.G. Field Guide 1954, plate 9.) Paul T. Walton and other geologists consider this to be a structure on the west flank of the San Rafael Swell rather than a structure related to the Wasatch Plateau.
3.4	0.45	Two benches of lower Garley Canyon Sandstone exposed to south (left). Upper ledge intersects pediment cover.
3.6	0.2	Bridge.
3.7	0.1	Good view of Emery Sandstone ahead.
3.8	0.1	Milepost 40.
4.0	0.2	Lower Garley Canyon Sandstone goes under creek about here. Upper bench dipping off Huntington Anticline at about 7°, north of road.
4.3	0.3	For next 0.3 mile the Emery Sandstone forms massive gray castellated cliffs to the north of the road ending with a pediment cover behind the Seely orchard.

4.7	0.4	Seely's orchard driveway. Emery (lower bench) exposed.
4.8	0.1	Milepost 39. Road grade steepens up canyon. For the next 0.5 mile the Emery Sandstone is split into several beds.
5.1	0.3	Bridge.
5.2	0.1	Emery Sandstone outcrop close to road (north) dips under cover to west.
5.6	0.4	Pediment boulders covering Masuk Shale above Emery for next 0.5 mile.
5.7	0.1	Milepost 38.
5.8	0.1	Cliffs of Masuk gray shale topped by three tongues of Star Point ahead.
6.0	0.2	Road to new reservoir dam on right (N) below massive cliffs.
6.1	0.1	Excellent view over reservoir of the Panther Tongue above the gray Masuk Shale slopes and the massive overlying Spring Canyon sandstone with a weak bench representing the Storrs Tongue in between.
6.2	0.1	Castellated Mancos (Masuk) Shale exposure along road is a typical condition due to cementation derived from overlying pediment. The upper 25-50' (8-15 m) of Mancos Shales below pediment covers are often cemented and form resistant, near-vertical cliffs.
6.7	0.5	Milepost 37.
6.9	0.2	Huntington Canyon Power Plant, Utah Power and Light Co. Panther Sandstone here is the first main cliff above Masuk Member of Mancos Shale slope, 200-300' (60-90 m).
7.5	0.6	Junction with road to Deer Creek Mine (Peabody Coal Co.), and to Huntington Canyon Power Plant. A major fault zone showing on the cliffs north of the road here is part of the Pleasant Valley Fault System.
7.7	0.2	Milepost 36. Excellent view to the NW. The whitecap sandstone at about mid-cliff in the re-entrant about 0.5 mile north is the top of the Spring Canyon with the Spring Canyon Coal (Hiawatha sequence) missing above (does not appear to be burned). The white, massive Aberdeen and the browner Kenilworth overlie this at the top of the cliff.
7.9	0.2	Good exposure of Masuk Shale with "ball & pillow" structure or concretionary cementation in zones on right (N) below the Panther Sandstone.

8.1	0.2	Dam on Huntington Creek.
8.3	0.2	Fault.
8.4	0.1	Major fault well-displayed. Part of Pleasant Valley Fault System.
8.7	0.3	Milepost 35. Fault on S side at 10:30 o'clock over corrals.
9.1	0.4	STOP 19, 1975 (OPTIONAL). FAULTING IN COAL-BEARING SEQUENCES Fault on south point at 10-11 o'clock and ahead about 0.5 mile at 1-2 o'clock. Junction gravel road to N. This is in the center of a main system of faults on the axis of the Straight Canyon Syncline which is NE-SW across the Wasatch Plateau intersecting the north-south graben-fault systems (Joe's Valley Graben and Pleasant Valley Graben, the latter of which plunges rapidly to the north and is lost [or buried] 4-7 miles west of Soldier Summit). The Pleasant Valley System is also transected 25-27 miles north of here by the WNW-ESE trending Fish Creek Graben. The purpose of this stop is to see the effects of faulting on the thick Upper Cretaceous coal-bearing sequences to appreciate the problems that must be met by the geologists and engineers in mapping and reserve studies and in mining the coals (Star Point and Blackhawk Formations). Continue NW toward mines.
9.5	0.4	Picnic grounds on left.
9.7	0.2	Milepost 34.
9.9	0.2	Panther Sandstone well-developed just above road.
10.0	0.1	Storrs Sandstone Tongue faulted down here to near road level.
10.3	0.3	Cattleguard. Panther Sandstone above road on right.
10.4	0.1	Manti-LaSal National Forest boundary. Massive Panther Sandstone here.
10.6	0.2	Good view of coal at 12-1 o'clock ahead. At the right (3 o'clock) the coal is burned-out.
10.7	0.1	Milepost 33. Junction. Coal stockpile storage yard entrance.
10.75	0.05	Coal road up canyon to right. (Rilda Canyon Road across Huntington Creek Valley to southwest, 0.15 mi.) Good exposures of white-capped Star Point (Spring Canyon Member). Hiawatha coal lies above this as we saw at the stop near Castlegate, Day 1. Bus turn-around in coal yard.
11.15	0.4	Manti-LaSal National Forest cattleguard.
12.4	1.25	Site of STOP 19. Major fault zone.

13.1	0.7	Major faults on north.
13.4	0.3	Dam on Huntington Creek to right.
13.8	0.4	Good view of Star Point sandstones in cliffs to north. Spring Canyon is first massive white-capped Ss. and Aberdeen lies next above, topped by Kenilworth, both of the Blackhawk Fm.
14.0	0.2	Road to Deer Creek Mine on right.
14.6	0.6	Huntington Canyon Power Plant on right.
15.4	0.8	Excellent view on north (left) above new reservoir showing gray Masuk Shale slopes (upper part of Mancos) topped by two weak benches (Panther Sandstone and Storrs Tongue) and one major sandstone (Spring Canyon) of Star Point Fm.
16.3	0.9	Emery Sandstone outcrop close to road on north.
16.6	0.3	Emery Sandstone in several beds along both sides of road.
16.8	0.2	Seely's orchard drive at base of grade. Emery Sandstone forms massive castellated cliffs to the north.
18.1	1.3	Two benches of Garley Canyon sandstone well-exposed in valley to right (south).
18.55	0.45	Axis of Huntington Syncline.
18.8	0.25	Low cliff behind ranch buildings south of road is a sandstone between Garley Canyon and Ferron below.
19.85	1.05	Bridge over Huntington Creek. Weak sandstone developed in lower part of exposure (Blue Gate Shale) (Ferron?).
21.05	1.20	Rodeo grounds.
21.5	0.45	Junction of Utah 31 with Utah 10—at Huntington. Turn right and continue south on Utah 10.

END SIDE TRIP TO HUNTINGTON CANYON & STOP 19 (OPTIONAL)

If this option is taken add 21.5 miles to road log for Day 2. Rejoin road log, Day 2, at Mile 84.75.

Day 2, Mile 126.8

SIDE TRIP. STOP 21 AND 21-A, 1975 (OPTIONAL)
TO FERRON SANDSTONE, 4 MILES E. OF CASTLE DALE
OBSERVE PROGRESSIVE SOUTHWARD COAL DEVELOPMENT IN UPPER FERRON SANDSTONES.

Study of Ferron Sandstone and associated coaly zones is in the south sides of Secs. 30 & 29 and the north sides,

Secs. 31 & 32, T. 18 S, R. 9 E, Emery Co., Utah, Hadden Holes 7.5' Quad.

SIDE TRIP *Road Log* begins at center of Castle Dale. Note: Text and collation from field notes by Aureal T. Cross, Christopher C. Cross and E. Blair Maxfield.

Leave *Day 2 Road Log* at *Mile 126.8* (at Emery County High School following trip to Straight Canyon-Joe's Valley) and proceed into Castle Dale to the south.

MILEAGE *Cumulative*	*Interval*	
(Day 2 Log)		
126.8		Emery County High School intersection at Utah 29. Turn south.
127.2	0.4	Cemetery on west side of street.
127.85	0.65	Intersection with Utah Road 10 at traffic light in Castle Dale.

Commence SIDE TRIP TO STOPS 21 AND 21-A, 1975 (OPTIONAL)

Side Trip	*Interval*	
0.0	0.0	Center of Castle Dale. Proceed east and north.
0.6	0.6	Leave Castle Dale.
0.9	0.3	Road curve ahead to NE up through very dark Blue Gate Shale.
1.4	0.5	Milepost 40.
1.6	0.2	Junction 5684. "Old Spanish Trail" to east over San Rafael Swell. Stock pens on right (SE corner of junction) and electric transmission line to east. Leave State Road 10. Turn right on "Old Spanish Trail."
2.8	1.2	End of pavement.
3.8	1.0	First turn in road to northeast. Road starts up very low dip-slope above the top of the Main (Middle) Bench of the Ferron sandstone. Road travels along a section of Ferron shales and siltstones, some more typical of Mancos Shale, above the Middle Bench of Ferron Ss. This shale is best exposed in the ravine to east paralleling the road (a NE headwater fork of Dutchman's Wash) and in small knobs to west of road. This shale is overlain by a series of alternating thin sandstones, siltstones, and shales and, near the top of the low scarp to the west, *carbonaceous and coaly shales and thin coals.*
4.0	0.2	The uppermost coaly zone is on the left (northwest) side of road. The lower coal zone, with some thin layers of coal, is in the bottom of the wash to the SE. The total section is 115' thick above the Middle Bench of Ferron.

4.1 0.1 STOP 21, 1975 (OPTIONAL), COAL ZONES DEVELOPING IN UPPER FERRON

Bench mark at about middle of section (U.S. Coast and Geodetic Survey, D - 40, 1934, el. 5661' (1720 m) el. on Sec. line between Secs. 30 and 31, T. 18 S, R. 9 E, Emery Co., Utah). Road crosses 2nd coal zone (lower) 0.2 miles ENE as it cuts across edges of lower and lower shales and siltstones to the top of the 2nd Bench of the Ferron. Coaly zone above Second (Main) Bench of Ferron and below Upper (3rd) Bench is exposed on the east-facing scarp of the low cuesta west of road here. A A higher coal zone, 15 to 20 feet above, is exposed a little further along to the northwest just under the sandstone ledge which forms the apparent top of the 3rd Bench of the Ferron Sandstone.

This double coaly zone, between 80 and 110' above the Middle (Main) Bench of the Ferron Ss. here, marks the maximum regression of the Mancos Sea at this time. If this is a southward extension of the Vernal Delta system, which is the postulated source for the shoreface sands forming the two lower benches of the Ferron here, then it is the only outcrop in the Castle Valley where a coaly sequence is exposed except in the Cleveland-Elmo area (DAY 2, Mile 65.8-71.15, STOPS 18 & 18A, 1975 (OPTIONAL). Palynologic analysis has proved to be inconclusive as to source area.

It must also be considered that this 3rd (Upper) Bench of the Ferron and its associated coaly shales, siltstones and carbonaceous zones, may have developed from the maximum northward prograding of the Ferron (Last Chance) Delta and its overlap of the nearshore-type sands which form the two lower benches. If this could be so, then the source of these offshore sands may actually be the Ferron Delta rather than the postulated Vernal system to the north.

A lower carbonaceous zone in the first 30' or so of section above the Middle Bench is to be seen particularly low in the gully (Dutchman's Wash East Fork) to the SE.

4.3 0.2 Road crosses lower coaly zone.

4.5 0.2 Turn 90° toward SE and continue up dip-slope at approximate contact of base of lower coaly zone and uppermost sandy layers of Middle (2nd) Bench of Ferron.

4.65 0.15 Electric transmission line.

4.9 0.25 Crest of hill 5832 and crest of north end of small anticlinal fold known as the "Castle Dale Structure" ("Oil Well Dome" on topographic sheet). Trail to the south here for 0.6 mile along the crest to Buckhorn Knob (5858') and to two oil well tests drilled to the Navajo Sandstone

at 3600' (1100 m) depth. Wells are spotted on topo sheet near the NE Cor., NE ¼, SE ¼, SE ¼, Sec. 31 (though address given on log as SW ¼, Sec. 32).

Road starts E and then NE down through Middle (Main) Bench of Ferron Ss.

5.1 0.2 Top of concretion zone in upper part of Middle (Main) Bench of Ferron. This is equivalent to upper concretion zone in the Elmo-Cleveland area at STOPS 18 and 18-A 1975 (OPTIONAL). Several sandstone layers here with shaly zones between.

5.35 0.25 Top of main concretion zone at top of Lower Ferron Sandstone Bench.

5.5 0.15 Cattle guard. Large deeply incised gulch on left (NE).

5.6 0.1 STOP 21-A, 1975 (OPTIONAL). BASE OF FERRON SS.

Bus will turn around on broad flat on left (east) side of road just before road makes 180° turn to west to go down through the Ferron escarpment into the top of Tununk Member of Mancos Shale.

Walk down through sandstone scarp to see relatively conformable contact with Tununk.

At the bottom of the very steep grade the road turns east away from the cliffs across the Mancos Shale valley of Huntington Creek (Bridges over the wash at 0.6 miles east and over Huntington Creek at 0.9 mile are unsafe for bus.)

The First Bench of the Ferron Sandstone sequence grades upward from the Mancos Shale through offshore marine siltstones and into thin nearshore (shoreface?) marine sands. Above this there is a return to nearshore or offshore marine siltstones and some silty Mancos-type shales and then, with another regressive pulse, the Middle (Main) Bench of nearshore marine sand is deposited. There are no coals associated with this part of the sequence as it is too far from the coastal plain.

As we proceed on up hill, for the next 0.3 mile, the road passes through a unit of Mancos-type shale (the minor transgression referred to above), which might be considered the lower part of the Blue Gate Shale Member of the Mancos but could also be considered a late pulse of the Tununk sea.

The best exposure of concretions at the top of this bench is along the road about 0.3 mile east, at the first curve to the SW.

5.7 0.1 Cattleguard.

5.85 0.15 Main lower concretion zone.

6.1	0.25	Upper concretion zone—Middle (Main) Bench.
6.3	0.2	Curve to NW at crest of hill. Start down dip slope of top of Middle (Main) Bench of Ferron Sandstone. Several thin sandstone and siltstone beds and intercalated silty-shales and shales, which lie above this stratigraphically, are exposed in a series of low knobs and cuesta scarps to the west; road starts down the dip-slope to northwest.
6.55	0.25	Electric transmission line.
6.7	0.15	Turn down small valley to SW which has been cut into the carbonaceous & coaly shales above the top of the Middle Bench of the Ferron. The small escarpment to the ENE for the next half mile has a conspicuous coaly zone near the top about 85' (25 m) above top of 2nd Bench Ferron. The lower coaly zone, at road level here, is found in about the first 25' of beds above the main 2nd Bench of Ferron Sandstone.
7.2	0.5	Uppermost coal zone exposed on right below low sandstone ledge which caps 3rd (Upper) Bench of Ferron.
8.4	1.2	Pavement begins.
9.6	1.2	Junction with Utah Highway 10. Turn south (left) toward Castle Dale (1.6 miles), or turn right 1.8 miles on Highway 10 to Junction with Utah 29 to Orangeville, and continue north on Utah 10 27.8 miles to Price, Utah.

END. SIDE TRIP TO FERRON SANDSTONE 4 MILES EAST OF CASTLE DALE.

Note: If this SIDE TRIP is taken, add 12.45 miles to *Road Log,* DAY 2, between mile 126.8 at Emery County High School and 128.9 at Junction of Utah Roads 10 and 29, 1.8 miles north of end of log (9.6 miles) above.

Day 3, Mile 0.0

ROAD LOG THIRD DAY (OCT. 19, 1975) SOUTHERN PART CASTLE VALLEY, FERRON (LAST CHANCE) DELTA, SOUTHERN WASATCH PLATEAU, SALINA CANYON.

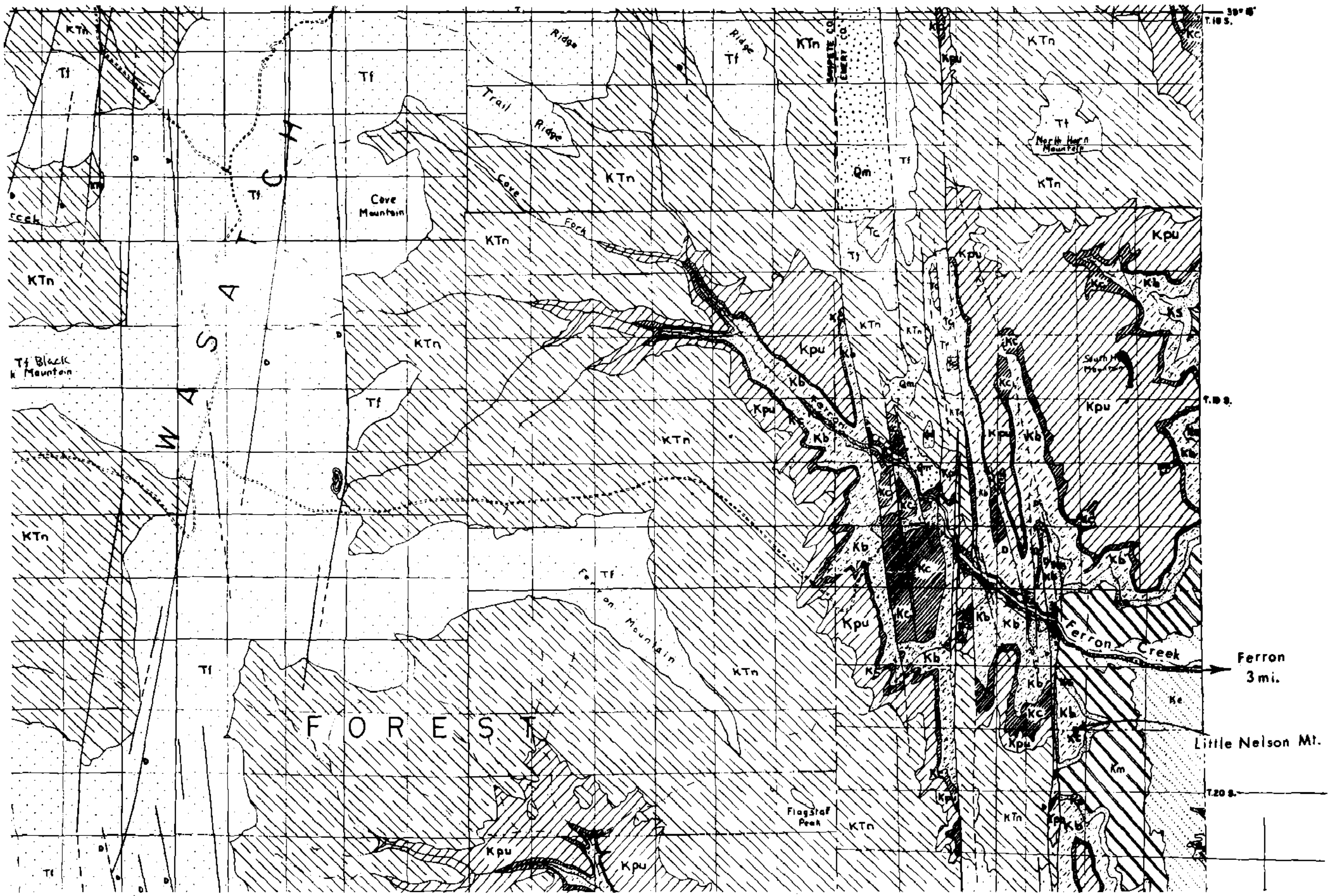
From Price to Castle Dale, Ferron, Emery and Ivie Creek area, to Salina and Salt Lake City.

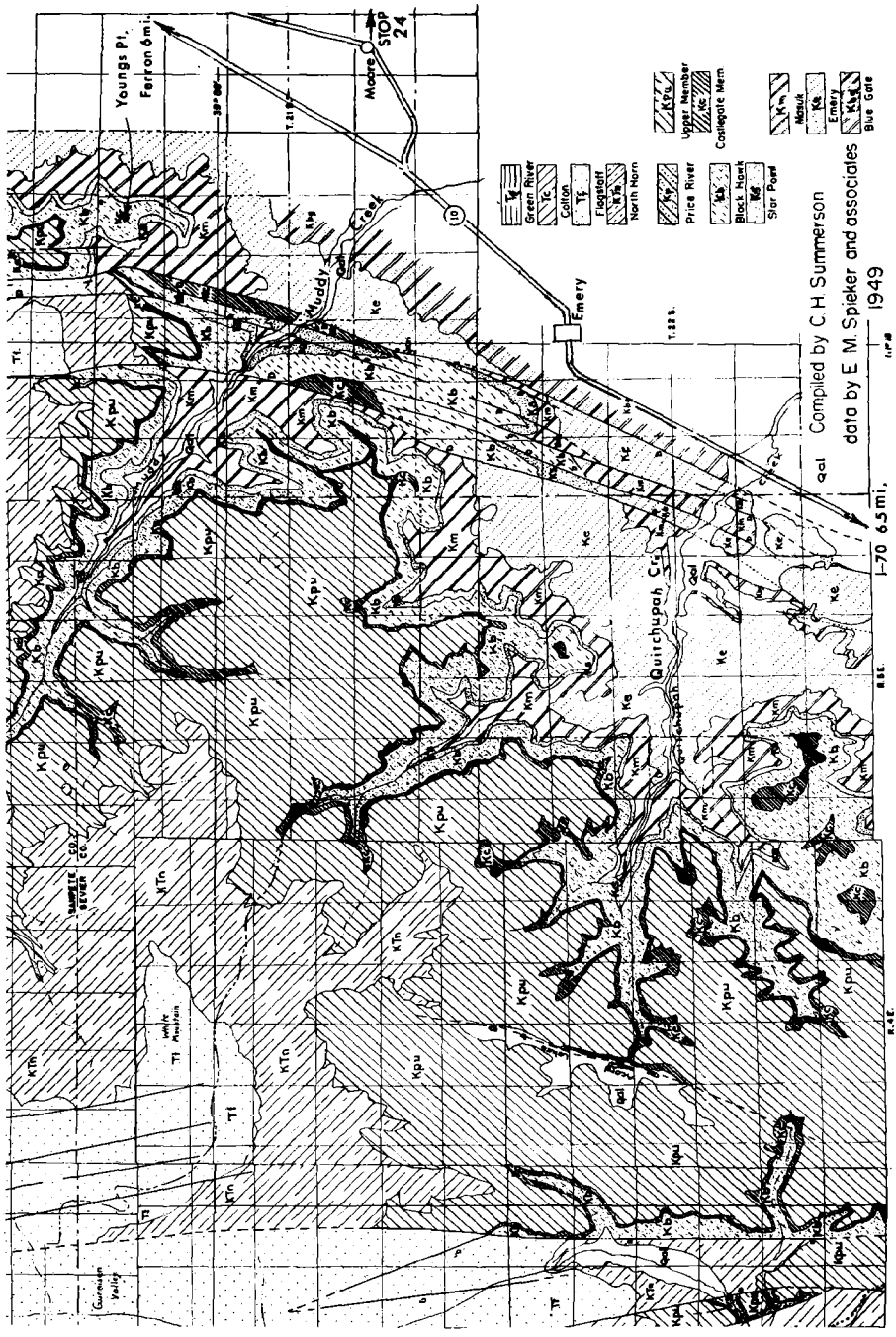
GSA 1975 ROAD LOG, PART III-A. PRICE THROUGH CASTLE VALLEY TO IVIE CREEK

Note: Most of this information has been prepared from field notes by Aureal T. Cross and Christopher C. Cross with contributions by Edward Cotter (particularly discussions at STOPS 24 and 26), E. Blair Maxfield and Lee R. Parker.

MILEAGE *Cumulative*	*Interval*	
0.0	0.0	Price. Junction of U.S. Highway 6 and 50 with Utah 10. Go south on Utah 10. For detailed log, follow DAY 2, Mile 32.2-44.25 for first 12 miles south of Price.
12.05	12.05	Junction. Utah Road 155 to Cleveland and Elmo. Continue SW on Utah 10.
12.45	0.4	Milepost 57. Excellent display of pediment caps, 5-7' thick (about 2 m), cutting at an angle across eroded surface of Blue Gate Shale.
13.15	0.7	Road cuts through Blue Gate Shale, both sides.
13.45	0.3	Milepost 56. Road rises ahead onto pediment.
13.95	0.5	Crossing deep wash (Wildcat Draw). Passing lane.
14.45	0.5	Mancos Shale road cuts at top of hill. Milepost 55. Note the greatly reduced size of the pediment gravels here at the greater distance from the source compared with those alluvial fans with giant boulders near Sunnyside. The trail at right (W) 0.1 mile ahead goes NW toward the Wasatch Cliffs up the pediment called "Poison Spring Bench." This bench is rising to the WNW at 90' per mile (about 28 m) where Utah 10 crosses it here; 2-3 miles west it is 125' (38 m) per mile; and between 7 and 8 miles WNW (11-13 km) it is rising 320' (100 m) per mile! The Hiawatha Mine is at the head of Poison Spring Bench.

Figures 22A, B, Mile 43, 64.1, 65.5, Day 3, Structural features.
Geologic map with major structural features of the SE portion of the Wasatch Plateau and adjacent western part of Castle Valley. The southern part of the Joes Valley Graben, beginning just south of Cottonwood Creek-Straight Fork (the north ½ of T. 18 S, R. 4, 5, 6 and 7 E, are not shown on either Figure 3 or 22 here, but for the main structural feature of the north half of the Wasatch Plateau, see Figure 3). Note the large number of faults and graben crossing Ferron Creek, at the east edge of the Wasatch Plateau. South of Ferron Creek, Little Nelson Mt., Nelson Mt., and Youngs Point are all isolated from the Plateau by the resulting graben. Note on this map the relatively unfaulted condition of the Wasatch Plateau for several miles west (of the Joes Valley system) to the faults paralleling (or part of) the next graben to the west, the Musinia Graben. This is extremely important in ultimate utilization of the Blackhawk coals of the headwaters area of Muddy Creek, Quitchupah Creek and its two main headwater tributaries, Convulsion Canyon and Water Hollow, and Saleratus Creek, further south. South of Youngs Point, the faults cut the lower strata in front of the main escarpment, paralleling Utah Highway 10 to south of I-70 at Fremont Junction (see Mile 95.2, Day 3). They are most clearly demonstrable where they have cut benches of Emery Sandstone from Muddy Creek (Mile 64.4, Day 3) southward. (Map modified from Spieker, 1949, Utah Geol. Soc. Guidebook No. 4.)


WASATCH
FOREST
Cove Mountain
Trail Ridge
Ridge
Cove Fork
Ferron Creek
Ferron Mountain
North Horn Mountain
Black Mountain
Flagstaff Peak
SANPETE CO.
EMERY CO.
T.18 S.
T.19 S.
T.20 S.
39°
Ferron 3 mi.
Little Nelson Mt.
KTn
Tf
Tc
Qm
Kpu
Kb
Kc
Ks
Km
Ke


Youngs Pt.
Ferron 6 mi.
Moore
STOP 24
Muddy
Emery
Quitchupah Cr.
I-70 6.5 mi.
Compiled by C H Summerson
data by E M Spieker and associates
1949
Green River
Colton
Flagstaff
North Horn
Price River
Upper Member
Castlegate Mem
Black Hawk
Star Point
Masuk
Emery
Blue Gate
White Mountain
Cottonwood Valley

15.45	1.0	Potter Wash, Milepost 54. Panther Ss. well displayed on Wasatch escarpment.
16.35	0.9	Very large arroyo (Sand Wash). Milepost 53 is 0.15 mi.
16.55	0.2	View of imposing promontory, "Red Point," at 2 o'clock, SW of Huntington, which shows burned zone of the Hiawatha above the Spring Canyon.
17.9	1.35	Airport east of highway.
18.1	0.2	Gravel road to east (left).
18.4	0.3	Cedar Creek at N edge of wide valley.
19.2	0.8	Jct. Utah State Road 155 and Utah 10, 19.25 miles SSW of Price, Utah, 7.15 miles SSW of point where we left Highway 10 for side trip to Elmo-Cleveland area yesterday, Day 2, at mile 44.25. (This junction is *equivalent* to cumulative mileage 82.6, DAY 2, at end of *Cleveland-Elmo Side Trip.*) Huntington Lake ahead, el. 5839' (1775 m).
19.35	0.15	Milepost 50. Excellent view of Masuk Shale & Star Point Fm. ahead over Huntington.
19.85	0.5	As you round the curve to the west, going down off the pediment surface, "Red Point" is well-displayed. The Panther Tongue of the Star Point Formation is the first cliff at the top of the Mancos Shale (Masuk Member). The Spring Canyon Member of the Star Point is the massive Ss. overlain next above the burned-out Hiawatha coal sequence. This burn, which oxidized the iron in the sands and clays above, imparts the red color to the rocks.
21.05	1.2	Huntington Creek bridge. Curve to left into north edge of Huntington.
21.35	0.3	Road Junction of Utah Road 31 with Utah Road 10. Utah 31 goes up Huntington Canyon and across the Wasatch Plateau into the San Pete Valley to Fairview. (See Road Log for SIDE TRIP UP HUNTINGTON CANYON and STOP 19, 1975 [OPTIONAL] at end of road log for Day 2, Mile 156.7, p. 72).
21.8	0.45	Traffic light at center of Huntington.
22.75	0.95	Drive-in theater. Milepost 45 ahead 0.1 mi.
23.35	0.6	Road to Lawrence ESE.
23.65	0.3	Deep wash (McElprang Wash). Milepost 46 is 0.1 mile.
23.95	0.3	Bridge over Guymon Wash.
24.75	0.8	Milepost 45. Profile of the SW extension of "Red Point" at 3-4 o'clock (4 mi WNW). Burned zone in Spring

Canyon; baked shales are mostly lower Blackhawk. Panther Tongue is first sandstone in the 3 bench profile above the Masuk Shale. The Storrs Tongue, which can scarcely be differentiated on the cliff face, shows clearly as a bench above the Panther and below the Spring Canyon.

The Emery Sandstone at 4-5 o'clock rises away from near the base of the cliff and intersects the pediment surface at a low angle.

25.75	1.0	Bridge over Five Mile Wash, north branch.
27.0	1.25	Junction of south end of loop-road to Lawrence to the NE.
27.55	0.55	Junction Utah 29 with Utah 10. State Road 29 goes west to Orangeville. (This was Mile 90.95 in DAY 2 Log and start of Side Trip to Cottonwood and Straight Canyon to Joe's Valley—STOP 19, 1975.) Continue SSW into Castle Dale.
29.45	1.9	Junction 5684 with old Spanish Trail to east. This is equivalent to Mile 1.6 on Side Trip east of Castle Dale to STOP 21, 1975. (See Road Log for Side Trip, STOPS 21 and 21-A, 1975 [OPTIONAL], at end of Day 2 log.)
29.95	0.5	Cuts at curve through very dark Blue Gate Shale with almost no sand or silt.
31.05	1.1	Center of Castle Dale. Caution light.
31.35	0.3	Bridge over Cottonwood Creek.
31.65	0.3	Milepost 38.
32.05	0.4	Bridge and road to east.
33.35	1.3	Bridge.
33.55	0.2	Site of new Emery Plant of Utah Power and Light. Coal to be brought from Huntington Canyon mines.
33.70	0.15	Milepost 36.
34.25	0.55	Junction with Utah 57 north to Orangeville.
35.75	1.5	Milepost 34. Rest area with tables and toilets. "Cedar Bench" at 3 o'clock shows the diminishing sandy character of the Panther and Storrs Tonques, i.e., the lower part of the Star Point Ss. The burn is on the Spring Canyon. The entire Blackhawk sequence is exposed with the Castlegate above forming the cap.
36.75	1.0	Milepost 33. Bridge 0.05 mile ahead.
37.05	0.3	Road cuts in Blue Gate at 3 o'clock. Excellent exposure of several castellated escarpments of Emery Sandstone in lower mid-distance.
38.05	1.0	Road to Clawson.

Figure 23, Mile 43, Day 3, (6.7 miles west of Ferron up Ferron Creek Canyon). Looking N at faulted Wasatch escarpment in a southward extension of Joes Valley Graben System. The magnitude of the main fault is indicated by the position of the upper bench of the Emery Sandstone ("Em") and the complete Masuk Member of the Mancos Shale ("Mas") above it up to the Panther Tongue of the Star Point Fm. To the west of the fault, in the downthrown block, less than half the Masuk Shale is present to the level of the valley floor of Ferron Creek. Some minor displacements west of the main fault pictured here are indicated. A second major fault is conspicuous 0.5 miles west; a third zone 0.9 miles west; and another major fault zone, with considerable dislocation of strata between numerous faults, occurs 1.4 miles west at Birch Creek. The Spring Canyon Ss ("SC"), which forms the first conspicuous cliff above the Mancos Shale, is extensively shattered at the right (above) as well as to the left (W) of the main fault here. On the south side of the canyon (behind the figure in the picture) Little Nelson Mt. is set off from the plateau by this main fault of the Joes Valley System. (For orientation of this, see Figure 22A.)

38.45	0.4	Road east to Clawson.
38.75	0.3	Main road into Clawson.
39.65	0.9	Milepost 30.
39.75	0.1	Wash. Good view of castellate escarpments of Garley Canyon Ss. in foreground. Wasatch cliffs show burned-out Hiawatha coals (Spring Canyon) on left above the first whitecap ss. and good coal splits showing at the right end of the cliffs. The Storrs and Panther Tongues below are barely distinguishable from the Masuk Member of the Mancos Shale below. Emery Sandstone does not show well from here behind the Garley Canyon. Note the down-faulted block through the canyon at 2 o'clock. The white cliffs toward the top are Tertiary. This is associated with the Joe's Valley Fault system and graben structure.
(adjust 1 mi.)		
42.95	2.2	Center of Ferron.

43.0	0.05	Road east to Molen and Larson Ranch.
		SIDE TRIP STOP 22, 1975 (OPTIONAL).
		For road log to Molen, STOP 22, see end of road log at Salina. Day 3, Mile 128.9. Add 10.8 miles if this trip is taken.
43.5	0.5	Ferron Creek bridge.
43.6	0.1	Junction. Road east along Ferron Creek SIDE TRIP STOPS 23 and 23A, 1975 (OPTIONAL). For Side Trip to STOPS 23 and 23A over Ferron Sandstone and developing coaly zones, see SIDE TRIP ROAD LOG. *(Add 15.6 miles if this trip is taken.)*
43.6		Ferron Creek Road Junction.
44.9	1.3	Road cuts in lower Blue Gate Shale (Mancos).
45.6	0.7	Mancos Shale slope held up by pediment. View of Young's Point (8982' el.) to WSW, just 3000' above the valley here. Emery Sandstone benches can be seen in the distance at the upper end of the sloping pediment.
45.8	0.2	Deep wash; bridge. Road climbs up over a spur of Blue Gate Shale to the south from this valley.
47.2	1.4	*Top of hill with deep cuts in Blue Gate Shale which is* very dark here with almost no sandstone lenses, no concretions and very little silt.
48.0	0.8	Wash.
48.2	0.2	Junction of Old Highway 10 with Utah 10. Bear left on Old Route 10. Rejoin Highway 10, 5.5 miles SW of this junction, after SIDE TRIP to STOP 24, 1975 AT DRY WASH SE of Moore.
49.9	1.7	Junction with south-heading secondary road to 0.5 mile east of Moore. (Because of bad surface at this time we will have to continue on Old Highway 10 to Moore.)
51.7	1.8	Junction 6296 at NW corner of Moore. Turn east for SIDE TRIP to DRY WASH STOP 24. Return to this Junction at Mile 62.5

Day 3, Mile 51.7

SIDE TRIP. STOP 24, 1975. TO DRY WASH SE OF MOORE. DELTA PLAIN COALS—RELATION TO STACKED, PROGRADING-DELTA SYSTEMS.

Study area about 3 miles SE of Moore, from the N Center to the SE corner, Sec. 34, T. 21 S,

R. 7 E, Emery County, Utah, Emery 1 NE 7.5' Quad. (Preliminary).

Note: Part of text from Edward Cotter and collation and additional notes by Aureal T. Cross, Christopher C. Cross and E. Blair Maxfield.

Leave main State Highway 10 at DAY 3, Mile 51.7 at Moore.

MILEAGE			
Cumulative		*Interval*	
GSA 1975	Side Trip		
51.7	0.0	0.0	Junction, BM 6269' el. at Moore, Emery Co. Proceed due east.
52.2	0.5	0.5	Junction 6228 with old Rochester Road due N. Continue east on gravel.
53.0	1.3	0.8	First curve to SE.
53.1	1.4	0.1	Town dump on right.
53.25	1.55	0.15	Cattleguard.
54.4	2.7	1.15	Wooden bridge. Heavy traffic take dirt detour through wash. Bus may not be able to proceed. If so, bus can turn around about 150 yards NW (back). Walk from here to first outcrop is 0.6 mile SE.
54.6	2.9	0.2	Base of dip slope of top of Ferron with Blue Gate Shale in low scarps on right (W).
55.0	3.3	0.4	Cattleguard in canyon at notch through Upper Ferron Sandstone. Fluvial section to S & W. We will proceed down through the canyon with Ferron cliffs on both sides to the base of the section (0.8 mile) or to the base of the prominent ripple-marked ss. (slabs on west side of road), 0.45 mi.
55.05	3.32	0.05	Coal below Upper Sandstone on narrow promontory on left (N). Same as coal mined across road high on north facing scarp. The total opening is 76" high but there is only 21" of coal at the bottom and 7" at the top separated by 48" shale. This is 10'-15' above the ripple-marked sandstone (FIRST DELTA CYCLE TOP) which we will see at the next bend in the canyon.
55.25	3.55	0.2	Top of lower coal zone goes under creek at base of promontory on right (at bend). Base of ripple-marked sandstone dips under cover to NW. This lower coal zone is probably equiva-

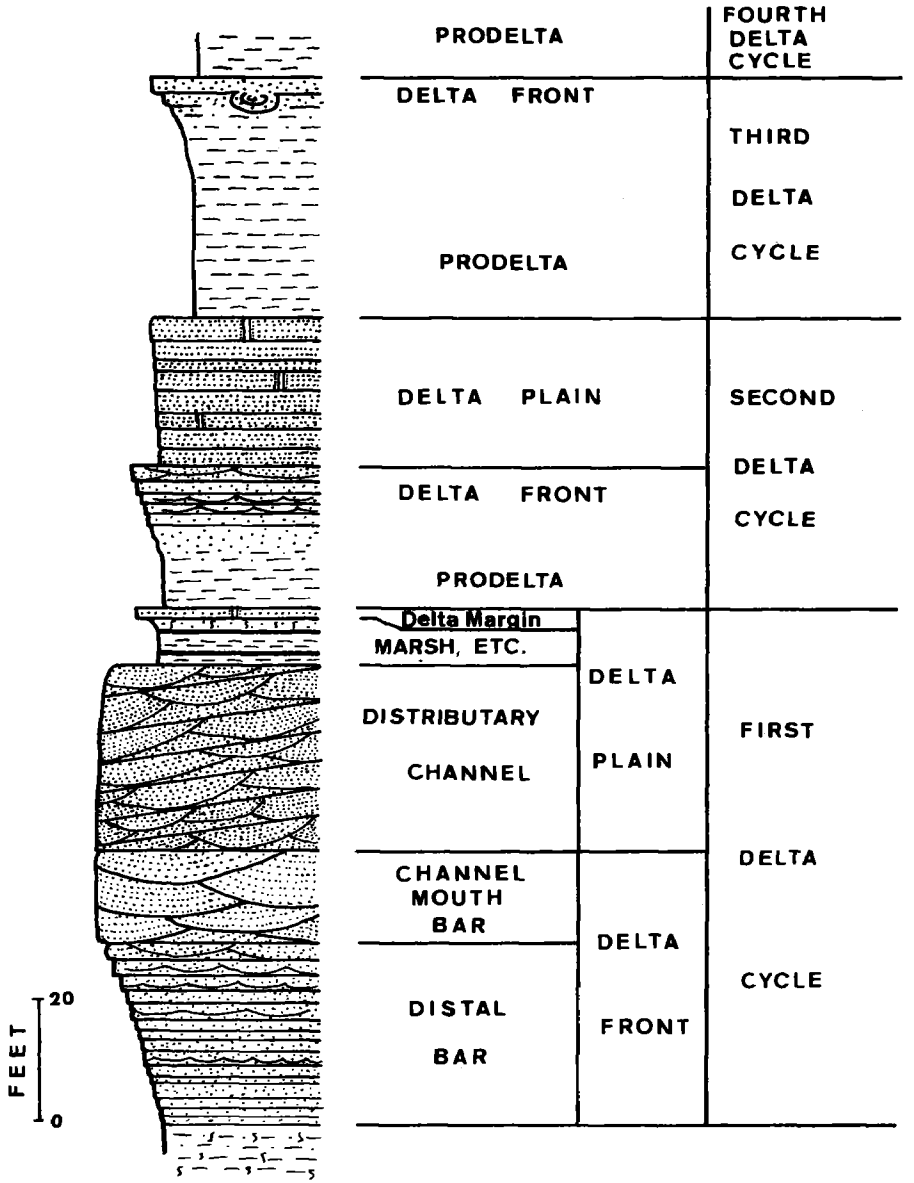
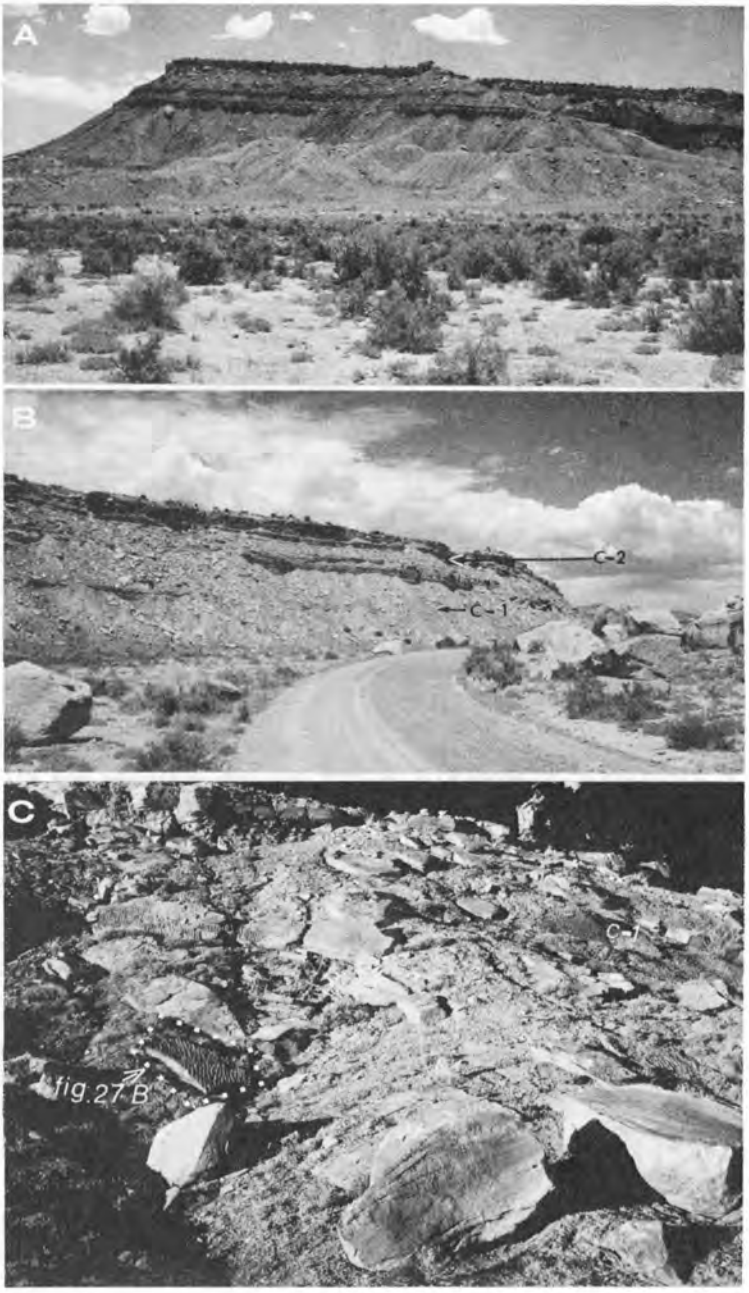


Figure 24, Mile 58.95, Day 3, Stop 24, Dry Wash east of Moore.
Diagrammatic stratigraphic section identifying sedimentary environments of various strata and indicating their grouping into cycles (Cotter).

			lent to the coaly zone seen in the Ferron Creek section to the NNE 8.2 miles.
55.35	3.65	0.1	SW facing slope ahead on left strewn with ripple-marked slabs; from cliff forming ss. at top.
55.4	3.7	0.5	Concretion zone at top of upper layer of First Bench (double) of Ferron Sandstone above Tununk Shale (in First Delta Cycle, Prodelta and Distal Bar).
55.5	3.8	0.1	Coal below ripple-marked ss. on east-facing scarp (right); same as coal dipping under cover at 55.25, one quarter mile NW. Another coal near top of canyon wall, below top sandstone (and perhaps interlayered in it), is equivalent to coal mined at point near cattleguard where we entered the canyon.
55.9	4.2	0.4	Mouth of canyon where road turns left (E).
57.1	5.4	1.2	Good view to west of upper 100' of Tununk Shale capped by First (Lower) Bench of Ferron which has some concretions visible along the top but the whole double bench is less well developed here than further NE at Castle Dale and the Cleveland-Elmo area. Turn around on flats. Retrace route with opportunity for detailed examination of sections beginning at rippled sandstone.
58.3	6.6	1.2	Mouth of canyon.
58.85	7.15	0.55	Concretion zone at top of Lower Bench Ferron.
58.95	7.25	0.1	Ripple-marked sandstones.
			STOP 24, 1975

Figures 25A, B, Mile 58.3, Day 3, Dry Wash east of Moore.
25A. View of Ferron Ss, Lower and Middle Benches, looking S from near mouth of Dry Wash Canyon.
25B. View of Ferron Ss looking W up Dry Wash. The lowest coal ("C-1") is equivalent to the coal zone marked "C-1" in Figure 25C, which is below the first delta cycle. The coal zone near the base of the upper sandstone ("C-2") is probably equivalent to the first delta cycle coal at Stop 24 (Mile 58.95) and to the coal mined near the place where we entered the canyon (Mile 55.05) near cattleguard.
Figure 25C, Mile 58.95, Day 3, Stop 24, Dry Wash.
This low slope is strewn with ripple marked slabs which came from the lower layers of the sandstone above. A coal zone ("C-1") is present about half-way up the slope. The relationship of this part of the section to the whole section pictured in Figure 26 is indicated by dotted outline in the lower right of Figure 26. A close-up of the rippled slab outlined here is shown in Figure 27B.


A
B
C-2
C-1
C
C-1
fig. 27 B

DISCUSSION OF DELTA CYCLES OF FERRON SANDSTONES AT DRY WASH, SOUTHEAST OF MOORE.

Ed Cotter

The Ferron Sandstone Member of the Mancos Shale is a regressive clastic wedge flushed generally eastward from the Sevier orogenic belt during middle Carlile time. In the southern part of Castle Valley this regression is recorded by the Last Chance Delta (Hale, 1972), whose deposits constitute a cliff-forming, coarsening-upward sequence at the base of the Ferron, almost continuously for a distance of 45 miles (72 km). Typically the deltaic sequence is 40 to 80 feet (12-24 m) thick, although in places it is thicker. It is underlain by the marine Tununk Shale Member of the Mancos Shale and overlain by deposits of the Ferron fluvial facies.

Facies of the Last Chance Delta were displaced sequentially to the north as the delta prograded into water on the order of 40 feet (12 m) deep in a relatively stable depositional basin. This northward progradation is also indicated by the generally northward inclination of the delta front beds, by the south-to-north orientation of distributary channels, and by the south-to-north orientation of current-produced sedimentary structures in both the deltaic and fluvial facies.

The Last Chance Delta formed as a broad, fan-shaped complex with numerous coalescing and overlapping subdelta lobes in the style referred to as a high-constructive lobate delta. The degree of marine reworking during active delta progradation was relatively minor, but was sufficient to produce an essentially continuous fringe of delta front sand. Superposition of later subdelta lobes over foundered earlier lobes has produced multiple delta cycles at many locations.

At essentially all exposures of the Last Chance Delta the deltaic sequence consists, from base to top, of three major facies: prodelta, delta front, and delta plain. Thin prodelta sandstones and siltstones are overlain by thicker, laterally continuous, sheetlike delta front deposits. Typically the delta front beds are essentially horizontal or have a slight primary inclination to the north, but several delta front sequences have steeper, Gilbert-type, primary inclinations.

It is the delta plain facies in which some of the more significant and extensive Ferron coals formed. Between and among the generally northward flowing distributary channels were broad marshes with occasional standing water bodies (lakes, etc.). When active progradation ceased, delta lobes foundered and the destructive shore-zone processes reworked deltaic sands into thin delta margin sands that cap the delta plain facies. Subsequently, at many localities, another subdelta lobe built out over the first.

Features at dry wash

Dry Wash is about ten miles (16 km) from the northernmost extent of the Last Chance Delta. In this distal portion of the delta, several delta lobes prograded seaward, subsequently foundered, and were in turn covered by another delta lobe. At this location there are four cycles of deltation stacked vertically. With conditions fluctuating so often, facies are not as thick and widespread as they are farther to the south. There are

Figure 26, Mile 58.95, Day 3, Stop 24, Dry Wash Section east of Moore.
View looking down on south-facing wall on north side of Dry Wash. Group will walk from point "O" (left center bottom) to point "X" (upper middle right) through the second delta cycle. Note the abandoned channel filled with carbonaceous mudstone overlying the laterally inclined distributary channel sandstone of the first delta cycle. Two coal beds are at "X," and beach sandstone, inclined to the left, at "Y." Following ascent of the slope, the group will proceed southwestward toward "Z" and the mouth of the canyon. Inset lower right appoximates top of Figue 25C (Cotter).

only two thin, weakly developed coal beds here; these are in delta plain facies of the first delta cycle.

The suggested procedure is to walk up through the sequence on the slope north of Dry Wash, beginning just west of the yellow road sign. A walk westward along the road will pass through the same sequence, but many of the units are very poorly exposed. Those of us who huff and puff up the north slope will find that the top of the second delta cycle affords a comfortable, near-horizontal walk westward on a very gentle surface over the cattleguard where the vehicles will be waiting.

A. *First delta cycle*

Black Tununk Shale is visible in parts of the rubble-veneered slope, but the thin prodelta facies is not well-exposed right here (can be seen about 100 yards to the east). The rippled sandstone slabs on the surface come from the well-bedded, coarsening-upward sequence just above. The ripples are symmetrical and occur throughout most beds in vertical trains, in the manner of an unusual ripple drift cross lamination. Ripple crests are oriented generally about north-south. These bedded and rippled sandstones were deposited in the distal part of the delta front environment. In the coarser and better-sorted upper part of this sequence, well-developed trough cross lamination showing generally northward transport signify deposition on the distributary mouth bar crest, the upper part of the delta front facies.

A second zone of trough cross-laminated sandstone overlies this. From the road below one can see that this unit shows lateral migration (to the west) as inclined large-scale beds. The troughs themselves indicate sand wave migration to the north or northeast. Where inclined, this sandstone is about 30 feet (9 m) thick, but where we walk through it, it is only about 15 feet (4.5 m) thick as a result of a channel form in the carbonaceous shale above. This sandstone was formed by a distributary channel as it flowed through the delta plain; some meandering of the channel caused the observed westward lateral migration.

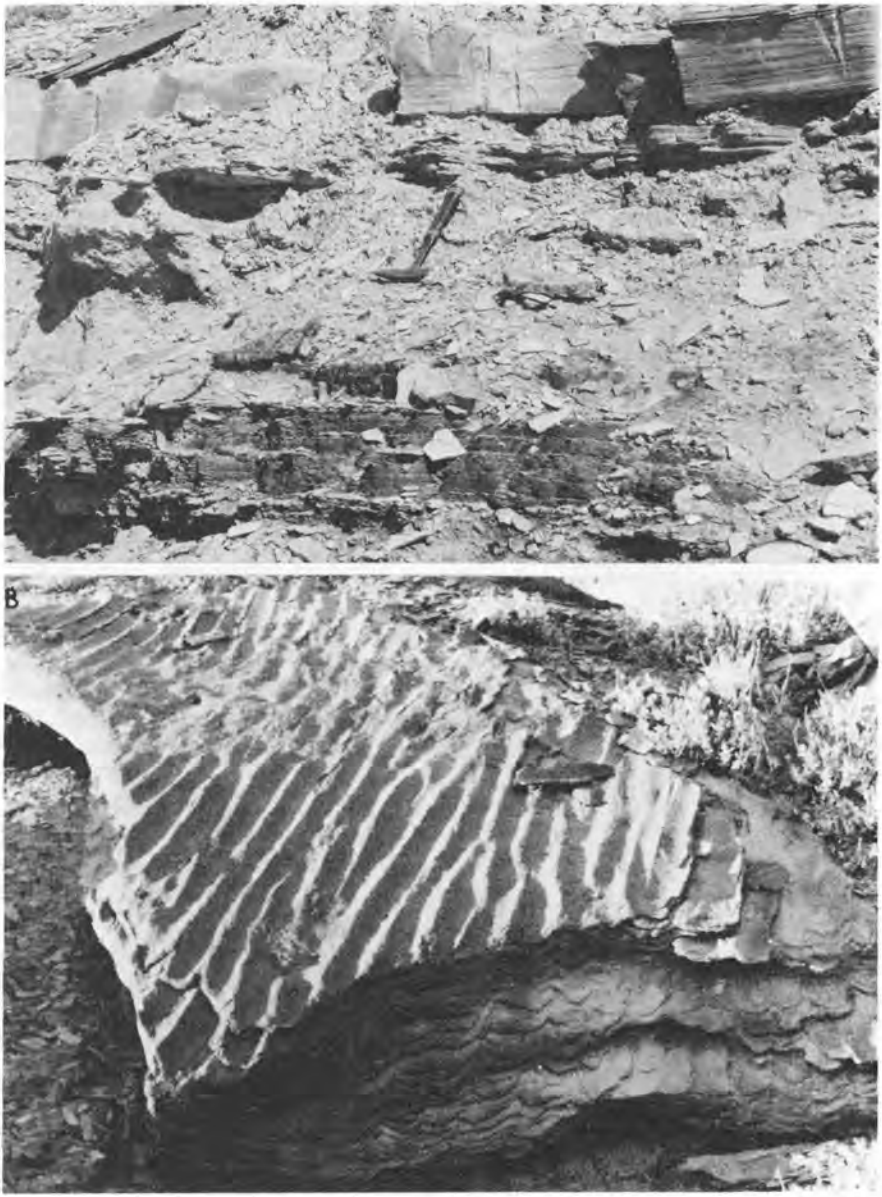
More delta plain sediments are present above this sandstone in the form of carbonaceous siltstone, bioturbated sandstone, and two beds of coal. Above the laterally inclined, 30-foot (9 m) thick part of the sandstone this coal-bearing unit is very thin, but when followed eastward it can be found to thicken to over 15 feet (4.5 m) in a channel form. Evidently a channel abandoned by a distributary stream was filled by finer delta plain muds and carbonaceous matter.

The two coal beds are beds B and C of Lupton (1916). They are among the most northerly of the Ferron coals, and nowhere in the vicinity are they more than 2.3 feet (0.7 m) thick, acording to Doelling (1972, p. 465), who also says that the coal appears lenticular and perhaps even discontinuous.

Capping the delta plain sequence is a thin, widespread sandstone. The even parallel lamination and broad trough lamination, as well as the biogenic structures of *Ophiomorpha* and *Rosselia* indicate that this is a destructive delta margin sand, formed as the delta plain subsided.

B. *Second delta cycle*

About 15 feet (4.5 m) of poorly exposed rippled sandstone and siltstone leads upward to another 15 feet of coarsening upward (to medium-



Figures 27A, B, Mile 58.95, Day 3, Stop 24, Dry Wash east of Moore.

27A. First delta cycle. Coal near base is overlain by bioturbated sandstone in center, and thin-laminated, *Ophiomorpha*-burrowed destructive delta margin sandstone at the top. (See location "X," Figure 26) (Cotter).

27B. Rippled sandstone block characteristic of lower part of delta front beds capping the lower slope at this Stop. These are stacked, symmetrical ripples. (See Figure 25C for orientation to source beds at top of slope.)

grained sandstone) thin bedded sandstone with ripple lamination, even parallel lamination, and toward the top, trough cross lamination. This is the delta front facies, recording the progradation of another delta lobe.

Above the delta front facies the delta plain facies is quite unusual. Above a thin zone of poorly exposed siltstone is nearly 20 feet (6 m) of well-sorted, white, medium-grained sandstone with even, parallel lamination and burrows of *Ophiomorpha.* The beds have a gentle primary inclination to the northwest. The only interpretation possible, in my opinion, is that this is a beach sandstone, formed in response to destructional processes operating on a foundering second delta cycle. Yet the exceptional thickness of these beds is a problem.

The problem is compounded when one walks westward toward the cattleguard and finds that this beach sandstone is laterally equivalent to a steeply inclined, *Ophiomorpha*—burrowed point bar deposit. The point bar is also medium-grained. Major bedding surfaces are inclined toward the north-northwest, whereas trough cross lamination within indicates current transport to the east-northeast. This laterally migrating channel must have been very close to the delta front to be burrowed so extensively by *Ophiomorpha.* A possible explanation of the association of this point bar and the beach to the east is that as the delta subsided for the second time and delta margin sands were being formed, a readvance of a meandering distributary channel cut out some delta plain sediments near what is now the cattleguard.

C. *Third delta cycle*

At least 30 feet (9 m) of fine-grained deposits covers the sandstones just discussed; these record the readvance of the sea over the foundered delta plain. Above the covered interval is bedded sandstone and shale. The sandstone is dominantly even parallel laminated, and there are many large and apparently chaotic ball-and-pillow structures.

This sandstone-rich sequence was deposited as the delta front facies of a third delta cycle. The delta did not prograde this time as far northward as earlier, for delta plain sediments were not deposited here.

D. *Fourth delta cycle*

From the area of the cattleguard one can look south down the side valley or west out toward the Wasatch Mountains and see another coarsening-upward sequence above the third delta cycle. This is similar to the third cycle and records the progradation of the delta front facies a fourth time. As in the third cycle below, delta plain facies did not develop.

MILEAGE			
Cumulative		*Interval*	
GSA 1975	Side Trip		
59.2	7.5	0.25	Coal on promontory to right. (Mined across road to north.) This coal seam varies considerably in thickness, partings, and character in the 3 exposures examined here. At the claim stake at the west rim of the canyon, the upper bench is 12"-15" thick, mostly coal; the parting is about 30", and there is additional coaly shale at the

Figure 28, near Mile 55.0 or 59.2, Day 3, Dry Wash.
Laterally inclined distributary channel deposit stratigraphically equivalent to the beach sandstone at the top of the second delta cycle. Most sandstone beds have *Ophiomorpha* burrows; they are not merely on and in the uppermost beds. Delta front beds of the second delta cycle are below the inclined beds. The cattleguard is just off the photo to the left (Cotter).

			base of the bottom bench, below the 21" found at the mine across the road. High up on the cliffs across the canyon, southeast of the prominent slabs of ripple-marked sandstone, this coal is only about 10" thick and contains shale and silt in high percentage. The continuity of the seam has not been clearly demonstrated. This is the most northerly development we have seen of clearly identifiable coal in this part of the section. It is represented by the upper coal zone at the Ferron Creek section and the carbonaceous & coaly shale zone above the Second (Main) Bench of Ferron at Castle Dale and in the Cleveland-Elmo area.
59.25	7.55	0.05	Cattleguard. 4th Delta cycle of Cotter at left (SW) and ahead (west). As we go up around the curve to the right note there is no apparent coal in this fluvial cycle.
59.85	8.15	0.6	Wooden bridge (detour through wash on left).
61.0	9.3	1.15	Cattleguard.

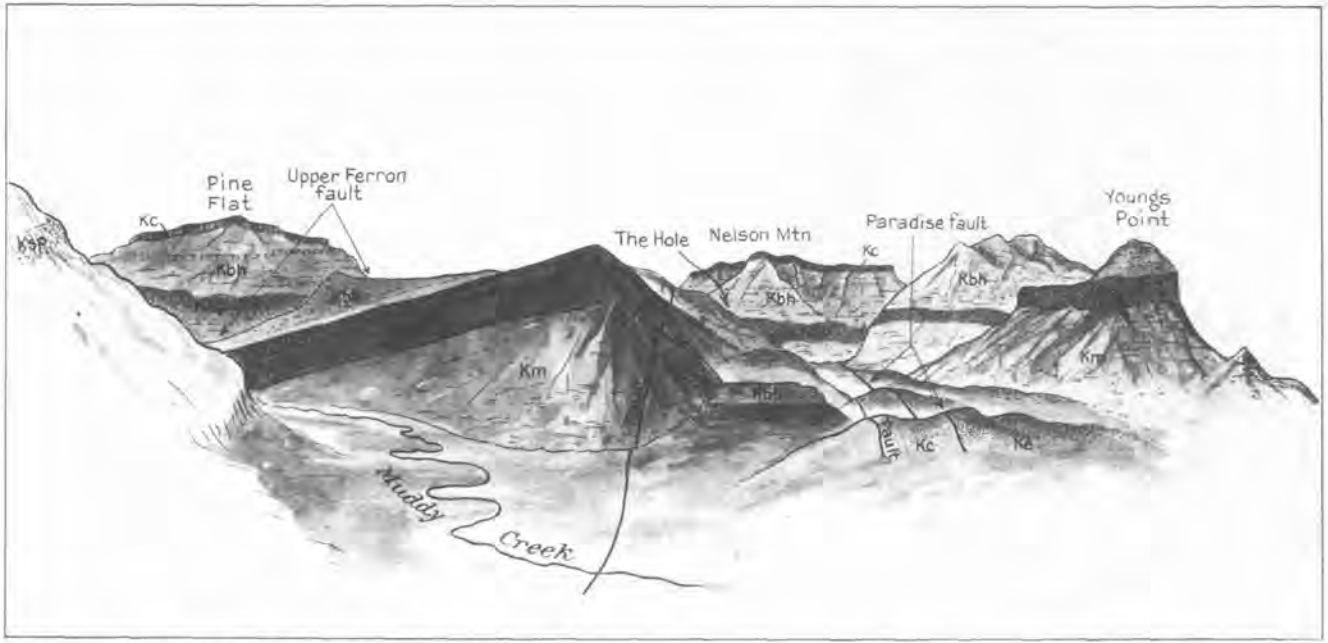


Figure 29, Mile 64.4-66.0, and 82.55-83.15, and 90.7-92.8, Day 3.

E. M. Spieker's drawing (reproduced from U. S. Geol. Surv. Bulletin 819, pl. 26) of the Joes Valley Graben and associated faults where the fault system cuts the edge of the Wasatch Plateau between Ferron and Emery. South of here the faults may be identified most easily where they cut the several benches of Emery Ss which extend eastward into Castle Valley from the eastern escarpment of the Wasatch Plateau. As we descend the hill toward Muddy Creek, on Old Highway 10 from Moore, we have an excellent view into "The Hole" behind Youngs Point northward along the Joes Valley Graben, behind (west of) Nelson and Little Nelson Mts., toward Ferron Creek (see Map, Figure 22A). The Castlegate Sandstone is conspicuous at or near the top of Nelson Mt., Pine (Sage) Flat and perhaps other high prominences of the Wasatch Plateau here including Youngs Point, but as can be noted from Spieker's panoramic drawing, the Castlegate is also dropped down to the floor of the valley north and south of Muddy Creek, over 1500' (460 m), below these detached promontories of the Wasatch Plateau. We will also have a good view of these features as we travel on I-70 toward Stop 26 on Ivie Creek.

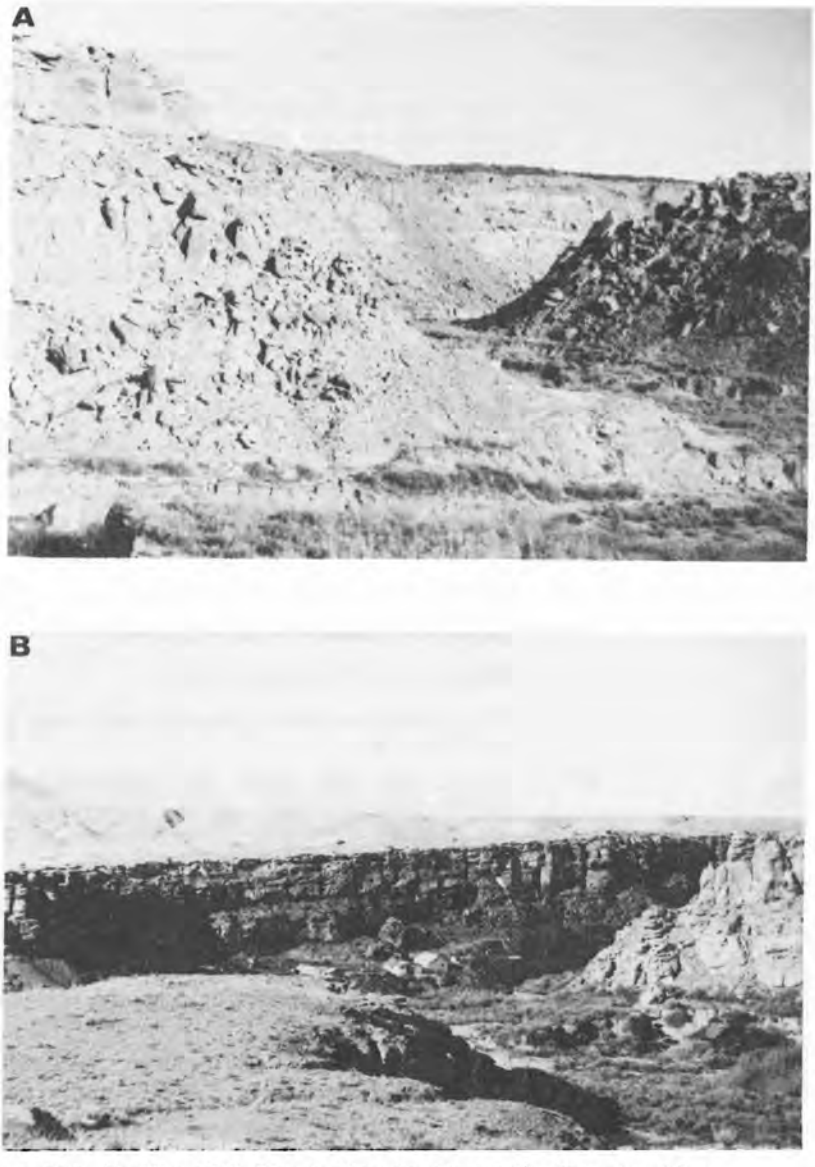
62.5	10.8	1.5	Junction 6269 with Old Highway 10 at W edge of Moore.

END. SIDE TRIP SE OF MOORE. STOP 24, 1975.

62.5		—	Junction 6269. Old Highway 10 at Moore. Turn left from Dry Wash SIDE TRIP and continue SW on Old Highway 10.
62.7		0.2	Curve at S edge of Moore.
63.4		0.7	Milepost 18. Electric transmission line.
64.1		0.7	Curve ahead down hill to right (W); excellent view up Muddy Creek; Emery benches; north to fault valley west of Young's Point. Gravel road to south here goes 6.5 miles S to "Molen Reef" Coal Cliffs exposure of Ferron Sandstones with coals.
64.4		0.3	Milepost 17. Excellent view at 2 o'clock of Emery Sandstone, several benches at base of steep slopes of Masuk Shale Member of Mancos Shale. Lowest disjunct castellated scarps at

Figure 30, Mile 66, Day 3. Emery Sandstone benches.
The Emery Sandstone Member ("EM") of the Mancos Shale increases in thickness to the SW and, as we near Emery, there are several benches through a much larger part of the Mancos Shale section than further north. So it is probable that, like the Ferron (Last Chance) Delta of earlier date in the same general area, the Emery prodelta sequence exhibited near Emery becomes deltaic or even fluvial a few miles further SW. The Star Point Formation ("SP") with the conspicuous white cap of the Spring Canyon Sandstone at the top forms the first conspicuous cliff above the Masuk Shale slopes (Upper Mancos Shale). The Storrs Sandstone is generally scarcely discernable below the Spring Canyon but the weak ledges of the Panther Sandstone below it are usually identifiable.

		mid-distance may be Garley Canyon Tongue of Blue Gate Shale Member. Panther Ss. not seen on the cliff below very massive Spring Canyon Ss.
65.2	0.8	Junction with Utah Highway 10 (which we left at Mile 48.2, DAY 3, for SIDE TRIP to STOP 24 SE of Moore). Turn left across valley of Muddy Creek.
65.5	0.3	Muddy Creek bridge. For the next mile and a half we go along a down-faulted block with Emery Ss. (?) in 2 benches in foreground and the Spring Canyon forming the first cliff in the background.
66.0	0.5	Historical monument on right.
66.4	0.4	Milepost 15.
67.4	1.0	Milepost 14. Road cuts in the Blue Gate Shale on both sides of Highway 10. Road to west at SW end of cuts.
68.35	0.95	Curve at east edge of Emery. Milepost 13 just ahead.
68.85	0.5	Center of Emery. Whole spur thrusting out toward Emery is faulted several times. A single down-faulted block sits out to the east.
69.5	0.65	Bridge 6306 over irrigation ditch at SW edge of Emery near road to rodeo grounds.
71.05	1.55	Bridge 6259 over very large wash, Christiansen Wash.
71.35	0.3	Top of hill with deep road cuts into Mancos Shale. No sandstones, sandy zones, or concretions in this zone. Milepost 10. Long view ahead across Blue Gate Shale Valley of Quitchupah Creek.
72.35	1.0	Milepost 9. Emery (?) Ss. in 3 benches.
72.8	0.45	Junction with road to Browning Mine, at confluence of Christiansen Wash and Quitchupah Creek. SIDE TRIP. BROWNING MINE IN FERRON COALS. STOP 25, 1975 (OPTIONAL). (For road log, see end of DAY 3 Log, p. 127).
72.9	0.1	Bridge over Quitchupah Creek ("Bad Water").
73.35	0.45	Milepost 8.



Figures 31A, B, Mile 72.8, Day 3, Stop 25 (optional), Browning Mine.
31A. Canyon of Quitchupah Creek below the Browning mine. At least four coal zones, two with seams 4 feet thick or more, are identifiable between the fluvio-deltaic sandstones in the cliff exposures here.
31B. Browning Mine in the canyon near the top of the thick Ferron Sandstone sequence. The mined seam (I of Lupton) varies in thickness here but it is about 20' (6 m) thick.

73.8	0.45	Emery-Sevier County line (N-S). Enter Sevier Co. Emery Sandstone along road ahead at 12-1 o'clock.
75.35	1.55	Milepost 6. Excellent exposures to west. Spring Canyon Sandstone Tongue (Star Point Formation of some; Blackhawk Fm. of Young, 1955) is split here into a massive lower half and upper half in 4-5 beds with partings. Coal lies directly above upper sandstone bed. Whole sequence very thick to north for 3-4 miles, perhaps 150', and there it appears extensively split with a very thick coal about 50'-75' above the top of the main bench. Storrs and Panther Tongue, of Star Point Sandstone Fm. below have united into about 100' siltstone or fine sandstone.
76.35	1.0	Milepost 5. Knob on right (W) of road is Mancos Shale with 2-3 benches of Emery Ss.
77.55	1.2	Cattle Guard.
77.85	0.3	Bridge 6143 over Saleratus Creek.
78.35	0.5	Milepost 3. Volcanic boulders strewn over the surfaces here derived from the Fish Lake or Aquarius Plateaus to the S and W.
78.55	0.2	Bridge over Oak Spring Creek.
78.95	0.4	The Emery sandstone sequence has many splits at 2 o'clock.
79.65	0.7	Bridge over Ivie Creek. Big fault visible at 2 o'clock. Mancos Shale on left; Emery Sandstone on right.

Figure 32A, Mile 87.4, Day 3, Ivie Creek near Muddy Creek.
Top of 17-20' (5.1-6.1 m) multiple-bedded Dakota Sandstone in center foreground. Entire Tununk Member of Mancos Shale exposed beneath conspicuous promontory of Ferron Sandstone (top center). Note several "hard benches" in the Tununk. There are abundant near-shore brachiopods and pelecypods 12-15' (3.6-4.6 m) above the Dakota here. Other invertebrate fossil zones are at 103-105' (31-32 m), 125-127' (38-39 m) (these two just above the principal lower bench of Tunuck Shale), and 186-188' (62-63 m) above the Dakota. For orientation, the first low bench with light platy surface is at 30' (9.1 m); and the second at 45' (13.7 m) (main flat at left middle). The most conspicuous is at 90' (27.5 m).

Figure 32B, Mile 85.95 and 88.8, Day 3. Uphill from Stop 26 (BYU 1974 mi 57.1, Part 2).
Parting in coal bed I of Lupton (1916), according to Doelling (1972), along I-70 on south side of highway near top of hill (just uphill from end of walk-up section, Stop 26). This is a channel sandstone which accumulated in the swamp, probably as a point bar.


A


B

81.25	1.6	Overpass. Junction with Interstate-70. Turn east (left) beyond underpass.
81.35	0.1	Enter I-70 access road. Road passes up through cuts in Blue Gate Shale. Pediment surface above covered with black andesite boulders from Fish Lake Plateau.
81.85	0.5	Junction of access road with I-70.
82.05	0.2	Highway cuts through terrace gravels (pediment) about 15' thick almost entirely of volcanic boulders.
82.55	0.5	Divided highway ends; one lane northeast.
83.15	0.6	Milepost 92. Ivie Creek Bench.
83.55	0.4	Highway begins gradual descent to NE via Dog Valley Wash through terrace gravels into Blue Gate Shale.
84.15	0.6	Milepost 93. Cuts on north side of highway are in a very sandy facies of Blue Gate Shale for next 1.2 miles downgrade to E.
84.45	0.3	Sevier-Emery County line (N-S). Enter Emery Co.
85.15	0.7	Milepost 94.
85.35	0.2	Contact of base of Blue Gate (middle Mancos Shale) with top of Ferron.
85.45	0.1	Contact top of Ferron with thin coals.
85.65	0.2	Swamp-formed coal deposits with distributary channel sands of delta plain.
85.95	0.3	Big split coal with distributary channel sand thickened to the west. Upper and lower splits almost form one bed to east.
86.15	0.2	Milepost 95. Next big road cut on left (N) just ahead.
86.25	0.1	Top of next coal below; multiple benches.
86.45	0.2	Interbedded siltstone and coal with sand lenses.
86.75	0.3	Very thick prodelta and delta front ss.
86.90	0.15	Base of Ferron Sandstones; top of Tununk.
87.1	0.2	East end of promontory.
87.15	0.05	Milepost 96. Ranch buildings in Ivie Creek valley to north. Extensive burned zones above Ferron coals ahead to east; steep Tununk

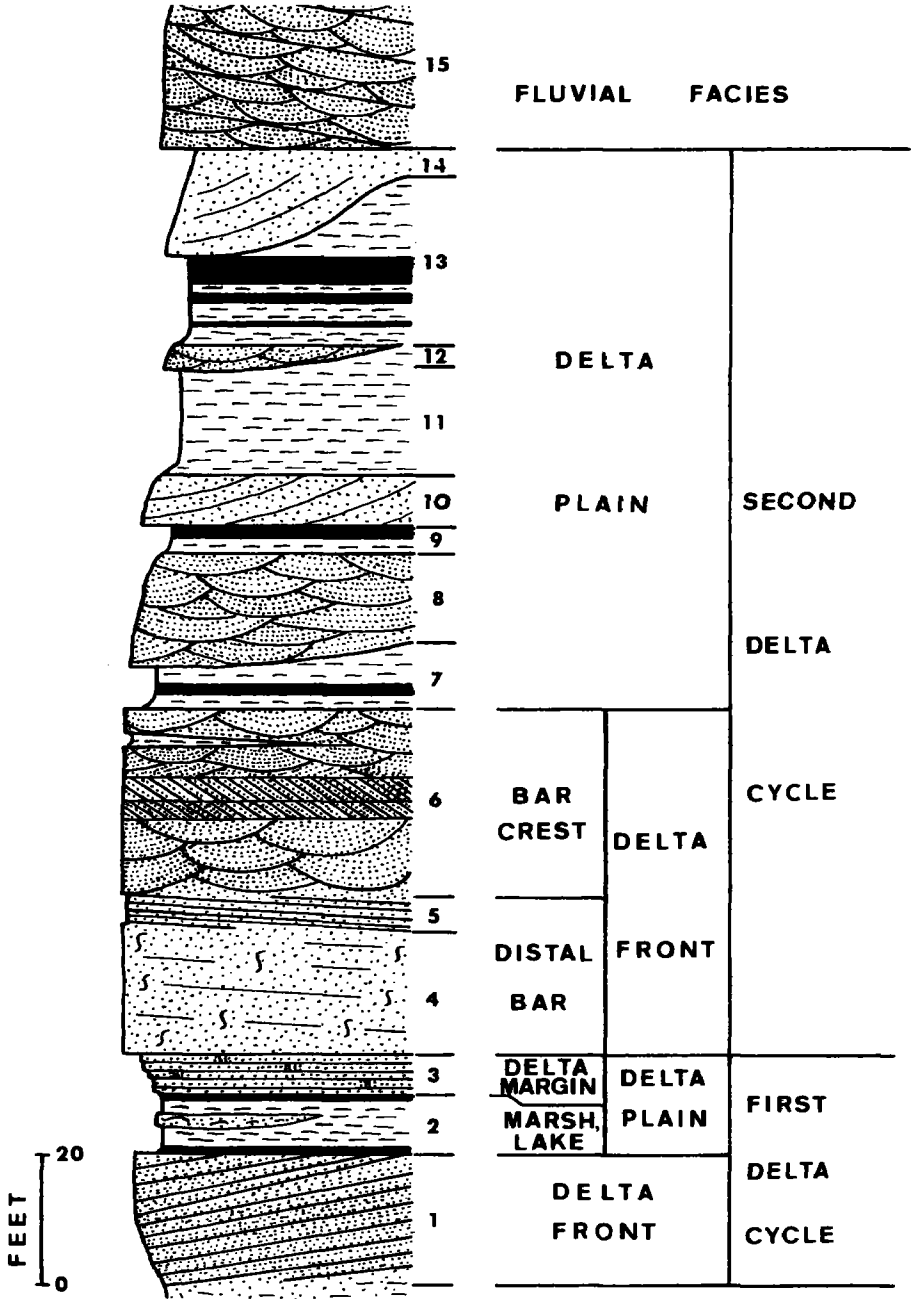
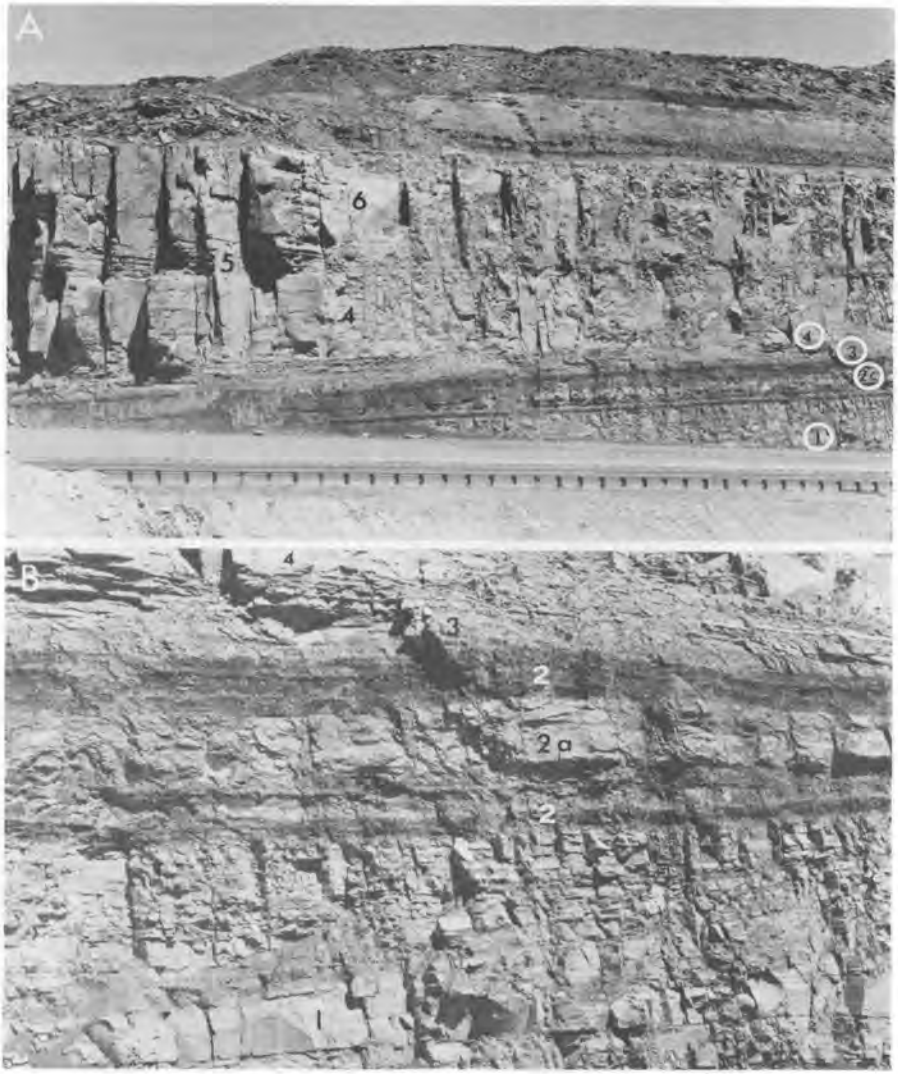


Figure 33, Mile 87.7, Day 3, Stop 26, I-70—Ivie Creek (BYU 1974 mi 56.0, Part 2). Diagrammatic representation of the sediments and paleoenvironments of the Ferron Sandstone Member of the Mancos Shale along I-70 up Dog Valley Wash from Ivie Creek (Cotter).



Figures 34A, B, Mile 87.7, Day 3, Stop 26, I-70—Ivie Creek (BYU 1974 mi 56.0, Part 2).

34A. Thick sandstone units comprising the delta front portion of the second delta cycle, units 4, 5 and 6, Figure 33. Note transitional nature of Unit 5, the more or less evenly thin interbedded sandstone, into the massive bar crest sandstone of unit 6 above. Numbers 1 to 4, in circles (lower right), are marked at exactly the same places as they are marked in the enlarged picture of the lower zones in Figure 34B (below) (Cotter).

34B. Delta front ("1") and delta plain ("2," "2a," "3") deposits of the first delta cycle and the lowermost sandstone bed of the distal bar ("4") of the second delta cycle exposed near the base of the big cut on the north side of I-70. "2a" is a sandstone deposited in a channel (distributary?) cutting through the marsh or lake sediments ("2"). Compare with Figure 33 (Cotter).

(Lower Mancos) Shale slopes beneath Ferron Ss. caps.

87.4 0.25 Pull across road to left (N) and turn around and pull along uncompleted north lane to base of promontory at about Milepost 96 and ranch buildings.

87.7 0.3 STOP 26, 1975. I-70 - IVIE CREEK. FERRON SANDSTONES & COALS. Base of conspicuous promontory on north side of gray marine upper Tununk Shale overlain by marine bench of Ferron Sandstone just west of Milepost 96 and opposite old ranch buildings on Ivie Creek valley terrace below.

Walk up along unfinished right (N) lane of highway for about 1 mile and re-board buses at about Milepost 95.

Figure 35, Mile 86.25 and 87.7 (top of section), Day 3, Stop 26.
Delta plain coals near the top of the second delta cycle (unit 13 of Figure 33) along I-70, 0.1 mile east of milepost 95 and 0.3 mile below (east of) split coal near top of hill. The coal is probably coal bed "C" of Lupton (1916).

Up valley from NW Cor., NW 1/4, Sec. 21, somewhat diagonally southwestward across the NE 1/4 and the north side of the SW 1/4, Sec. 20, and across the SE 1/4, Sec. 19, and the NW Cor., Sec. 30, T. 23 S, R. 6 E, Emery County, Utah, Walker Flat 7.5' Quad.

STOP 26, 1975. Discussion of nature and environments of sedimentation, exhibited in exposures of Ferron sandstone and coals along Interstate 70 near junction of Dog Valley Wash with Ivie Creek, about 7.5 miles (12 km) east of Fremont Jct.

Edward Cotter

General Orientation

At Interstate 70 we are about 12 miles (19 km) closer to the source area of the Last Chance Delta of the Ferron Sandstone than we were at Dry Wash. Here also there are multiple progradation deltaic sequences at the base of the Ferron, but their style of accumulation is somewhat different, and they are overlain by many coal beds and a well-developed fluvial facies.

At this locality, we shall begin on the unpaved lanes of Interstate 70 with a view across Ivie Creek to the extensive north scarp and a general discussion of the style of the Last Chance Delta exhibited there. We shall then walk up through the sequence along the north side of Interstate 70 to a point where the vehicles will be reboarded.

The Ferron Sandstone at this locality is about 450 feet (136 m) thick, whereas at Dry Wash the Last Chance Delta system was about 230 feet (66 m) thick. The unit thickens to about 800 feet (242 m) at its southernmost (sourceward) exposure, about 20 miles (32 km) away.

A. *First delta cycle*

The prodelta and delta front facies of the first cycle of progradation are much thinner and somewhat finer than on the scarp north of Ivie Creek, but the beds have the same general features and are inclined relatively steeply in the same direction at both places. This steep delta front inclination makes the Last Chance Delta a Gilbert-type delta here; the possible causes of this situation should certainly bear some discussion. Note that the progradation proceeded westward.

The delta front facies along the highway is basically a fine to medium sandstone, with poor sorting and subangular grains, containing very abundant plant debris, particularly in the finer interbeds. Some bioturbation is present, but the chief sedimentary structure is even, parallel lamination, with subordinate amounts of ripple lamination and some troughs in a cut-and-fill manner in the uppermost couple of feet.

Above the inclined beds, the delta plain consists of horizontally bedded coal and carbonaceous shale. Within this sequence is a lenticular bioturbated sandstone containing very abundant mollusk shells intimately associated with coaly plant debris. This unit represents a standing body of water (lake, etc.) on the delta plain, surrounded by marshes on and in which plant matter accumulated.

The carbonaceous delta plain facies is overlain by a relatively thin sequence of sandstone beds that contain structures characteristic of shoreface conditions. This is unit 3 on the columnar section. Most of the sandstone beds are even, parallel laminated, and some contain "wave ripple lamination." Many beds are examples of Howard's "parallel to burrowed" sequences. *Ophiomorpha* and *Thalassinoides* are the most common burrowers. Unit 3 can be interpreted as the marine destructive facies, formed as the delta plain foundered beneath the sea.

B. *Second delta cycle*

Immediately after marine conditions returned, another delta prograded across this area, this time from southwest to northeast. The distal bar of this delta front cycle (Unit 4) differs from that of most other Last Chance Delta distal bar deposits. Unit 4 is so thoroughly bioturbated that there are very few primary physical sedimentary structures remaining. Burrowing was done by *Cylindrichnus,* and some helicoid funnels (Howard) are noted. The sandstone is not well sorted through most of the unit, and scattered plant trash is quite common, including at least one *Teredo*—bored log. The few physical sedimentary structures preserved are mostly even, parallel lamination. The major bedding planes in this almost massive unit are very gently inclined toward the northeast (can be viewed on the opposite side of I-70).

Between this thick sandstone and the next (Unit 6), Unit 5 is thinner bedded and contains even, parallel laminae and stacked symmetrical ripples. Again, plant debris is abundant. This unit can be seen to be transitional between the thicker sandstones above and below.

The second thick sandstone (Unit 6) is trough and planar cross-laminated throughout, with transport generally to the northeast. This unit also has subtle gentle inclination of major bedding surfaces to the northeast. When traced to the northeast, Unit 6 thins, and it is not present in such an outstanding manner about 2 miles (3.2 km) away on the scarp north of Ivie Creek.

This thick unit probably was deposited as the crestal area of the distributary mouth bar. This is the upper part of the delta front environment, the part that is influenced by channel processes.

Above Unit 6 is a composite sequence of mudstones, carbonaceous mudstones, coals, and lenticular, plant-rich, laterally-migrated sandstones. These are various deposits of the delta plain environment, including marshes and creeks and possible crevasse splays. Because there is no marine destructional facies at the top of these delta plain units, it is difficult to define the exact transition from delta plain to alluvial plain conditions. I have arbitrarily placed the transition at the top of Unit 13, which is Lupton's (1916) Coal Bed C, because Coal Bed C is such a widespread unit (Doelling, 1972, Fig. 13, p. 439) and I subjectively feel that such a distribution is more likely on a delta plain. The sandstone units in this delta plain facies are thinner along the highway, and I have placed the boundary with the fluvial facies at the base of the first thick point bar sandstone unit.

C. *Fluvial facies*

Alluvial channel sandstones in this facies are characteristically 30 to 35 feet (9.0 to 10.8 m) thick and contain almost exclusively trough and

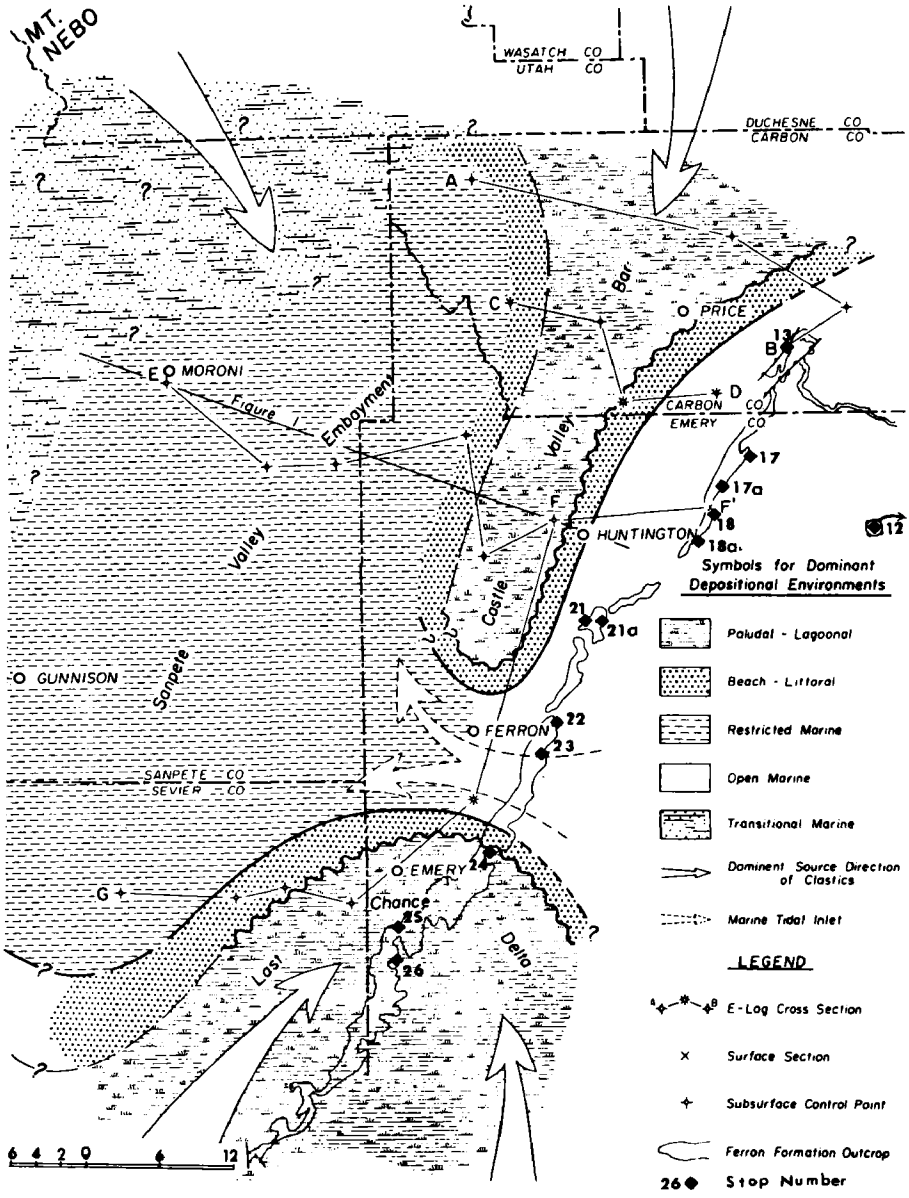


Figure 36, Mile 87.7, Day 3, Stop 26, I-70, Ivie Creek Section. Paleogeographic interpretation of early Ferron time (Upper Cretaceous) in the Wasatch Plateau-Castle Valley Area. Modified after Hale (1972, fig. 2, p. 33, *in* Plateau—Basin and Range transition zone, central Utah, 1972: Utah Geol. Assoc. Publ. 2).

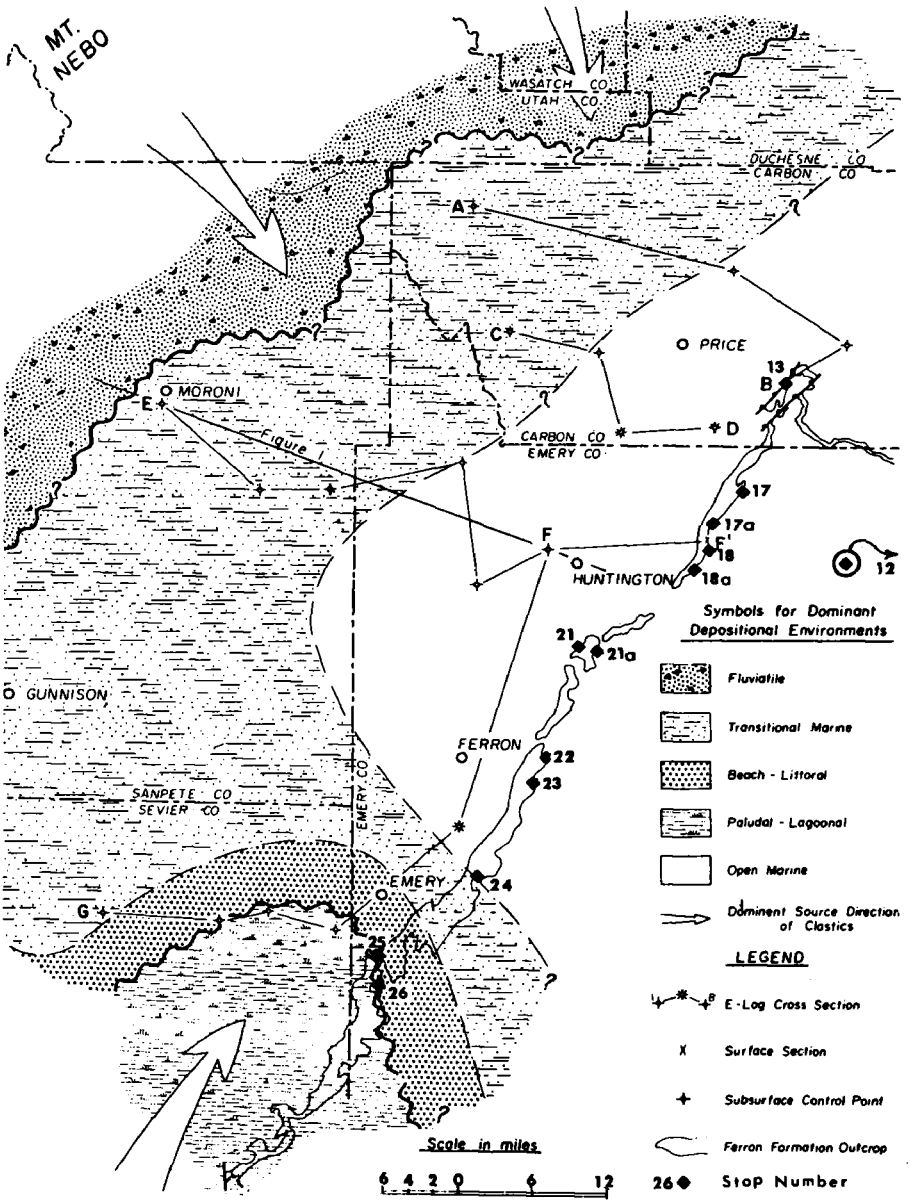


Figure 37, Mile 87.7, Day 3, Stop 26, I-70, Ivie Creek Section.
Paleogeographic interpretation of late Ferron time (Upper Cretaceous in the Wasatch Plateau—Castle Valley area). Modified after Hale (1972, fig. 3, p. 34, Utah Geol. Assoc. Publ. 2).

planar cross-lamination. Cross sections transverse to the paleoflow direction, which was generally northward to northeastward, show them to be very broadly lenticular; that is, they are elongate ribbons of sandstone that taper out at the sides. Individual sandstone bodies are wider than the dimensions of the channels in which they were deposited as a result of lateral migration of the channel caused by meandering. This lateral migration in a direction normal to the sediment transport direction can be seen in Unit 15, but a more striking example occurs just up the road on the other side of the highway in association with a split coal bed. It is well worth the effort to examine this situation before returning to the vehicles.

The finer alluvial flood plain overbank deposits are not as commonly observed in outcrop, unless they are cut back as along this highway. They comprise mudstone, carbonaceous mudstone, very thin-bedded sandstone, and coal. Information from Lupton (1916) and Doelling (1972) indicates that individual alluvial flood plain coals are not as widespread as delta plain coals. The split coal bed on the southeast side of the highway just west of mileage marker 96 is stated by Doelling (1972) to be Lupton's Coal Bed I, the same bed that is being mined at the only two mines currently active in the Ferron Sandstone.

Within these finer alluvial plain deposits the laterally migrated sandstone bodies are not at any consistent stratigraphic position, for they occur scattered through the fluvial facies in a manner dependent on the vagaries of meandering and avulsion.

END. STOP 26 STUDY AND DISCUSSION

END GSA 1975 ROAD LOG PART III-A

Day 3, Mile 87.7

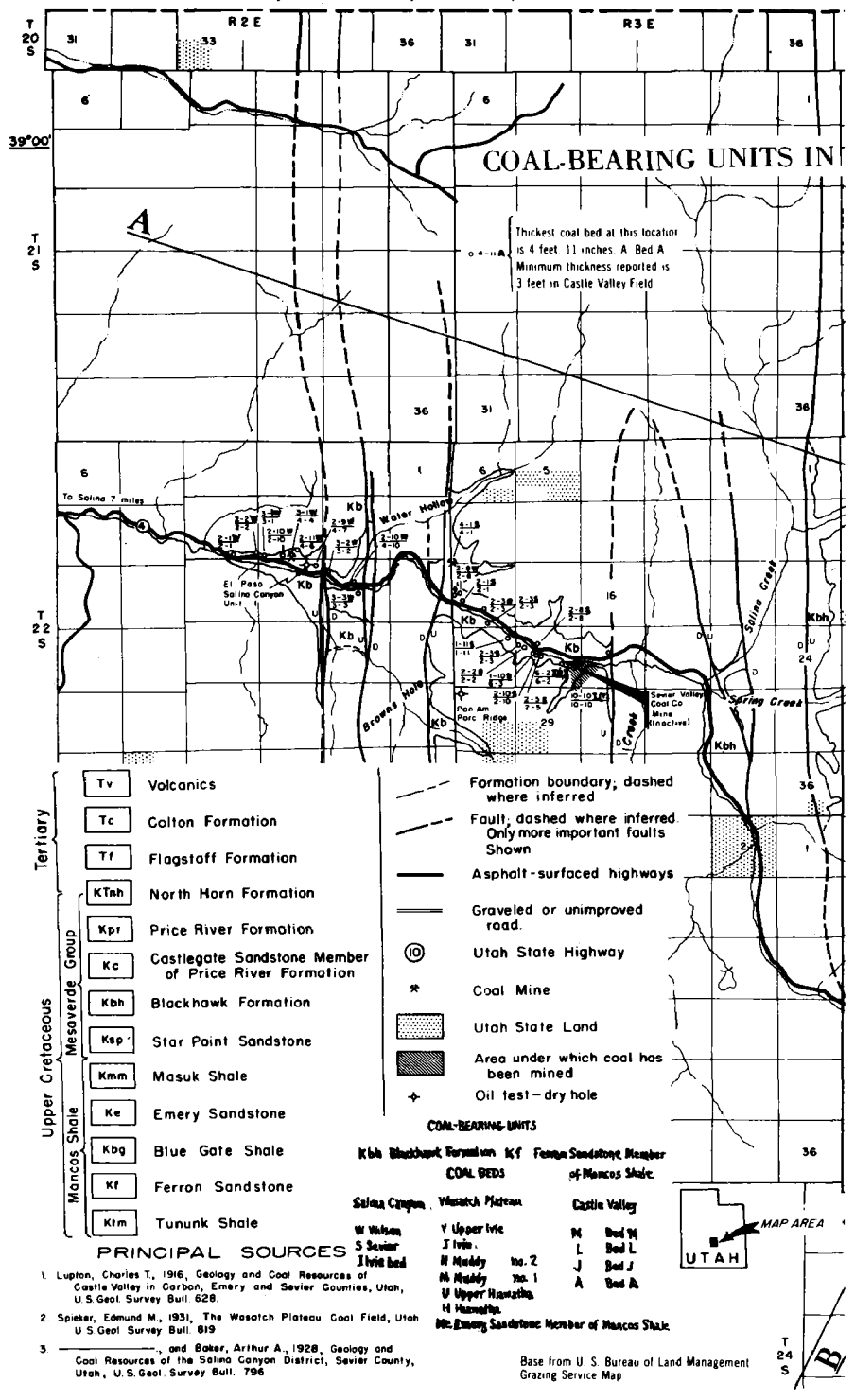
ROAD LOG. THIRD DAY (OCT. 19, 1975) CONT.
GSA 1975 ROAD LOG, PART III-B
SUPPLEMENT TO BYU 1974 GUIDEBOOK, PART II, P. 76-93
SOUTHERN PART OF WASATCH PLATEAU AND SALINA CANYON

Miles 87.7-128.9, GSA 1975, Part III-B.
Miles 55.6-93.7, BYU 1974, Part II, pp. 76-93.

MILEAGE *Cumulative* GSA 1975	BYU 1974	*Interval*	
87.7	55.6	0.0	STOP 26, 1975, I-70, Milepost 96-95. Dog Valley Wash confluence with Ivie Creek. (BYU 1974, STOP 7, Part 2, p. 76) Walk up through Ferron sequence.
88.7	(56.6)	1.0	Milepost 95. Reboard buses.
88.8	56.7	0.1	Split coal. Big channel sand below.
89.0	(56.9)	0.2	Top of split coal.
89.4	—	0.4	Top of Ferron Sandstone. Blue Gate Shale above slightly sandy.

90.4	58.0	1.0	Sevier County line; leave Emery Co.
90.7	—	0.3	Mancos Blue Gate Shale cuts concealed by pediment to west. Milepost 93.
92.4	59.7	1.7	Begin divided highway. (See BYU 1974, Mile 59.7, p. 78.)
92.7	—	0.3	Milepost 91.
92.8	(61.1)	0.1	Crest of plateau. Pediment gravels (mostly volcanic gravel and boulders) over 15' thick; Blue Gate Shale beneath.
95.6	60.8	0.8	Overpass above Utah Highway 10.
94.5	61.7	0.9	Temporary end Interstate-70. Continue west on Utah 4.
95.2	62.4	0.7	Fremont Junction. Utah 10 east and north; Utah 72 south to Fremont, 31 miles (51 km). Last Chance Creek about 6 miles due south. The small conical knob to left of road 0.2 mile (0.31 km) south is bisected by a fault. Emery Sandstone is on the right. Continue on 10 up Ivie Creek.
96.7	63.9	1.5	Look ENE at exposures of Emery Ss. in several benches truncated by thick pediment cover.
96.9	—	0.2	Look WNW at promontory with bold exposure of Spring Canyon Ss., considered to be the top of the Star Point Formation here with prominent baked zone above but also with some coal in several thin beds showing beneath the burned zone. Note, also, clearly identifiable below the Spring Canyon, the Storrs and Panther Sandstone Tongues.
97.3	64.5	0.4	Three divisions of the Star Point Sandstone are well displayed.

Figures 38A, B, Mile 98.9, Day 3, Ivie Creek Lunch Stop.
Figures 38A and B are modified from a summary map of the coal deposits of eastern Sevier County, Utah, compiled by Robert E. Maurer, principally from Lupton (1916) (SE corner), Spieker (1931) (most of Figure 38B), and Spieker and Baker (1928) (most of Figure 38A). The importance of the position of the principal coal areas on the eastern map (38B) between the major N-S trending fault and graben systems should be noted. (Originally printed as Special Studies No. 15, Utah Geol. and Mineralog. Surv., May, 1966 and reprinted in "Central Utah Coals, A Guidebook Prepared for the Geological Society of America, and Associated Societies" [Rigby and Hamblin, eds., 1966] for the Coal Geology Division field trip, Nov. 1966, Bull. 80, pl. 1 [opposite p. 112], Utah Geol. and Mineralog. Surv.).



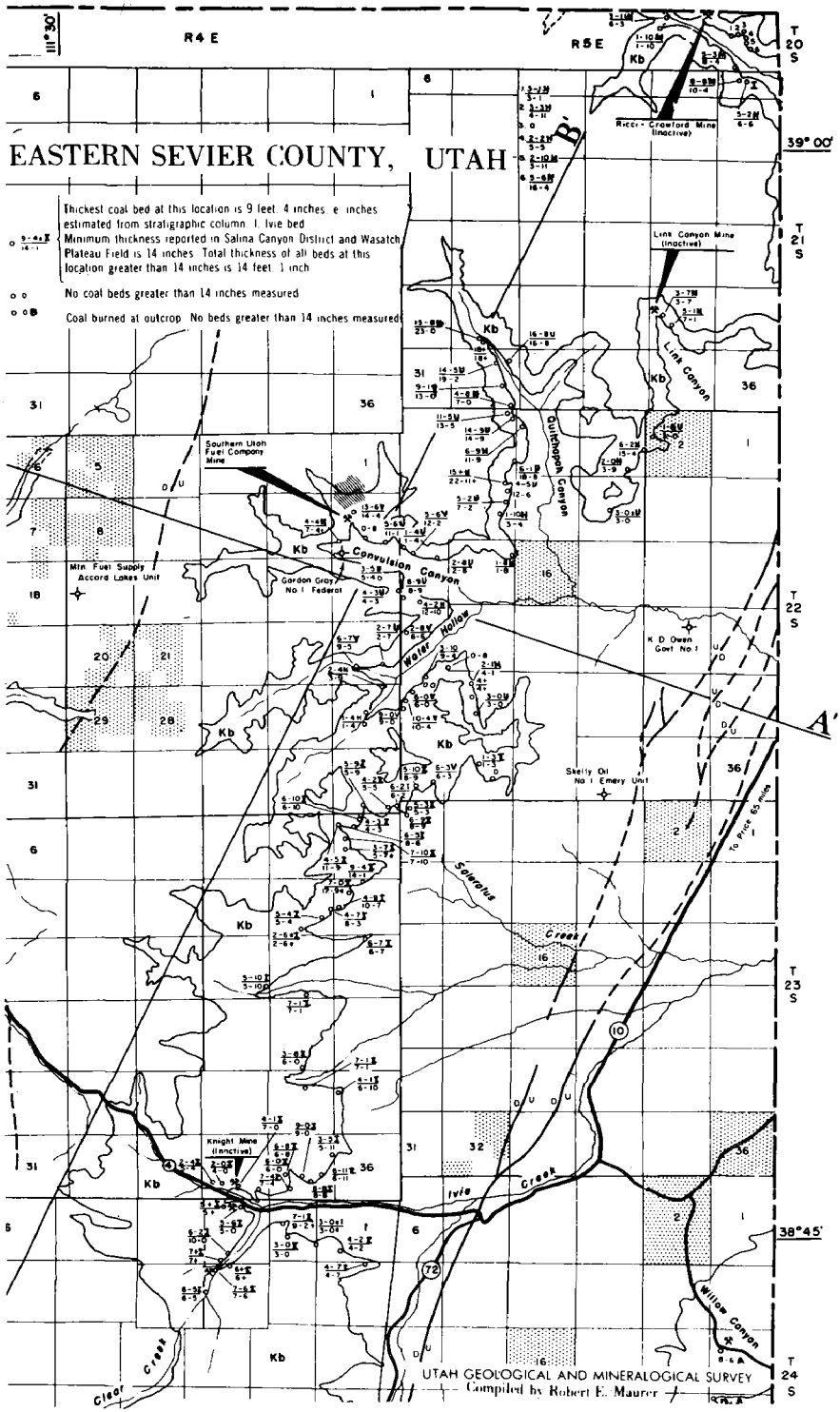
PRINCIPAL SOURCES

1. Lupton, Charles T., 1916, Geology and Coal Resources of Castle Valley in Carbon, Emery and Sevier Counties, Utah, U.S. Geol. Survey Bull. 628.

2. Spieker, Edmund M., 1931, The Wasatch Plateau Coal Field, Utah U.S. Geol. Survey Bull. 819

3. ———, and Baker, Arthur A., 1928, Geology and Coal Resources of the Salina Canyon District, Sevier County, Utah, U.S. Geol. Survey Bull. 796

Base from U. S. Bureau of Land Management Grazing Service Map


EASTERN SEVIER COUNTY, UTAH
Thickest coal bed at this location is 9 feet 4 inches. e inches estimated from stratigraphic column. l. lvie bed
Minimum thickness reported in Salina Canyon District and Wasatch Plateau Field is 14 inches. Total thickness of all beds at this location greater than 14 inches is 14 feet 1 inch
No coal beds greater than 14 inches measured
Coal burned at outcrop. No beds greater than 14 inches measured
111° 30'
R4E
R5E
T 20 S
T 21 S
T 22 S
T 23 S
T 24 S
39° 00'
38° 45'
A
A'
B
B'
Kb
Southern Utah Fuel Company Mine
Min. Fuel Supply Accord Lakes Unit
Gordon Gray No. 1 Federal
Convulsion Canyon
Quitchupah Canyon
Link Canyon Mine (Inactive)
Link Canyon
Rees-Crawford Mine (Inactive)
K. D. Owen Govt. No. 1
Skelly Oil No. 1 Emery Unit
Molar Hollow
Knight Mine (Inactive)
Ivie Creek
Sqwaw Creek
Willow Canyon
Clear Creek
To Price 65 miles
72
10
UTAH GEOLOGICAL AND MINERALOGICAL SURVEY
Compiled by Robert E. Maurer

98.6	65.3	1.3	Highway crosses Clear Creek.
98.9	65.6	0.3	LUNCH STOP. IVIE CREEK & SPRING CANYON SANDSTONE. Camp ground on right. Excellent close-up view of cross-bedded, regressive Spring Canyon Tongue of Star Point Sandstone across Ivie Creek.
99.0	—	0.1	West entrance to camp. (Bus may not be able to pull through here.)
99.1	65.8	0.1	Small coal mine across creek up on bank to south is in the Spring Canyon. The coal is equivalent to Hiawatha. Plant fossils in profusion associated with coals up on bluff to right (north) opposite the mouth of Red Creek, just ahead. Small mines formerly worked these Spring Canyon coals on north bluff, as well. These coals and plant beds have been sampled for study. There is a bed bearing good *Araucaria* leaves and cones about 45' above the Spring Canyon Sandstone, and 100-200 yards (90-180 m) west of the coal mines on the north side, about midway between two invertebrate fossil beds (pelecypods) which lie 2' (0.6 m) and 70' (21 m), respectively, above the top of the massive Spring Canyon Sandstone. These seem to be marine and, if so, would indicate the coals here are probably lagoons behind occasionally breached bars.
99.6	—	0.5	Tommy Hollow to left. Blackhawk fluvial sands are exposed from here on to top of hill.
101.2	—	1.6	Old Woman Road to NE up onto Old Woman Plateau. Massive white-cap sandstone of Blackhawk visible through the trees at 2 o'clock.
101.6	67.9	0.4	Summit 7900' (2400 m) el., Emigrant Pass. (See BYU 1974, p. 81-82, Mile 67.9.) Just ahead are good road cuts through fluvial Blackhawk Sandstones with swamp mudstones of probably limited extent intercalated.
102.1	68.4	0.5	Aspen Hollow Road on left (SW). Note white-cap Blackhawk Sandstones.
102.4	—	0.3	Milepost 81—abandoned reservoir.
103.6	—	1.2	Begin divided highway I-70. End Utah 4.
104.7	71.0	1.1	View of Mount Musinia ahead NNW.
105.1	—	0.4	Crossing east boundary of fault trace, Musinia Graben.

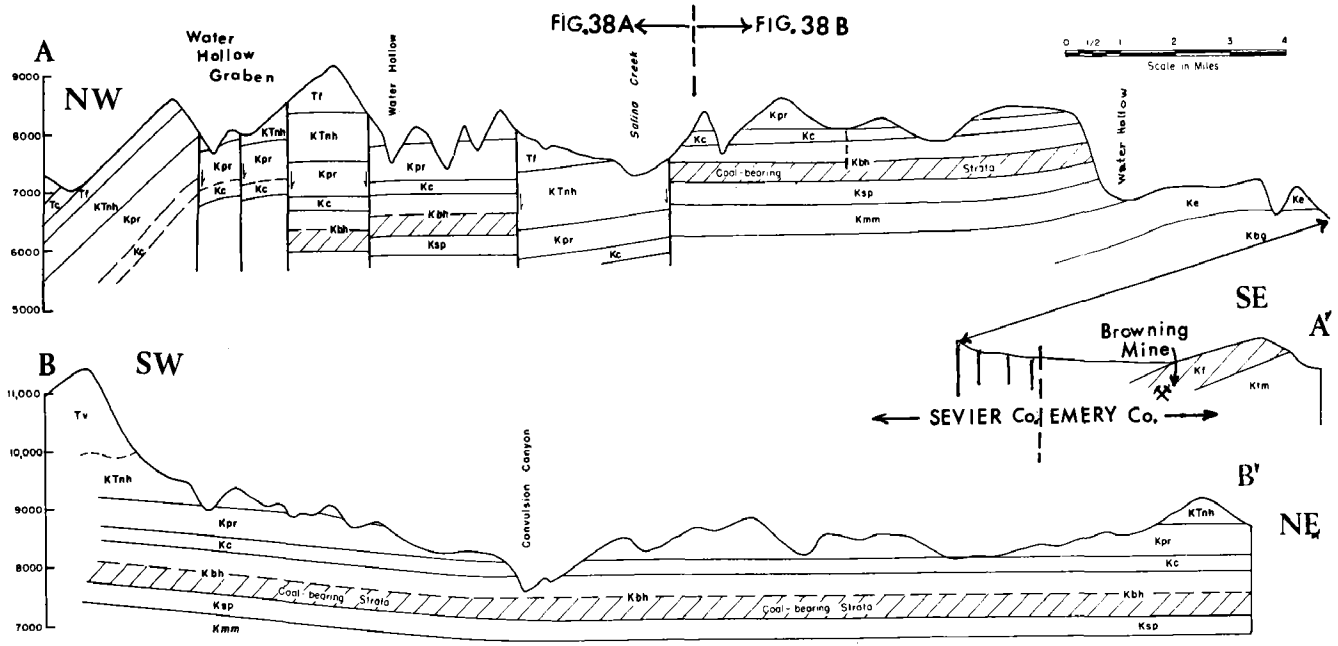


Figure 39, Mile 98.9, Day 3, Ivie Creek Lunch Stop.
Cross-sections "A-A'" and "B-B'" from Figure 38A, B, showing the general distribution of coal-bearing sequences (Cretaceous Blackhawk Formation and Ferron Member of Mancos Formation) in Eastern Sevier County, Utah. "A-A'" crosses the area approximately paralleling and 4.5 miles north of our route of travel across the Wasatch Plateau from here and down Salina Canyon. Prominent faults of the Joes Valley System have been added here east of the Wasatch escarpment near the county line. East of these faults the subtended portion of the Cross-section "A-A'" lies east of the county line in Emery Co., and includes the Browning Mine at its approximate location in the Ferron Sandstone Member of Mancos Shale. (Modified from Maurer, R. E., 1966, Pl. 1 [opposite p. 112], Utah Geol. and Mineralog. Surv. Bull. 80).

105.5	71.8	0.4	Thin coals of Blackhawk along new cuts on east side of I-70. Highway continues along east side of graben along fault trace. (See BYU 1974 log, p. 83, Mile 71.8, *et seq.*)
106.1	72.4	0.6	Down-dropped North Horn Formation on left (W) and Upper Blackhawk Sandstones on right, east of fault.
107.0	73.3	0.9	Fault. North Horn beds on west.
108.2	—	1.2	White ledges in road cuts are in North Horn Formation.
109.4	—	1.2	Exit 72.
110.5	(76.3)	1.1	Crossing main border fault on west side of Musinia Graben. Taylor Flat, to right, is part of flat floor on "down-block." Blackhawk beds on west side of fault; North Horn east of fault. Text-fig. 66, BYU 1974, p. 84.

STOP 27, 1975. TAYLOR FLAT
BLACKHAWK PLANT BEDS; SALINA CANYON.
PLANT COLLECTING INCLUDING PALMS.
DISCUSSION OF FAULTING

North side of I-70 where escarpment rises abruptly above flats to east. Exact center Sec. 21, T. 22 S, R. 3 E, Sevier Co., Utah, Water Hollow Ridge 7.5' Quad.

Bus pull-off at west end of railing on right on short pull-off near MP 72.

The Upper Blackhawk section here was reported by Spieker and Baker (1928, U.S.G.S. Bull., 796:125-170) on page 138 of that report, to be 537' 7" (about 165 m) thick as measured up the spur to the NW to the Castlegate Sandstone about half-way up the north wall of Salina Canyon (west wall of Musinia Graben). This sequence contains 5 coal and carbonaceous shale zones, none of which exhibit lateral continuity sufficient to be traced to other localities and none is minable. A zone of cinders at the 10" (0.25 m) resinous coal 50' (15 m) up from the road may have been a minable coal before being burned. These sand and ephemeral coal swamp deposits indicate an upper delta plain sequence.

Good fossil plant collections have been made at 28' (8.6 m) above the road, where palm fronds were abundant, and in the first big sandstone from 45-65' (14-20 m) above the

			road. Parker traced the 11' (3.3 m) massive sandstone at 115-125' (35-38 m) above the road (and immediately overlain by a 2' 6" [.75 m] coaly zone) to Pipe Creek, about a mile or so west, where excellent fossil plants were also recovered in some of the beds below it. Additional plant fossil horizons have been found up to within 100' (30 m) of the Castlegate. Re-board buses and continue west down Salina Canyon.
110.8	76.8	0.3	Multiple coals and carbonaceous shale zones of middle upper Blackhawk Fm. exposed in new road cuts on north. Good fossil plants in sand and siltstone layers.
111.1	77.1	0.3	Sevier Valley Coal Mine on left (S) side I-70. (See BYU 1974, p. 85, fig. 65, Mile 77.1.)
111.3	77.3	0.2	Coal-bearing sequence on north side is dipping steeply east due to proximity to one of N-S faults.
111.7	—	0.4	Pipe Springs on south side of I-70. An excellent canyon for collecting plant fossils is directly opposite, heading NNE. Lee Parker reports on fossils from this locality in his paper here. Coal beds on N side are dipping E.
112.0	—	0.3	Milepost 71. West edge of steeply dipping beds. Several exposures in next mile with multiple thin coal zones.
114.1	—	2.1	Coal Hollow. A major fault here has brought Castlegate Sandstone into contact with Blackhawk.
114.4	80.0	0.3	1st RR Tunnel (east end of east tunnel).
114.6	80.2	0.2	2nd RR Tunnel (east end of west tunnel).
115.3	—	0.7	STOP 28, 1975. WATER HOLLOW AREA. UPPER BLACKHAWK PLANT BEDS. WATER HOLLOW GRABEN. EXCELLENT DISPLAY OF FOSSIL PALMS up on ledges to north. Major graben crosses I-70 just ahead. SW ¼, NE ¼, Sec. 14, T. 22 S, R. 2 E, Sevier Co., Utah, Steves Mtn. 7.5' Quad. Along the north side of Salina Canyon 0.35 mi east of Water Hollow Road Jct. with new I-70, a short distance east of Milepost 67. (Bus can pull off on right (north) at west end of railing at "Speed Limit 55" sign or we will go on to Water Hollow stockman's road.) The fossil

palm ledges here are about 170' (52 m) above the highway on the SE facing scarp just below the major sandstone and intercalated in its lower layers. Fossil *Sequoia* branch tips with cones attached have been collected a few feet higher near the palms here and many other types of leaves are present at several levels. Mats of palm leaves are best seen looking up under protruding ledges. FALLING ROCKS ARE A HAZARD HERE. There are also some standing palm trunks locally at this site and stumps or rooted plant bases are found at 53' (16.5 m), 76' (23 m), 165' (50 m), and 177' (53.5 m).

The sedimentation at the sites of the coal exposures along the highway, both east and west are typical of the Blackhawk in this area. In the section above us to the north there are 7 coal or carbonaceous shale zones in the first 272' and there are four associated sequences containing good fossil plants. Such plant and swamp accumulations together with the irregular sedimentary lenses, dirty sands and silts, point to coastal plain—delta plain lakes and swamps and ephemeral distributary channels as the environment prevailing for the accumulation of the Blackhawk sequence here.

Figure 40, Mile 115.3, Day 3, Stop 28, Water Hollow area.
Palm locality ("P"), 0.3 mile west of Water Hollow Road on SE facing spur. Upper part of Blackhawk Formation. Other fossil leaves, particularly dicots, are abundant at several levels.

			The major fault which crosses the road about one-half mile west is part of the north-south system characteristic of the Wasatch Plateau which we have been reviewing the past three days. The Castlegate, at the top of the section here, is down against the older Blackhawk Formation to the west. This is the last scheduled stop. Geologic features are brought to your attention for the remaining 11 or 12 miles to Salina in both guidebooks, particularly the BYU 1974 Guidebook, pages 87-93. After we leave Salina, Blair Maxfield will give some explanation of geologic features as we proceed to Salt Lake City.
115.6	80.6	0.3	Water Hollow Road (may be site of the STOP 28). West side of graben 0.2 mi ahead (west).
116.4	81.4	0.8	Two old coal mines in Blackhawk 350' above road in cove 1200' (330 m) NNW (3 o'clock) at Milepost 66. The Castlegate Sandstone forms the main rim of the canyons for some distance.
120.4	85.4	4.0	Road south to Gooseberry Valley. Price River Fm. goes under cover near here.
123.9	89.2	3.5	Major unconformity to north. See BYU 1974, p. 90-91, Mile 89.2, Text-fig. 72. Angular unconformity between Price River and earlier rocks.
124.7	89.5	0.3	Leave Fishlake National Forest.
125.2	90.0	0.5	End divided highway.
127.1	91.9	1.9	Mouth of Salina Canyon.
128.9	93.7	1.8	Junction Utah Highway 4 with U.S. Highway 89 in Salina. North on U.S. Highway 89 to Gunnison; Utah Highway 28 to Nephi; and Interstate-15 to Salt Lake City.
267.		138.	Salt Lake City-various hotels.
			END FIELD TRIP

Day 3, Mile 43.0

SIDE TRIP. STOP 22, 1975 (OPTIONAL)
EAST OF FERRON THROUGH MOLEN TO LARSON RANCH AREA
LARSON RANCH SECTION OF FERRON BEACH(?) SANDSTONE

Exposures along Ferron Creek, 5 miles E of Ferron, Utah, west side Sec. 9, T. 20 S, R. 8 E, Emery County, Utah, Castle Dale 15' Quad.

Note: Text and collation from field notes by Aureal T. Cross, Christopher C. Cross and E. Blair Maxfield.
Begin at Mile 43.0 DAY 3

MILEAGE *Cumulative*	*Interval*	
0.0	0.0	Ferron (center). Go south 2 blocks.
0.2	0.2	Junction. Road east to Molen.
1.7	1.5	Gravel road to north.
2.2	0.5	Cross road. Good view ahead and right, 12-2 o'clock, of juniper-covered dip-slopes of Ferron cuesta rising on west flank of San Rafael Swell.
3.2	1.0	Molen crossroad junction 5785.
3.7	0.5	Ranch road to south. Crosses Ferron Creek when bridge not washed out(!) to Ferron Creek road.
4.25	0.55	Cemetery on north side of road.
4.5	0.25	Turn left across wash.
4.8	0.3	Road goes up out of wash onto pediment surface.
5.1	0.3	Junction 5127 on pediment flat. Road to north & northeast goes about 3 miles to Paradise Ranch with some excellent Ferron exposures in Ferron Creek to the SE. The west branch goes 0.2 mile due west to the Larson Ranch house (abandoned) at the edge of the Ferron Sandstone Cuesta.
5.3	0.2	Larson Ranch house (abandoned). STOP 22, 1975 (OPTIONAL). FERRON SANDSTONE: BEACH OR CHANNEL? Low cliffs here on both sides of Ferron Creek show some relatively even-bedded, thin to thick, washed sands, medium to coarse grained. Some layers are undulating; some with laterally extended, dipping cross-bed sets. Some layers extend laterally from higher to lower in the pile; some are truncated. This could be a tidal channel area. Total thickness exposed about 40'.
10.6	5.3	Return to Ferron.
		END. SIDE TRIP TO FERRON ESCARPMENT EAST OF MOLEN.
		STOP 22, 1975 (OPTIONAL) (If this trip is taken, add 10.6 miles to DAY 3 Log)

Day 3, Mile 43.6

SIDE TRIP. STOP 23, 1975 (OPTIONAL)
DOWN FERRON CREEK SE OF FERRON TO FERRON SANDSTONES AND COALS
COALS DEVELOPING IN DELTAS PROGRADING OVER DELTA FRONTS

Outcrops begin about 4.5 miles ESE of Ferron up dip-slopes of Ferron Sandstone cuestas developed on west

flank of San Rafael Swell along the road to Horn Silver Gulch; principally the north side Sec. 29, the SE Cor. Sec. 20, diagonally from SW to NE across Sec. 21 into the NW ¼ Sec. 22, T. 20 S, R. 8 E, Emery County, Utah, Castle Dale 15' Quad.

Note: Text and collation from field notes by Aureal T. Cross and E. Blair Maxfield.

Begin at Mile 43.6, Day 3, 0.6 mile S of center of Ferron and 0.1 mile S of Ferron Creek Bridge at Utah Road 10.

MILEAGE

Cumulative	*Interval*	
0.0	0.0	Junction Utah Road 10 with Ferron Creek road to Horn Silver Gulch. Go east on gravel road.
0.8	0.8	Ferron Compressor Station, Mountain Fuel Supply Co. on right (south).

Figure 41A, Mile 43.6, Day 3, Stop 23A (optional), (at Mile 7.65 on Side Trip over Ferron escarpment on the Ferron Creek Road SE of Ferron).

(The Ferron cliffs above show a multiple Lower Bench ("LB Fer") with a zone of concretions ("con") at the top of the main bed of ss and a few concretions dispersed up through the upper sandstone of the Lower Bench. The Middle Bench of the Ferron Sandstone ("MB Fer") forms the caprock here. Below the Ferron, the Tununk Member of the Mancos Shale may be easily divided into two parts here, the Upper Tununk ("UT") which is lighter gray in color above a hard bench of more silty shale ("Silty Bench") and the darker Tununk below. There are at least two additional "harder" zones below this conspicuous, weak-bench-forming "Silty Bench" in the Lower Tununk down to the Dakota (see also Figure 32A).

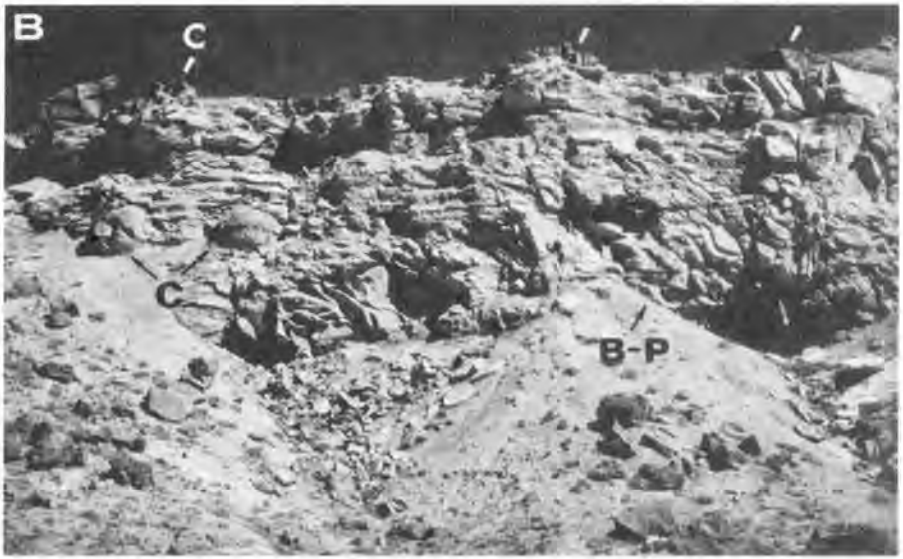


Figure 41B, Mile 43.6, Day 3, Stop 23A (optional), (at Mile 7.4 on Side Trip over the Ferron escarpment on Ferron Creek Road, near cattleguard).
Lower Bench of Ferron Sandstone with conspicuous ball-and-pillow ("B-P") structure locally in zones and concretions ("C") in a layer at the top of the bench (3 concretions indicated at top) and a few intercalated in the lower part.

1.5	0.7	Small electric transmission line.
1.7	0.2	Concrete silo (leaning). Excellent view of juniper-covered cuesta of Ferron rising to SE on west flank of San Rafael Swell.
2.15	0.45	Junction gravel road to Molen (bridge washed out this date).
2.2	0.05	Turn right over *new* culvert over irrigation ditch.
2.3	0.1	Turn left.
2.6	0.3	Curve right & left across plank bridge over irrigation ditch (9' long, 15' wide with 7 12" pine log beams on 12" cribbing).
2.9	0.3	Stock pen (loading corral) on north (left).
3.0	0.1	Short dip over wash (culverts). May be too short for bus.
3.2	0.2	Cattleguard.
3.5	0.3	Y-Junction; bear right.
3.95	0.45	Curve southeast along fence. Crossing lower Blue Gate.
4.6	0.65	Junction 5782. Trail to S to Molen Seep Wash and excellent Ferron exposure, 2 miles.

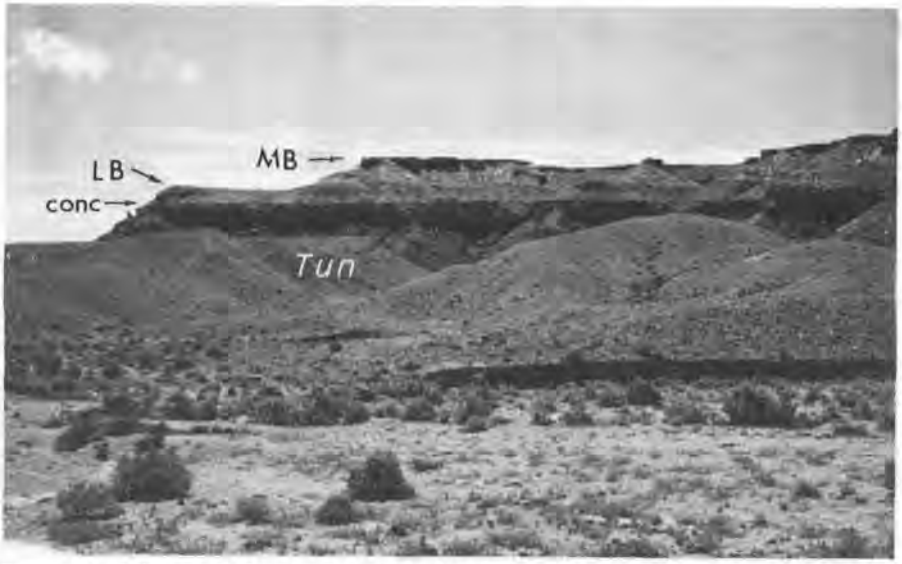


Figure 42, Mile 43.6, Day 3, Stop 23A (optional), (Mile 7.4 on Ferron Creek Road Section at Cattleguard).

View to SE at profile of Ferron Sandstones on long, NE-pointing spur. Position of main zone of concretions ("conc") in Lower Bench of Ferron Sandstone ("LB") is top of Lower Bench). Some concretions occur nearly halfway up to the base of the prominent, flaggy, fluvial sandstones of the Middle Bench. The lowermost carbonaceous zone occurs in the lower part of the interval, just above the top of the uppermost layers of the Lower Bench.

4.75	0.14	Fence line; contact of Upper Bench Ferron Sandstone. Carbonaceous siltstones below.
4.95	0.2	Road crosses slowly through carbonaceous zone below top sand beds as we go up dip-slope.
5.05	0.1	Low mound on left (north) has a 15' section of dark and carbonaceous shales.
5.10	0.05	Quonset hut on left (this is conspicuous from Ferron).
5.15	0.05	Excellent display of lower part of carbonaceous zone on undulating surface of next bench of sandstone below (Middle Bench?).
5.25	0.1	Road crosses wash just below Middle Bench Ss. ledge below carbonaceous zone. Good display at 10-11 o'clock of entire sequence of the upper carbonaceous shale zone and thin, overlying capping sandstone forming top of cuesta. This is Upper Bench of Ferron Sandstone and coal sequence. At 1-2 o'clock several successive ledges of hard sandstone below the carbonaceous zone are well displayed. Upper part of flaggy Middle Bench of Ferron.

Figure 43, Mile 43.6, Day 3, Stop 23A (Mile 7.4 Ferron Creek Road Section) and Mile 126.8, Day 2, E of Castle Dale (Mile 5.6 on Side Trip, Stop 21A).

East of the Ferron escarpment and the Mancos Shale valley, developed in the generally soft, marine Tununk Member, lies a variably thin Dakota Formation and east of this (overlain by the Dakota) is the Cedar Mountain Formation. The Shale Member at the top of the Cedar Mountain, probably of upper Lower Cretaceous age, is shale and mud-stone, variegated, purple to light gray with abundant limestone nodules and pebbles. At several localities around the San Rafael Swell, fossil plants have been found, especially the tree-fern *Tempskya*. Southeast of Castle Dale, at the confluence of Huntington and Cottonwood Creek to form the San Rafael River, *Tempskya* stems have been found rooted in the ancient soil of this flat Cretaceous plain. This is one of several specimens from this locality (see Figure 44), which have been excavated by Dr. W. D. Tidwell (left) and his students. The dark line on the Dakota-capped cliff across the creek in the distance is correlative with the soil zone which bears these plants. Leaves have also been collected from this bed. This specimen has been identified as *T. jonesi*.

5.45 0.2 STOP 23, 1975 (OPTIONAL). COALY DEVELOPMENT, SEAWARD SIDE OF LAGOON(?).

5.75 0.3 Top of rise. Turn left to NE. Small trail to right. Road descends gradually through upper flaggy layers of Middle (Main) Bench. Many layers are lenticular undulating, with cross-beds (fluvial channels?).

6.55 0.8 Lower part of Middle (Main) Bench below thicker flaggy beds; thinner bedded sands and silts with carbonaceous zones toward base.

Figure 44, Mile 43.6, Day 3 (same as Figure 43).
Three *Tempskya* tree fern trunks partially excavated from the Cedar Mountain Formation southeast of Castle Dale. These are still rooted in the soil in which they grew.

6.95	0.4	Road crosses wash. Concretion zone at top of Lower Bench of Ferron. Some concretions are found sparsely distributed above this main zone for at least 20'. This main zone is about 15' thick.
7.4	0.45	STOP 23-A, 1975 (OPTIONAL). TOTAL FERRON SEQUENCE. Cattleguard below cliffs of Lower Bench of Ferron. This is an excellent display of the gradation from the sandy upper part of the Tununk Member into the marine facies of Ferron Sandstone, with "ball and pillow" structure and concretions in the upper part of the main sandstone bed. Concretions can be observed to be sparsely distributed above this main zone up to the base of the thin carbonaceous zone below the prominent flaggy 6"-12" beds of the Middle (Main) Bench. The upper flaggy beds appear to be a fluvial sequence here. Looking at the profile of this entire sequence on the promontory to the SE, the relative thickness of the 3 benches of the Ferron and the relationship of the carbonaceous zones to the Middle and Upper Benches can be more easily recognized.
7.5	0.1	Road crosses draw.
7.65	0.15	At 9-10 o'clock (NE), note the hard thin bench in the Tununk shale slope. At this bench or break in slope the character of the Tununk changes from darker (below) to lighter and more sandy above. At 12-2 o'clock on the promontory to the south, note the profile of the lower 2 benches of Ferron and the low bench in the Tununk Shale near road level.
15.3	7.65	Turn around. Return to Utah Highway 10 at Ferron Creek Bridge. END. SIDE TRIP TO FERRON SANDS AND COALS SE OF FERRON. STOPS 23 & 23A, 1975 (OPTIONAL). Rejoin DAY 3 Road Log at Mile 43.6. (If this trip is taken add 15.3 Miles to Day 3 Log.)

Day 3, Mile 72.8

SIDE TRIP. STOP 25, 1975 (OPTIONAL).
TO BROWNING COAL MINE. FERRON COALS.

4.3 Miles south of Emery at confluence of Christiansen Wash with Quitchupah Creek, near S center of NW ¼, Sec. 33, T. 22 S, R. 6 E, Emery Co., Utah, Walker Flat 7.5' Quad.

Cumulative	*Interval*	
0.0	0.0	Junction with Highway 10 and road to Browning Coal Mine. Turn left (east) at base of hill.
2.6	(2.6)	Browning Coal Mine gate. Walk from here to tipple. The coal in this area is split into 4 to 6 seams with at least 4 major cross-bedded sandstones, three of which have a well-developed "white-cap" at top. The mined seam, I (Lupton, 1916) is 20' thick.
5.2	(2.6)	Return to main road (Route 10) and continue south.

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Aureal T. Cross,
in behalf of the authors

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