

Measured sections of the Shinarump, Monitor Butte,
and Moss Back Members of the Chinle Formation (Upper Triassic)
in the White Canyon and Red Canyon area, southeastern Utah

By
Russell F. Dubiel

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INTRODUCTION

Seven sections of the Shinarump, Monitor Butte, and Moss Back Members of the Chinle Formation (Upper Triassic) were measured in the White Canyon and Red Canyon area of southeastern Utah (fig. 1) to investigate depositional environments and their possible relationship to uranium mineralization. The Petrified Forest Member and upper (red-bed) part of the Chinle Formation (Stewart and others, 1972a) were not included because uranium mineralization in the White Canyon and adjacent areas is restricted to the Shinarump, Monitor Butte, (Finch, 1959; Thaden and others, 1964), and Moss Back Members (Lewis and Campbell, 1965).

The Shinarump, Monitor Butte, and Moss Back Members comprise a series of continental beds deposited in a fluvial-lacustrine environment (Stewart and others, 1972). Facies relationships in this lower sequence are shown in figure 2. Depositional environments were interpreted from rock types, thicknesses, bedding and sedimentary structures, fossils and burrows, and vertical and horizontal facies relationships.

Meandering stream deposits consist of coarse-grained and conglomeratic sandstones characterized by deep channel scours and medium- to large-scale trough-crossbeds. Beds are typically lenticular with conglomeratic bases, grade upwards and laterally into finer-grained deposits, and often contain gray to greenish-gray, carbonaceous clay "plugs" characteristic of cut-off meander fills (Stewart and others, 1972a, Reineck and Singh, 1975). In contrast, braided stream deposits are composed of medium- to coarse-grained and sometimes conglomeratic sandstones in laterally extensive tabular beds that lack isolated, deep channel scours. The sandstones exhibit small- to medium-scale trough-crossbeds, abundant planar-crossbeds, and contain thin, discontinuous gray to greenish-gray claystone. Finer-grained overbank deposits are generally lacking. The recognition criteria are similar to those used to categorize the Moss Back Member in the San Rafael Swell (Lupe, 1977) and to distinguish meandering stream deposits from braided stream deposits in general (Reineck and Singh, 1975; Smith, 1970).

Overbank deposits associated with fluvial sandstones are finely laminated to thin-bedded red mudstone with minor fine-grained sandstone deposited on floodplains and very thin limestones, possibly deposited in small pools. Bedding in the overbank deposits often dips away from the adjacent fluvial deposit.

Recognition criteria for lacustrine environments are similar to those used by Lupe (1977) for the Chinle Formation in the San Rafael Swell, by Picard and High (1968, 1972a, 1972b) for the Green River Formation (Eocene), and by Monroe (1981) for the Passamari Member of the Renova Formation (late Oligocene-early Miocene). Fine-grained marginal lacustrine sandstones and siltstones contain scattered, coarse- to very-coarse, well-rounded quartz grains indicative of reworking in a nearshore environment. White, yellow, and

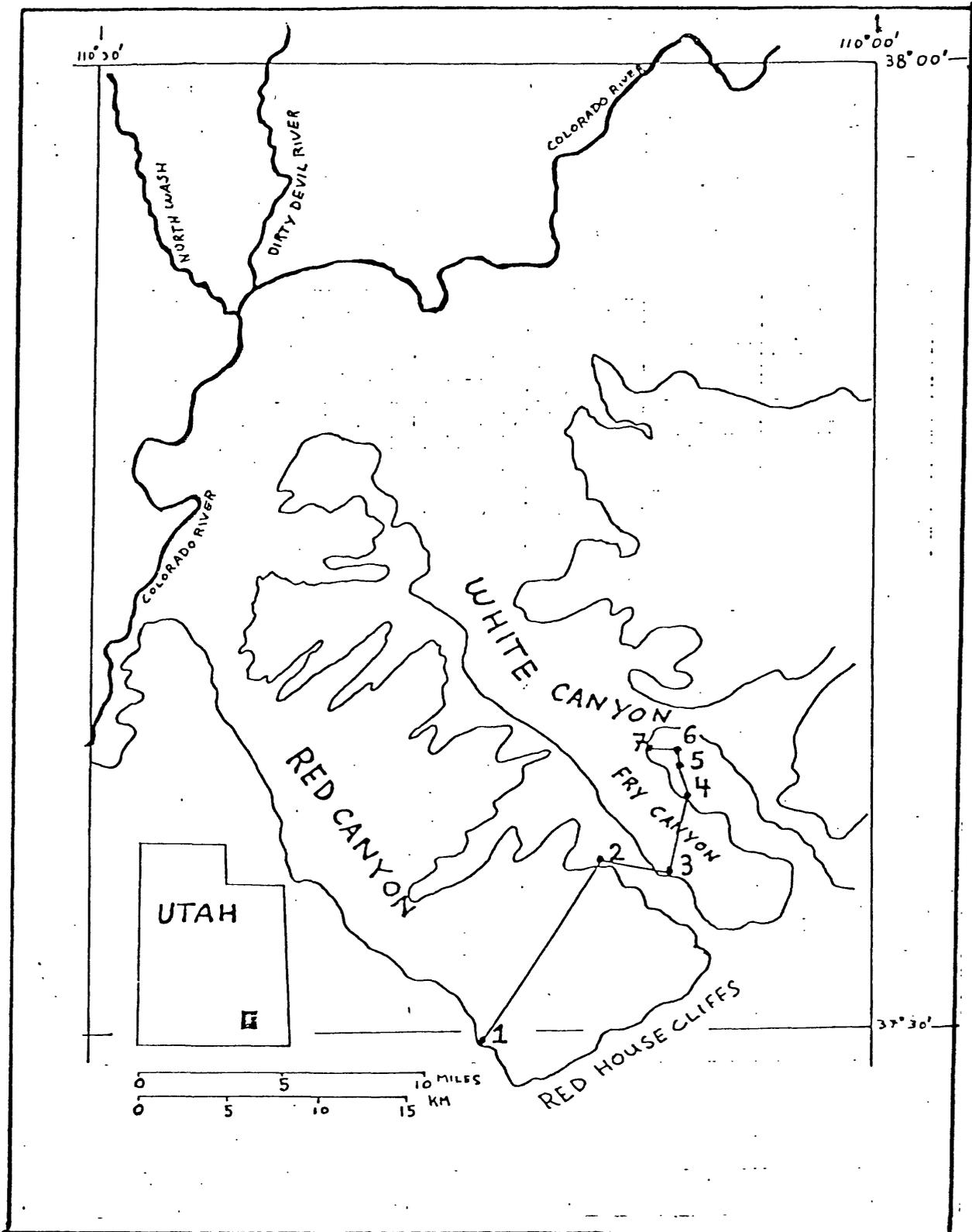


Figure 1. Index map showing location of measured sections, line of section, and study area in southeastern Utah. Thin lines denote approximate edge of canyons.

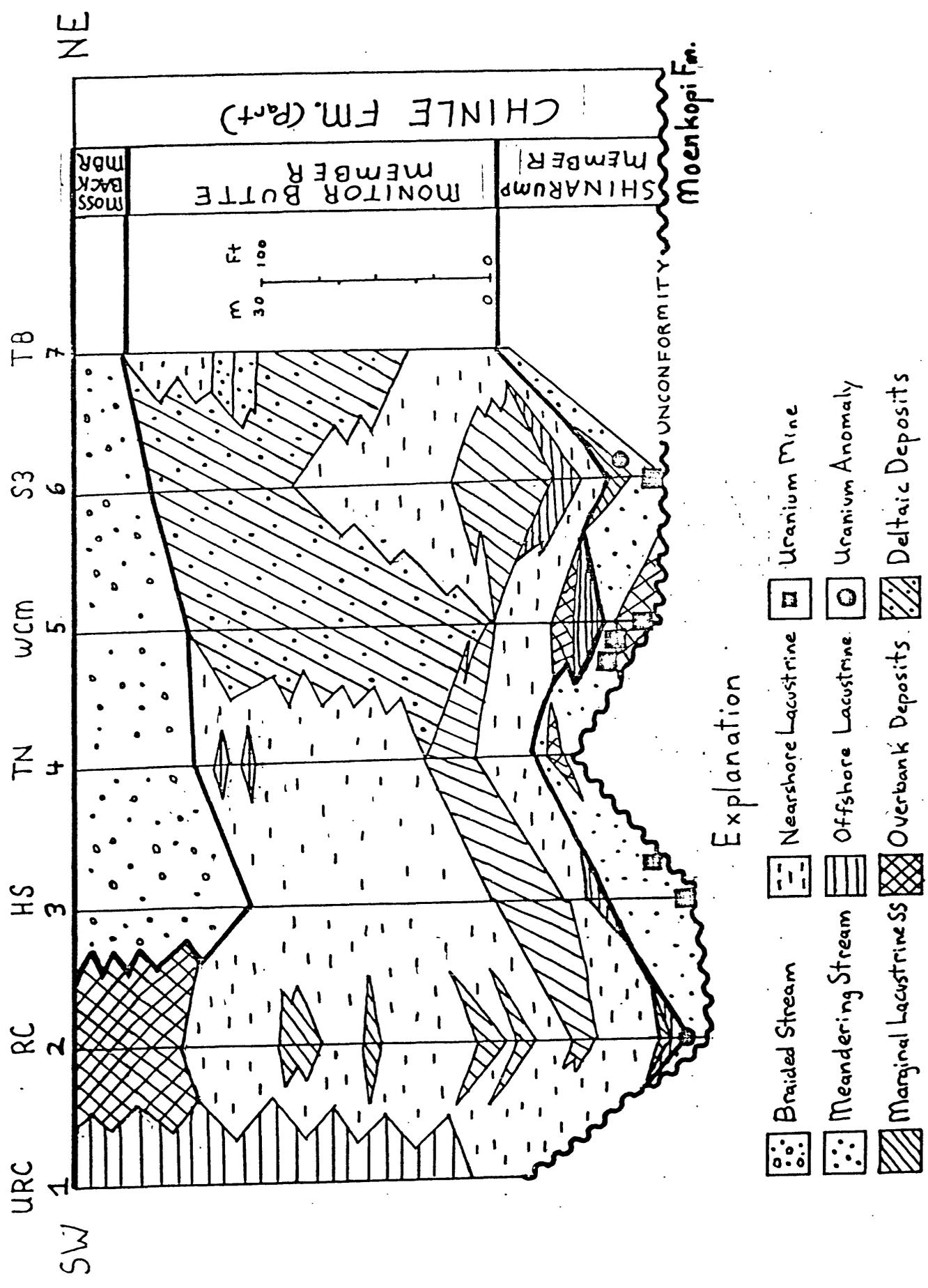


Figure 2. Stratigraphic section in the White Canyon and Red Canyon area showing facies relationships of the fluvial-deltaic-lacustrine sequence

purple mottling is common and often associated with locally abundant bioturbated beds with large, vertical burrows.

Nearshore lacustrine deposits are red to sometimes gray silty mudstones with minor amounts of fine-grained sandstone. Organic matter is occasionally present as fine-grained carbonized plant fragments in the gray mudstones. Mudstones are often calcareous and may contain numerous limestone nodules. Offshore lacustrine deposits are commonly organic-rich, gray to black, very thinly laminated mudstones with conchostracan (order Conchostraca, class Branchiopoda, phylum Arthropoda) assemblages (R. Forester, oral commun., 1982; P. Tasch, written commun., 1982). Conchostracans have been described from a Late Triassic lake in the Monitor Butte Member of the Chinle Formation in the Ft. Wingate area of New Mexico (Tasch, 1978). Occasionally, offshore lacustrine deposits are characterized by light-gray silty mudstones locally interbedded with thin gray limestones. Laterally extensive, horizontal beds are typical of the lacustrine environment.

Deltaic deposits are green to greenish-gray, fine- to very fine-grained, micaceous sandstones and siltstones that exhibit a distinctive cyclic bedding (fig. 3) indicative of a river-dominated system (Miall, 1979). At the base of the deltaic sequence cyclic beds are predominantly mudstone that grades upward into siltstone. In the middle portion of the sequence individual cycles have a mud base, grade upward into fine sand with climbing ripple-cross-lamination, oscillation ripples in thin reworked zones on upper bedding plane surfaces, and locally contain abundant burrows. At the top of the deltaic sequence, cyclic beds have very thin mud bases overlain by small scale, sandy foreset bedding. Finely comminuted carbonized plant fragments are found throughout the deltaic sequence. Numerous carbonized whole specimens of Zamites powelli, Phleboteris smithii (S. Ash, oral comm., 1981; Ash, 1978; Gottlefeld, 1972), and other Late Triassic flora are locally abundant in the mud at the bottom of each cycle indicating deposition in quiet water.

The uranium deposits of the Shinarump Member (sections 2, 3, 5, and 6) occur in coarse-grained to conglomeratic fluvial sandstones characterized by deep channel scours, large-scale trough-crossbedding and overbank siltstones and mudstones. Overlying the fluvial sandstones are very thinly laminated, organic-rich, gray to black mudstones. The mudstones range in thickness from 2 ft (0.6 m) to more than 16.5 ft (5 m) and contain as much as 20 percent organic carbon by weight. The presence of conchostracan assemblages in the mudstones suggests deposition in a lacustrine environment (R. Forester, oral commun., 1981). The non-mineralized sections that contain basal fluvial sandstones (sections 4 and 7) do not have organic-rich lacustrine mudstones. Section 1 is composed totally of offshore and nearshore lacustrine mudstones, siltstones, and very fine- to fine-grained sandstones.

Uranium mineralization appears to be related to specific facies in the depositional environment. Sections 1, 4 and 7 are not mineralized while sections 2, 3, 5, and 6 are mineralized. A comparison of the sedimentology of these two groups indicates that the mineralized sections contain thick coarse-grained fluvial sandstones which are the host rocks for uranium mineralization and organic-rich lacustrine mudstones which overlie the host sandstones. Although the non-mineralized sections contain basal fluvial sandstones to act as potential host rocks for uranium mineralization, they do not contain the organic-rich lacustrine mudstones.

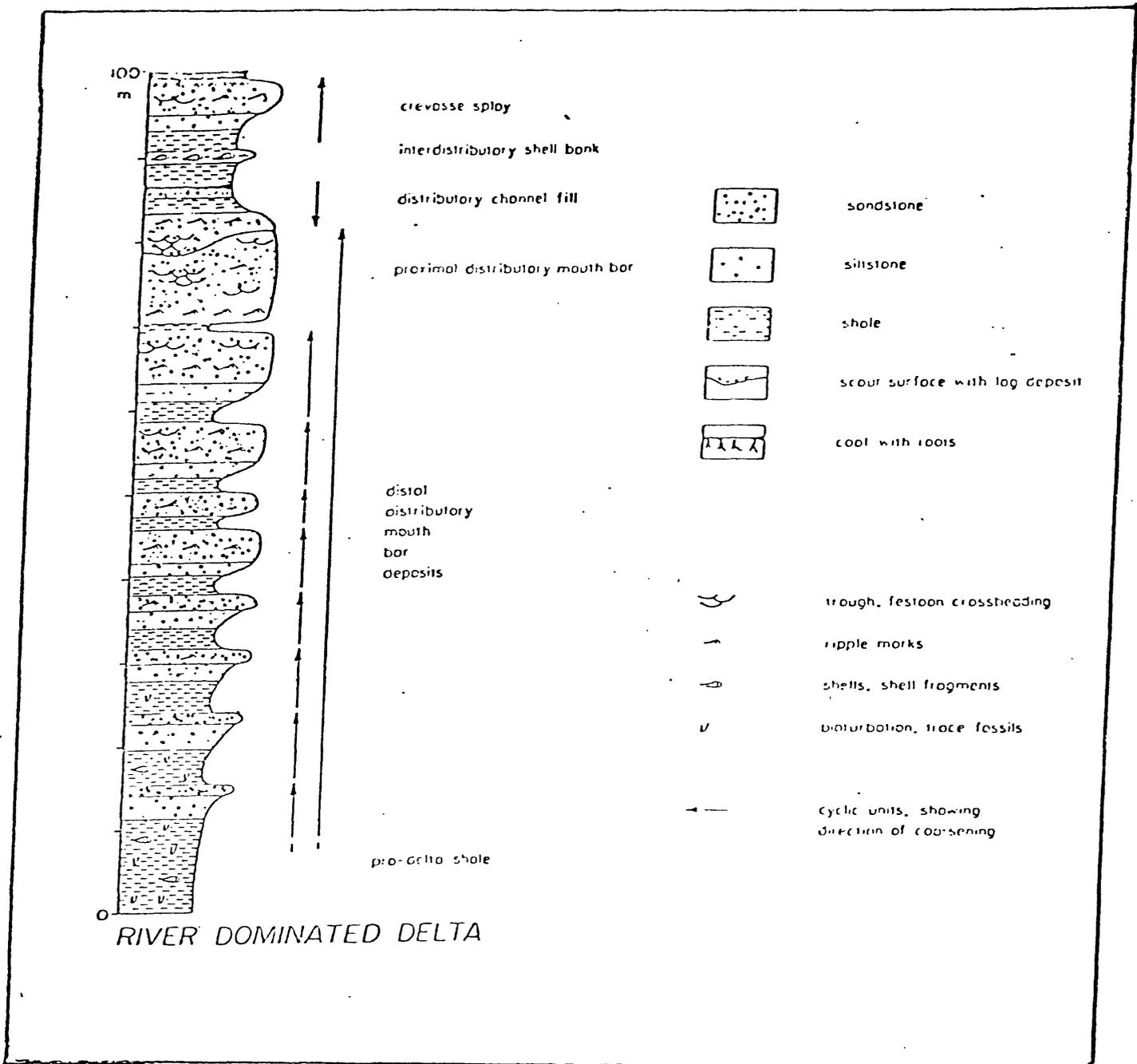


Figure 3. Diagrammatic section of a river-dominated deltaic sequence (from Miall, 1979)

In the White Canyon and Red Canyon areas, uranium mineralization appears to be localized in sandstone beds below black, organic-rich, offshore lacustrine mudstones at the top of the Shinarump Member or at the base of the Monitor Butte Member. A similar relationship of uranium mineralization in sandstone strata associated with gray carbonaceous lacustrine mudstone beds occurs in the Stockton and Lockatong Formations (Triassic) in the Newark Basin (Pennsylvania and New Jersey) (Turner-Peterson, 1980) and in the Salt Wash Member of the Morrison Formation (Upper Jurassic) in the Henry Basin (southern Utah) (Peterson, 1980). In the latter area, the mudstones also tend to occur in depositional environments dominated by low-energy fluvial processes (Peterson, 1980). Lupe (1977) also noted a relationship between uranium mineralization and low energy depositional environments lateral to Moss Back streams in the San Rafael Swell. The accumulation of organic-rich sediments in the low-energy lacustrine environments associated with Shinarump streams suggests a similar relationship in the White Canyon and Red Canyon areas.

MEASURED SECTIONS

Sections were measured using standardized section cards (Reynolds and others, 1975) denoting rock type, visual porosity estimate, median grain size by field estimate with hand lens and grain size chart, bedding parameters and sedimentary structures (McKee and Weir, 1953), biologic constituents, cement, and percent feldspar. Units as thin as 1 ft. (15 cm) were measured, recorded and characterized by these parameters. Measurements of transport trends were taken on weathered out channels and crossbedded units. Measurements were made in feet and converted to meters, accounting for discrepancies in the addition of the meters column.

ACKNOWLEDGMENTS

Fossil identification and comments on their use as indicators of depositional environments were made by R. M. Forester (conchostracans), P. Tasch (conchostracans), and S. R. Ash (plants). Assistance in the field was provided by M. J. Larson and C. G. Patterson. Helpful comments and constructive criticism of the manuscript were given by R. Lupe, R. E. Thaden, and J. L. Ridgley. Fred Peterson initially suggested the study and provided helpful comments and discussions throughout its course.

Section 1--Upper Red Canyon

[Section begins on south side of dirt road into Red Canyon from Red House Cliffs, in low bentonitic hills, 2.5 miles (4.1 km) northwest of Red House Spring. Section extends up bentonitic hills to pinkish-orange limy unit in Petrified Forest Member in SW 1/4, SW 1/4, sec. 2, T.38S., R.14E., San Juan County, Utah]

	Thickness	
	Feet	Meters
Chinle Formation (part):		
Petrified Forest Member (part):		
16. Sandstone, pinkish-orange; fine-grained; very calcareous; weathers to steep slope.....	10+	3+
Total Petrified Forest Member measured.....	10+	3+
Monitor Butte Member:		
15. Mudstone, medium-gray, bentonitic, contains scattered fine- to very fine grained quartz sand, structureless; weathers to "popcorn-like" soil-covered slope(Stewart and others, 1972a); small, 2 in. (5 cm) limestone nodules; offshore lacustrine, mudflats.....	35	10.6
14. Mudstone, grayish-red-purple, silty, slightly bentonitic; weathers to "popcorn" slope; offshore lacustrine.....	10	3
13. Mudstone, reddish-brown-purple, slightly bentonitic, silty; weathers to "popcorn" soil-covered slope; offshore lacustrine.....	50	15.2
12. Mudstone, grayish-red-purple, slightly bentonitic, silty; weathers to "popcorn" soil slope; offshore lacustrine.....	40	12.1
11. Mudstone, light-gray, bentonitic, with widely dispersed very coarse grained quartz sand; base of unit is 4 in. (10 cm) white quartz bed, bentonitic, medium- to fine- grained; forms steep "popcorn" slope; offshore lacustrine	12	3.6
10. Mudstone, light-gray-purple, slightly bentonitic, slightly calcareous, very fine to fine-grained sandy, forms "popcorn" slope; offshore lacustrine.....	7	2.1
9. Mudstone, very pale-orange with purple mottles, and light gray-green, bentonitic siltstone; forms "popcorn" slope; offshore lacustrine.....	10	3

8. Mudstone, light-gray, stained yellow with purple blebs, fine- to very fine-grained sandy; contains 2 in. (5 cm) iron concretions; forms steep slope; nearshore lacustrine.....9	2.7
7. Sandstone, white, micaceous, calcareous, fine-grained, weathers to small rounded ledge, and mudstone, purple-blue, silty, very thin horizontal laminations; forms slope; nearshore lacustrine.....2	0.6
6. Mudstone, light gray-green, bentonitic, very fine-sandy; forms "popcorn" slope; nearshore lacustrine.....5	1.5
5. Mudstone, medium purple-brown, slightly bentonitic with yellow mottles and iron concretions; nearshore lacustrine.....6	1.8
4. Mudstone, light red-purple to mottled purple, gray, and yellow, bentonitic, contains widely scattered well-rounded, coarse quartz sand, mudstone contains faint horizontal laminations, weathers to "popcorn" slope; nearshore lacustrine.....9	2.7
3. Mudstone, mottled purple, yellow, and white, contains scattered coarse, well-rounded quartz sand, and well-rounded quartz pebbles, generally 1.5 in. (4 cm), pebbles in a lag concentrate at top of unit; forms "popcorn" slope; nearshore lacustrine.....5	1.5
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Total Monitor Butte Member.....200	60.6
Total Chinle Formation (part):.....200	60.6
Unconformity, based on regional studies (Stewart and others, 1972a, 1972b); contact sharp but obscured by mottling.	

Moenkopi Formation (part):

2. Siltstone, purple, brown, and white mottles; micaceous; forms steep slope; regional studies suggest mudflat (Stewart and others, 1972b).....5	1.5
1. Siltstone, dark reddish-brown, micaceous; forms forms steep slope with ledges; mudflat.....	Not Measured

Section 2--Red Canyon

[Section begins 200 ft (60 m) south of dirt road leading into Red Canyon from Fry Canyon-Hillside Mine, at a small southwest-facing reentrant canyon containing an old dirt prospect road. Reentrant is at head of large drainage heading up to gap in Wingate Sandstone between Red Canyon and Fry Canyon. Section continues up across road to bentonitic hills on left side of reentrant. Top of section is in NW 1/4, NE 1/4, sec. 9, T.37S., R.16E., San Juan County, Utah]

	<u>Thickness</u>	
	<u>Feet</u>	<u>Meters</u>
Chinle Formation (part):		
Petrified Forest Member (part):		
25. Sandstone, white to very light-gray, very coarse to coarse-grained, thin-bedded, cross-bedded; weathers to rounded knobby ledge.....	10+	3+
Total Petrified Forest Member measured.....	10+	3+
Monitor Butte Member		
24. Sandstone, white to pale-brown, medium to fine-grained, thin-bedded, horizontal laminations at top; thin-bedded, cross-bedded at base; white sandstone has calcareous cement; overbank deposit	22	6.3
23. Sandstone, micaceous, calcareous cement dark brown to reddish-purple, very coarse grained, contains 2 in. (5 cm) limestone-ripup clasts; forms angular ledge; overbank deposit.....	2	0.6
22. Sandstone, light-gray to light brown, fine-grained, and light-gray to light-brown, thin-bedded, faint cross-bedded siltstone; weathers to slope; overbank deposit.....	8	2.4
21. Same as unit 23.....	2	0.6
20. Sandstone, medium light-gray, mottled purple at top, coarse- to medium-grained, thin-bedded, planar crossbedded; weathers to rounded knobs; overbank deposit.....	11	3.3
19. Mudstone, green at base, grading to purple and purple mottles at top, slightly bentonitic, micaceous, silty; contains 1 ft (0.3 m) limestone nodule layer at top; weathers to "popcorn" covered slope; nearshore lacustrine, mudflat.....	17	5.1

18.	Same as unit 19.....	29	8.8
17.	Sandstone, pale-green, micaceous, medium to fine-grained, thin-bedded, aggradational cusped ripples, calcareous cement at top; interbedded with pale-green, micaceous siltstone, weathers to slope with small ledges; marginal lacustrine.....	18	5.5
16.	Mudstone, gray olive-green, bentonitic, micaceous, contains some silt, irregular horizontal laminations; forms gray slope; nearshore lacustrine.....	18	5.5
15.	Sandstone, light-brown, weathers moderate-brown, fine-grained, thin-bedded, small 1 ft. (0.3 m) trough-crossbeds, horizontal laminations, with limestone nodules at base; contains small bits of silicified wood; forms ledge, marginal lacustrine.....	5	1.5
14.	Mudstone, gray, micaceous, silty, slightly bentonitic; contains calcareous nodules increasing in abundance to top; forms slope; nearshore lacustrine, mudflat.....	8	2.4
13.	Mudstone, same as unit 14, contains medium-grained sand at base with small organic bits; forms slope; nearshore lacustrine, mudflat.....	38	11.5
12.	Sandstone, dusky yellow-green, micaceous, very fine-grained, thin-bedded, with wavy parallel and climbing ripple laminations, variable calcareous cement, and small (1 mm) microfaults; forms ledgy cliff; marginal lacustrine.....	15	4.5
11.	Mudstone, gray, bentonitic, forms "popcorn" slope; nearshore lacustrine.....	4	1.2
10.	Sandstone, light gray-green, limonite stained, medium-grained, thin-bedded with horizontal, organic-rich laminations; contains calcareous nodules; forms ledge; marginal lacustrine.....	3	1
9.	Mudstone, olive-gray with purple and green mottles, slightly bentonitic; very thin bedded yellow and red chert layers; forms slope; offshore lacustrine.....	20	6
8.	Sandstone, dusky yellow-green with purple mottles, slightly calcareous, medium- to fine-grained, thin-bedded, with cusped ripples; forms flaggy ledge; marginal lacustrine.....	7	2.1

7. Mudstone, limonitic, purple mottled, contains some fine- to medium-grained sand; forms steep slope; nearshore lacustrine.....	2	0.6
6. Chert, yellow and red, very thin-bedded; offshore lacustrine.....	1	0.3
5. Mudstone, gray with some purple-yellow mottles slightly bentonitic, silty, contains small carbon bits and silicified wood fragments; forms "popcorn" slope; nearshore lacustrine.....	31	9.4

Total Monitor Butte Member.....261 79

Shinarump Member:

4. Sandstone, medium-gray to black, very fine-grained, thin-bedded, with 1 ft (0.3 m) gray mudstone; forms rounded ledge; marginal lacustrine.....	5	1.5
3. Mudstone, black to dark-gray, organic-rich with paper thin horizontal laminations and organic fragments; forms slope; offshore lacustrine.....	5	1.5
2. Sandstone, yellowish-gray, very coarse to fine-grained with maximum 2 in. (5 cm) pebbles, thick-bedded, horizontal laminations at top and large scale trough-crossbeds at base, with basal channel scour; forms blocky ledge; meandering stream.....	9	3

Total Shinarump Member.....19 5.7

Total Chinle Formation (part).....280 85

Unconformity, based on regional studies. Undulating, locally has 10 ft (3 m) relief below Shinarump channel fills.

Moenkopi Formation (part):

1. Siltstone, dark reddish-brown, micaceous, fine-grained sandy; regional studies suggest mudflat deposits; not measured.		
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Section 3--Hillside Mine

[Section begins at base of adit in Shinarump channel fill at Hillside Mine, head of Fry Canyon and continues directly up slope to left of channel to top of small tree-covered knoll. Section continues directly up to top of Moss Back bench, SE 1/4, NW 1/4 sec. 2, T.37S., R.16E., San Juan County, Utah]

	<u>Thickness</u>	
	<u>Feet</u>	<u>Meters</u>
Chinle Formation (part):		
Moss Back Member:		
13. Sandstone, grayish-orange to yellow-brown, very coarse- to medium-grained, thick bedded and structureless with some faint, horizontal laminations; forms a steep massive cliff; braided stream.....	24	7.3
12. Sandstone, grayish-orange to yellow-brown, thick-bedded, very coarse to medium-grained, faint low-angle large-scale crossbeds; forms steep cliff; braided stream.....	20	6.1
11. Sandstone, yellow-brown, very coarse to medium-grained, thick-bedded, with large-scale trough-crossbeds; forms steep cliff; braided stream.....	10	3
10. Sandstone, yellow-brown, coarse- to medium-grained, thick-bedded, in part structureless, in part large scale, low-angle crossbeds; forms steep cliff; braided stream.....	20	6.1
Total Moss Back Member.....	74	22.4
Monitor Butte Member:		
9. Covered slope, (probably mudstone).....	24	7.3
8. Mudstone, medium-gray, silty, and covered slope.....	28	8.5
7. Mudstone, medium-gray, silty, and covered slope.....	58	17.6
6. Sandstone, grayish-green, very coarse- to medium-grained, thick-bedded, structureless to faint cross-beds; forms blocky ledge; marginal lacustrine.....	16	4.8

5. Sandstone, very pale-orange to grayish-yellow, mottled yellow and red, silicified, very fine-grained with scattered, well-rounded, very coarse-grained quartz, bioturbated and burrowed, burrows are vertical, 2 in. (5 cm) to 4 in. (10 cm) in diameter by 2 ft (0.6 m) to 3 ft (0.9 m) long; also contains silicified wood fragments; grades laterally in 100 ft (30.3 m) into red silty mudstone; forms blocky ledge; marginal lacustrine.....	14	4.2
4. Mudstone, red to red-purple, silty, and mudstone, black, organic-rich with organic fragments, thin-bedded, with paper thin horizontal laminations; forms slope; nearshore and offshore lacustrine.....	20	6.4
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Total Monitor Butte Member.....	160	48.4

Shinarump Member:

3. Sandstone, white to grayish-yellow, coarse- to medium-grained, and siltstone, gray to grayish-yellow, with horizontal laminations, organic fragments, and mudstone, gray, horizontal laminations; forms steep cliff; meandering stream, possibly marginal lacustrine.....	14	4.1
2. Sandstone, yellowish-orange to white, very coarse to coarse-grained with maximum 2 in. (5 cm) pebbles, thick-bedded with large scale trough-crossbeds, flow S65W by channel shape and cross beds; large channel eroded into underlying Moenkopi Formation; forms steep cliff; meandering stream.....	26	86
<hr/>		
Total Shinarump Member.....	40	12
Total Chinle Formation (part).....	274	83

Unconformity, based on regional studies; local relief 25 ft (2.6 m) in Shinarump channel. Contact sharp, erosional.

Moenkopi Formation (part):

1. Siltstone, dark reddish-brown, micaceous, forms steep slope to small cliff, regional studies suggest mudflat.....	Not Measured	
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Section 4--The Needle

[Section is on southwest side of Fry Point remnant mesa between Fry Canyon and White Canyon, 1 mi. (1.6 km) due north of The Needle. Section begins in small reentrant north of The Needle and continues north up bentonitic slope to top of Moss Back bench in NE 1/4, NW 1/4, sec. 36, T.36S., R.16E., San Juan County, Utah]

	<u>Thickness</u>	
	<u>Feet</u>	<u>Meters</u>
Chinle Formation (part):		
Moss Back Member:		
18. Sandstone, yellowish-orange to light-brown, calcareous, coarse- to medium-grained, structureless with a scoured base and 6 in. (15 cm) local relief; forms steep, blocky cliff; braided stream.....	5	1.5
17. Sandstone, yellow-orange, calcareous, medium- to coarse-grained, thin-bedded, with horizontal laminations to very low-angle trough-crossbeds; forms steep cliff; braided stream.....	5	1.5
16. Sandstone, same as unit 17.....	12	3.6
15. Sandstone, yellow-orange to light-brown, calcareous, coarse- to medium-grained, with large-scale, low-angle trough-crossbeds; forms blocky cliff; braided stream.....	14	4.2
14. Sandstone, light-brown to medium-brown, calcareous, medium-grained, thick-bedded, with horizontal laminations and large-scale, low-angle crossbeds; forms blocky cliff with basal scour surface, local relief 1 ft (0.3 m); braided stream.....	14	4.2
Total Moss Back Member.....	50	15
Monitor Butte Member:		
13. Mudstone, medium gray, contains some fine-grained sand; weathers to "popcorn" soil-covered slope; offshore lacustrine.....	60	18.2
12. Mudstone, grayish-purple, slightly bentonitic; forms "popcorn" slope; nearshore lacustrine, mudflat.....	10	3
11. Mudstone, medium- to light-gray, slightly bentonitic, contains very fine grained carbonized organic fragments; forms "popcorn" slope; offshore lacustrine.....	25	7.6

10. Mudstone, grayish-purple, slightly bentonitic, contains very fine carbonized organic fragments; forms "popcorn" slope; nearshore lacustrine.....	10	3
9. Sandstone, pinkish-gray to yellow-orange, siliceous cement, coarse- to very fine grained, with scattered very coarse, well-rounded quartz grains, bioturbated and burrowed, burrows 2 in. (5 cm) to 4 in. (10 cm) by 2 ft (0.6 m), structureless to thick lenticular beds; contains carbonized sticks; forms steep blocky cliff; marginal lacustrine.....	20	6.1
8. Mudstone, grayish-purple, very clayey; forms slope; offshore lacustrine.....	2	0.6
7. Sandstone, yellow-orange, micaceous, calcareous, very fine grained, and siltstone, dark reddish-brown, micaceous; forms slope with rounded ledge; marginal lacustrine.....	2	0.6
6. Limestone, dark-gray to black, structureless; forms small ledge; offshore lacustrine.....	1	0.3
5. Mudstone, purple, very slightly bentonitic, contains coarse- to medium-grained sand; forms slope; nearshore lacustrine.....	22	6.6
<hr/>		
Total Monitor Butte Member.....	152	46
Shinarump Member:		
4. Sandstone, yellow-orange, calcareous, medium- to coarse-grained, thick-bedded, with abundant small trough-crossbeds; forms small cliff; meandering stream.....	8	2.4
3. Sandstone and siltstone, mottled purple, yellow and white, fine-grained with angular parallel laminations; forms slope; overbank.....	3	1
2. Sandstone, white to yellow-orange, very coarse- to medium-grained, medium- to thick-bedded, with small 6 in. (15 cm) trough-crossbeds, scoured base on channel has 6 in. (15 cm) local relief; forms small cliff; meandering stream.....	7	2.1
<hr/>		
Total Shinarump Member.....	18	
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Total Chinle Formation (part):.....	220	66.6

Unconformity, based on regional studies; contact is sharp and erosional with up to 5 ft (1.5 m) of relief under Shinarump channel fill.

Moenkopi Formation (part):

1. Siltstone, red-brown, micaceous, with oscillation ripples; regional studies suggest mudflat.....**Not Measured**

Section 5--White Canyon Mine

[Section begins at base of channel with adit on southwest side of Fry Point below a small saddle between two distinct Moss Back benches. The adit here is approximately 5000 ft (1500 m) northwest of the main adits of the White Canyon Mine on the Utah State Highway 95-side of Fry Point; section continues up to the saddle and then up survey road on left to the top of the Moss Back bench in SW 1/4, SW 1/4, sec. 22, T.36S., R.16E., San Juan County, Utah]

	<u>Thickness</u>	
	<u>Feet</u>	<u>Meters</u>
Chinle Formation (part):		
Moss Back Member:		
20. Sandstone, moderate-brown to grayish-orange, very coarse grained, with indistinct large scale trough-crossbedding; forms massive cliff; braided stream deposit.....	34	10.1
19. Sandstone, same as unit 20; braided stream deposit.....	6	7.8
18. Sandstone, moderate-brown to light grayish-yellow, very coarse grained, with maximum 2 in. (5 cm) pebbles; contains silicified log fragments 3 in. (7.6 cm) by 1 ft (0.3 m); structureless, to large-scale trough-crossbedding in a channel scour 20 ft (6 m) wide at the base; forms massive cliff; braided stream deposit.....	10	3
Total Moss Back Member measured.....	50	15
Monitor Butte Member:		
17. Mudstone, medium bluish-gray, with some silt and very fine-grained sand, structureless to faint horizontal laminations; weathers to gray slope. Probably nearshore lacustrine.....	4	1.2
16. Sandstone, light bluish-gray, micaceous, silty, calcite and limonite cement on case-hardened surfaces, very fine-grained, 1 ft (0.3 m) to 1.5 ft (0.45 m) cyclically bedded with small-scale foreset bedding and 2 in. (5 cm) to 6 in. (15 cm), light- to medium-bluish-gray silty mudstone at the base; beds dip 4° SW, beds on SW side of saddle dip 6° SE; weathers to "popcorn" soil-covered slope; marginal lacustrine river-dominated (Miall, 1979) deltaic sandstone.....	6	1.8

15.	Mudstone, light-gray, micaceous, silty to very fine-grained sand, grading into sandstone, light-gray, micaceous, silty to very fine-grained, 2 ft (0.6 m) to 4 ft (1.2 m) cyclically bedded, coarsening upward with gradational contact between mudstone and sandstone within, cycle, sharp contact between sandstone and mudstone of next cycle; sandstone weathers to small cliffs, mudstone weathers out; marginal lacustrine river-dominated deltaic sandstones and mudstones, farther offshore than unit 16.....16	4.8
14.	Sandstone, dark yellowish-orange, white calcite matrix, very fine grained, maximum very coarse-grained sand with coarse-grained mudstone chips; weathers to small ledge; marginal lacustrine.....1.5	0.3
13.	Sandstone, light-gray to tan, micaceous, silty, very fine grained, 2 ft (0.6 m) to 4 ft (1.2 m), cyclically bedded, coarsening upwards, with ripple cross-lamination at tops of beds; contains small carbonized organic fragments and whole leaves of <u>Zamites powelli</u> at base of cycles; 1 cm diameter by 1 ft (0.3 m) to 1.5 ft (0.45 m) long, J-shaped burrows locally present; marginal lacustrine river-dominated deltaic sandstones, siltstones, and mudstones, cyclicity as in unit 16; weathers to small cliffs, mudstones weathering more; marginal lacustrine deltaic distal distributary bar.....76.5	26
12.	Covered slope.....5	1.5
11.	Siltstone, light-gray to tan, micaceous, contains very fine to fine-grained sand, with horizontal and wavy parallel laminations less than 1 mm, 2 ft (0.6 m) to 5 ft (1.5 m), cyclically bedded; contains fine carbon bits and <u>Zamites powelli</u> ; forms gray slope; marginal lacustrine offshore-deltaic siltstones.....20	6
10.	Covered slope.....3	1
9.	Mudstone, light reddish-purple, with very fine grained sand and silt; forms "popcorn" slope; nearshore lacustrine.....8	2.4
8.	Mudstone, light-gray, silty with some very fine grained sand; structureless; forms gray slope; nearshore lacustrine.....9	3
7.	Siltstone, gray, bentonitic, very fine- to fine-grained; forms rounded ledge; overbank.....1.5	0.45

6. Mudstone, light grayish-purple, with yellow-brown mottles, silty with some very fine grained sand; contains some secondary gypsum and scattered carbon bits; forms "popcorn" slope; overbank.....	13.5	4.1
5. Covered slope.....	4	1.2
	<hr/>	
Total Monitor Butte Member.....	168	51

Shinarump Member:

4. Sandstone, yellowish-gray, coarse-grained to granular, with maximum 1.5 in. (4 cm) pebbles; contains 2 ft (0.6 m) gray claystone split; laterally, 200 ft (60 m) to east, is 15 ft (4.5 m) black paper laminated, organic-rich mudstone containing conchostracans; forms flaggy slope with thin, rounded ledges; meandering stream, possibly marginal lacustrine and offshore lacustrine.....	14	5.4
3. Sandstone, yellowish-gray, very coarse grained to pebbly, trough-crossbedded; lower surface channel scour; forms small rounded cliff; meandering stream.....	6	1.8
2. Sandstone, light-gray, silty, and siltstone, light-gray, very fine grained sandy, thinly-bedded, 1 mm laminations, contains small carbon bits and dessication cracks; forms gray slope; overbank deposits.....	16	4.8
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Total Shinarump member.....	36	12

Total Chinle Formation (part).....254 77

Unconformity, from regional studies; contact sharp and undulatory, local relief approximately 20 ft (6 m) at base of Shinarump channel fill.

Moenkopi Formation (part):

1. Siltstone and sandstone, micaceous, dark-reddish-brown, very fine-grained; forms steep slope and rounded sandy ledges; mudflat, from regional studies.....	Not Measured	
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Section 6--White Canyon Mine-S3

[Section is on northwest side of Fry Point remnant butte, between Fry Canyon and White Canyon, above Utah State Highway 95. Section begins at adit on dirt survey road, 1.1 mi (1.8 km) northwest of White Canyon Mine workings. Section continues diagonally up to the northwest to the top of the Moss Back bench, SE 1/4, NE 1/4, sec. 23, T.36S., R.16E., San Juan County, Utah]

	<u>Thickness</u>	
	<u>Feet</u>	<u>Meters</u>
Chinle Formation (part):		
Moss Back Member:		
13. Sandstone, moderate yellow-brown to light-brown, medium- to coarse-grained, thick- to very thick-bedded, structureless to trough-crossbedded; contains clay clasts and pebbles locally, maximum 2 in. (5 cm); contains silicified wood fragments; forms steep cliff; braided stream.....	32	9.7
		9.7
Total Moss Back Member.....	32	9.7
Monitor Butte Member:		
12. Sandstone, light bluish-gray to medium bluish-gray; fine- to medium-grained, thin-bedded in cycles, bottom of cycle weathering back more than the upper portion of the cycle; marginal lacustrine, deltaic.....	30	9.1
11. Sandstone, greenish-gray, micaceous, silty, very fine to medium-grained, and siltstone, greenish-gray, micaceous, contains very fine- to fine-grained sand with some mud; thin bedded in cycles; climbing ripple cross-lamination at tops of cycles; base of cycles are muddy with numerous carbonized organic fragments, whole specimens of <u>Zamites powelli</u> and <u>Phlebopteris smithii</u> , and large, 2 ft (0.6 m) by 5 ft+ (1.5 m+) silicified log; beds contain small rotated blocks with preserved internal structure; weathers to small cliffs, base of cycles weathering back; marginal lacustrine, river-dominated deltaic distributary mouth bars.....	32	9.7
10. Mudstone, gray-blue to medium-gray; forms slope; nearshore lacustrine.....	30	9.1
9. Covered slope.....	38	11.5
8. Sandstone, grayish-pink to yellow-orange, mottled purple, yellow and white, very fine to fine-grained with scattered very coarse,		

well-rounded quartz grains; structureless; forms cliff; marginal lacustrine.....	12	3.6
7. Covered slope.....	26	7.8
6. Sandstone, white to yellowish-orange, fine- to medium-grained, lenticular, structureless; forms small cliff; marginal lacustrine.....	8	2.41
5. Mudstone, dark-gray to black, very thin-bedded with paper laminations, organic-rich with plant fragments; secondary gypsum on bedding planes; weathers to dark slope; offshore lacustrine.....	10	3
4. Mudstone, medium light-gray to medium bluish-gray, very thin bedded with very thin to paper laminations; contains finely comminuted carbonized plant fragments; forms slope; nearshore lacustrine.....	16	4.8
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Total Monitor Butte Member.....	202	61.2

Shinarump Member:

3. Sandstone, gray to grayish-yellow, very coarse to fine-grained, thin- to thick-bedded, in lenticular units with crossbedding and foreset bedding, horizontal laminations to curved, parallel, low-angle laminations; forms small rounded cliff; marginal lacustrine, delta.....	8	2.4
2. Sandstone, gray to yellowish-orange, very coarse to medium-grained, with maximum 2 in. (5 cm) pebbles, thick-bedded, structureless to trough-crossbedded; with scoured basal surface in channel; forms small rounded cliff; meandering stream.....	16	4.8
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Total Shinarump Member.....	24	7.2

Total Chinle Formation (part).....258 78.2

Unconformity, based on regional studies, contact is sharp and erosional, local relief 8 ft (2.4 m) at base of channel fill.

Moenkopi Formation (part):

1. Siltstone and sandstone, reddish-brown, very fine- to fine-grained, thin-bedded, forms ledgy slope; regional studies suggest mudflat.....	Not Measured	
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Section 7--Tilted Beds

[Section is on northwest end of Fry Point remnant butte between Fry Canyon and White Canyon. Section begins 100 ft (30.3 m) north of the end of the dirt survey road that traverses Fry Point on the Fry Canyon side, leaving from the White Canyon Mine workings. Section continues directly uphill to top of the Moss Back bench, NE 1/4, NE 1/4, sec. 22, T.36S., R.16E., San Juan County, Utah]

	Thickness	
	Feet	Meters
Chinle Formation (part):		
Moss Back Member:		
9. Sandstone, medium- to dark-brown, coarse- to medium-grained, thick-bedded, faint trough-crossbeds; forms small cliff; braided stream.....	20	6
		6
Total Moss Back Member.....	20	6
Monitor Butte Member:		
8. Siltstone, light- to medium-gray, very fine to fine-grained sandy, and covered slope.....	40	12
7. Sandstone, greenish-gray, micaceous, calcareous, fine- to medium-grained, thin- to thick-bedded, horizontal laminations, small scale trough-crossbedding, lower contact is scoured and erosional, local relief 1.5 ft (0.45 m); climbing ripples; forms steep and blocky cliff; meandering, cliff; tributary, deltaic-marginal lacustrine stream.....	20	6
6. Sandstone, greenish-gray, micaceous, silty, very fine- to fine-grained, and siltstone, greenish-gray, micaceous, sandy, very fine grained; very thin- to thick-bedded, climbing ripple cross-lamination; small micro-faults; contains carbonized organic bits whole specimens of <u>Zamites powelli</u> , and sole marks on lower bedding plane surfaces; beds dip from 37 ⁰ to 43 ⁰ S35W and represent a tilted block; disrupted bedding in some beds resulting from movement prior to lithification is expressed as knobby weathering; other beds with ripple bedding preserved weather to small blocky cliffs; slump block feature on distal end of cyclic distributary mouth bars, river-dominated delta.....	20	6
5. Covered slope.....	16	4.8

4. Same as unit 6, siltier, weathers to slope, but dip and strike of beds are the same.....	16	4.8
3. Covered slope.....	53	16
<hr/>		
Total Monitor Butte Member.....	165	50

Shinarump Member:

2. Sandstone, yellowish-orange to white, coarse- to medium-grained, with maximum 2 in. (5 cm) pebbles, thin-bedded, faint trough-crossbeds; forms rounded ledge; meandering stream, possibly marginal lacustrine.....	5	1.5
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Total Shinarump Member.....	5	1.5
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Total Chinle Formation (part).....	190	57.6
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Unconformity, based on regional studies; contact is sharp and erosional, local relief 6 in. (15 cm).

Moenkopi Formation (part):

1. Siltstone, dark reddish-brown, micaceous, very thin-bedded; forms slope; regional studies suggest mudflats.....	Not Measured	
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