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STRATIGRAPHIC MEASURED SECTIONS OF THE UPPER CRETACEOUS MANCOS SHALE (UPPER PART) AND MESAVERDE GROUP (LOWER PART), MOFFAT COUNTY, COLORADO

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STRATIGRAPHIC MEASURED SECTIONS OF THE UPPER CRETACEOUS MANCOS SHALE (UPPER PART) AND MESAVERDE GROUP (LOWER PART), MOFFAT COUNTY, COLORADO[1]

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Twelve sections of the uppermost part of the Mancos Shale and the lower part of the Mesaverde Group (Iles Formation) of Late Cretaceous age have been measured in a linear distance of about 50 mi (83 km) in northwestern Colorado as part of a study of depositional environments of impermeable ("tight", <0.1 md) gas-bearing reservoirs in the Sand Wash basin of the Greater Green River Basin. This study focused on interpretation of facies based on lateral and vertical associations of rock types, textures, sedimentary structures, contact relations, and faunas. The depositional model derived from this study (Kiteley, 1979) indicates that most reservoirs--shallow shelf sand bars, barrier beaches, delta margin sands, distributary and fluvial channels--are discontinuous but nevertheless systematic and predictable, and that reservoir quality is related to depositional environment.

Most gas production in the Sand Wash basin has been from stratigraphic traps on small anticlines at shallow depths. This production is only marginally economic because of low permeability and lenticularity of reservoirs. Gas production from these reservoirs has been improved somewhat by hydraulic fracturing in the report area. Nuclear fracturing in the nearby Piceance Creek basin has been generally unsuccessful. The present study shows that quality and distribution of the producing sand bodies can be predicted so that exploration can be better focused. Moreover, reservoir characteristics such as geometry, distribution of pore space, and barriers influencing fluid flow, which are needed in enhanced recovery programs, can be delineated in the subsurface based on the stratigraphic data presented herein (Kiteley, 1979).

[1] Prepared in cooperation with the U.S. Department of Energy (NVOO).

MEASURED SECTIONS

COAL CREEK SECTION, C E1/2 sec. 20, C sec. 21, T. 4 N., R. 98 W., Elk Springs 15 min. Quadrangle, Moffat County, Colorado. Section from Units 1 through 24 measured with Jacob Staff and tape by J. R. Dyni and R. R. Cunningham, Sept. 5, 1962, and remeasured and annotated by L. W. Kiteley, assisted by Jason Ota, July and August 1977. Section from Units 25 through 43 measured with Jacob Staff and tape by L. W. Kiteley and E. B. Forester, September 1977. Megafauna identified by E. G. Kauffman, U.S. National Museum, and W. A. Cobban, U.S. Geological Survey.

		Feet	Meters
Mesaverde Group:			
Iles Formation:			
43.	Trout Creek Sandstone Member equivalent: Sandstone, light-gray (N7); weathers "whitish"; fine to medium grained (at base to calcareous at top); subrounded, cherty, noncalcareous at base to calcareous at top	77.0	23.5
42.	In part covered, claystone, gray; contains ironstone concretions; and interbedded thin silty lenticular sandstone; fine-grained	130.0	39.16
41.	Covered	163.0	49.7
40.	Sandstone, silty, dark-yellowish-orange, (10YR 6/6), very fine to fine grained, poorly sorted, slightly calcareous; medium bedded (up to 1 ft, 0.3 m); weathers massive	29.0	8.8
39.	Claystone, gray, and thinly interbedded sandstone; ironstone concretions (poorly exposed)	164.0	50.0
38.	Sandstone, lenticular, clayey, light-gray (N7) to dark yellowish-gray (10YR 6/6), fine-grained, cherty, trough crossbedded; contorted in places	4.0	1.2
37.	Claystone, gray, mostly covered; very calcareous	15.0	4.6
36.	Sandstone, similar to 38, fine-grained fining upward to silt-sized; trough and wedge planar crossbedding; sharp scour base over shale with ironstone concretions	10.0	3.0

COAL CREEK SECTION-(cont.)

Mesaverde Group-(cont.)

Iles Formation-(cont.)	Feet	Meters
35. Claystone, gray, and interbeded carbonaceous shale, ironstone concretions, and thin siltstones (up to 3 ft, 0.9 m) near top	38.0	11.6
34. Sandstone, shaly, light-gray (N7) to dark-yellowish-orange (10YR 6/6); very fine grained at base to silt sized at top; small-scale trough crossbeds (ca. 0.5 ft (0.15 m) in length); very thin clay "drapes"	18.0	5.5
33. Claystone, gray, and interbedded carbonaceous shale (fissile because of alined plant fragments); interlaminated coal stringers	10.0	3.0
32. Sandstone, clayey, light-gray (N7), very fine grained; large-scale foresets with very thin clay "drapes" vertical root traces in basal 4 ft (1.2 m)	10.0	3.0
31. Mudstone, grayish-brown (5YR 3/2), noncalcareous, slightly coaly	7.0	2.1
30. Sandstone, lenticular, wedges out against overlying sandstone, light-gray (N7), dark-yellowish-orange (19YR 6/6)-weathering, very fine to fine-grained at base to dominantly fine-grained at top; large-scale foresets; sharp scour base	17.0	5.2
29. Claystone, lenticular, medium-gray (N5)	5.0	1.5
28. Sandstone, lenticular; wedges out against overlying sandstone; light gray (N7), fine grained at base to silt sized at top; ripple laminated to contorted; contains some thin clay "drapes"; sharp scour base	11.0	3.4

COAL CREEK SECTION-(cont.)

Mesaverde Group-(cont.)	Feet	Meters
Iles Formation-(cont.)		
27. In part covered with upper 7 ft (2.1 m) better exposed; claystone, medium-dark-gray (N4) and interbedded siltstone, medium-gray (N5) to dark-yellowish-orange (10YR 6/6); carbonaceous plant debris; root traces (?) or possibly burrowed(?) near top	67.0	20.4
26. Sandstone, clayey, "salt and pepper", light-gray (N7) to dark-yellowish-orange (10YR 6/6) ("root mottled"), very fine grained fining upward to silt-sized, ripple-laminated; sharp scour base	6.0	1.8
25. In part covered; shale, carbonaceous; lower two-thirds brown, dark brown weathering, upper one-third weathers "whitish"	11.5	3.5
(Offset due west to Point C on Photo 161 of J. Dyni; following section measured by J. R. Dyni, R. R. Cunningham, 1962, annotated by L. W. Kiteley, assisted by J. Ota, 1977)		
24. Sandstone, yellowish-tan and light-tan fine- to medium-grained, slightly calcareous; medium-scale trough crossbedded (6-8 ft, 1.8-2.4 m in width), asymetrically filled, grading upward to ripples at tops of troughs; claystone pebbles and light-gray clay "drapes"; upper 22 ft (6.7 m) contains small spheroidal calcareous sandstone concretions that weather out on outcrop	98.0	29.9
23. Shale, sandy, carbonaceous; weathers gray	16.0	4.9
22. Sandstone, shaly, mottled gray and yellow-tan ("root mottled"), very fine to fine-grained; thinly laminated; contorted; root markings near top	6.3	1.9

COAL CREEK SECTION-(cont.)

Mesaverde Group-(cont.)

Iles Formation-(cont.)	Feet	Meters
21. Shale, carbonaceous; interbedded sandstone, light-gray (N7), very fine grained; and coal	16.0	4.9
20. Sandstone, light-gray, yellowish-tan weathering, fine-grained (a few medium grains), slightly calcareous; small scale crossbedded; clay pebbles and thin clay "drapes"; interbedded siltstones and claystones (up to 2 ft, 0.6 m thick) in basal part	55.0	16.8
19. Largely covered; shale, carbonaceous, sandy; interbedded gray carbonaceous sandstone	26.5	8.1
18. Coal	1.2	0.4
17. Same as unit 15	18.0	5.5
16. Coal	0.4	0.1
15. Shale, carbonaceous; interbedded sandstone and siltstone; weathers light gray. Sandstone and siltstone, lenticular, very thin bedded, carbonaceous; current rippled	1.1	0.3
13. Shale, carbonaceous, and interbedded claystone, gray	5.5	1.7
12. Coal; basal few cm is very organic-rich carbonaceous shale (paleosoil?)	1.0	0.3
11. Sandstone, very light gray to tan in basal one-third, very fine to fine grained, well-sorted; trough crossbedded near base (inferred "swash zone"); flat bedded in upper one-third; *Ophiomorpha* abundant in lower part, fewer in upper half	27.0	8.2

COAL CREEK SECTION-(cont.)

Mesaverde Group-(cont.)	Feet	Meters
Iles Formation-(cont.)		
10. Sandstone; interbedded gray shale (0.8 ft, 0.2 m) at base. Sandstone, light-gray (N7), very fine grained; weathers massive and rounded; laminated (1.0 cm) horizontally bedded near top; *Ophiomorpha* throughout	4.0	1.2
9. Sandstone, light-tan, very fine to fine-grained, calcareous; thinly interbedded siltstone (bioturbated); dominantly flat bedded; *Ophiomorpha*, some parallel to bedding	10.4	3.2
Total thickness Iles Formation	1,110.9	338.6
Mancos Shale (part):		
Buck Tongue, upper part:		
8. In part covered, shale, sandy, gray; forms slope	10.0	3.0
7. Sandstone; interbedded sandy shale; tan (base) and light gray (upper half). Sandstone fine-grained, subrounded, moderately well sorted, trough crossbedded; some flat bedding at top; medium bedded (up to 20 cm); bioturbated in places	13.5	4.1
6. Sandstone, silty, tan, very fine to fine-grained, very thin bedded to laminated (1.0 cm) (at top); trough crossbedded. One foot (0.3 m) shale layer at top	4.1	1.2

COAL CREEK SECTION-(cont.)

Mancos Shale (part)-(cont.)	Feet	Meters
Buck Tongue, upper part-(cont.)		
5. Claystone; thinly interbedded siltstone (near top), greenish gray, thin bedded; a few selenite crystals; forms slope ----------	15.5	4.7
4. Sandstone, tan, fine-grained, calcareous; large *Ophiomorpha* parallel to bedding ----------	5.5	1.7
3. In part covered; sandstone, shaly, tan, fine-grained, subangular, thick-bedded ----------	11.0	3.4

COAL CREEK SECTION-(cont.)

Mancos Shale (part)-(cont.)	Feet	Meters
Buck Tongue, upper part-(cont.)		
2. Shale, sandy, mostly olive gray, in part tan and yellowish-brown, subfissile; some selenite gypsum crystals and a few rusty brown clay ironstone concretions; forms slope Ammonite: *Placenticeras intercalare* ----------	165.0	50.3
Total thickness Buck Tongue, upper part --	224.6	68.4
1. Loyd Sandstone Bed: Sandstone, gray, brown-to orangish-brown -weathering, very fine to fine -grained; calcareous, low-angle crossbedded to flat-bedded; very large (about 10-15 ft (3-4.5 m) diameter) spheroidal fossiliferous limy sandstone concretions: *Ophiomorpha* throughout; pelecypod on uppermost bedding surface ----------	29.0	8.8
Bivalvia: *Inoceramus* sp. cf. *I. barabini* Morton (s.s.) equally rugate form *Inoceramus proximus* Toumey (s.s.) *Inoceramus proximus subcircularis* Meek (?= *I. vanuxemi* Meek and Hayden, of Meek, 1876, pl. 14, fig. 2) *Inoceramus barabini* Morton s.l. (of Meek, 1876, pl. 13, fig. 1a-c), finely unequally ribbed variant. *Nucula* sp. cf. *N. obsoletistriata* Meek and Hayden *Phelopteria linguiformis* (Evans and Shumard) **Lucina* (=Nymphalucina) subundata* (Hall and Meek) *Crenella elegantula* Meek and Hayden *Granocardium (Ethmocardium)* n. sp. aff. *G. (E.) whitei* (Dall) (=*G. (E.) speciosum* Meek and Hayden) *Corbula* sp. indet *Clisocolus dubius* (Grabb)? *C. moreauensis* (Meek and Hayden) *C. dubius* (Gabb)		
Total Thickness Mancos Shale (part) ----------	253.6	77.3

COAL CREEK SECTION-(cont.)

Mancos Shale (part)-(cont.)

Cymbophora? sp. (mold)
Endocostea? barabini (Morton)
"Inoceramus" regularis d'Orbigny
"I." cf. *balchii* Meek and Hayden
"I." oblongus trans. to *I. balchii* Meek and Hayden
Anatina
A. n. sp. aff. *A. lineata*
Pseudoptera (juv.) aff. *P. subtortuosa* (Meek and Hayden)

Ammonites:

Baculites perplexus Cobban
Hoploscaphites sp.
Placenticeras sp.

DECEPTION CREEK SECTION, W1/2 sec. 23, NW1/4 sec. 26, SE1/4SE1/4 sec. 22, N1/2 sec. 27, T. 5 N., R. 95 W., Citadel Plateau 15 min. Quadrangle, Moffat County, Colorado. Section measured with Jacob Staff and tape by L. W. Kiteley and J. R. Peterson, July 1977. Microfauna identified by D. L. Eicher and E. B. Forester; megafauna identified by E. G. Kauffman, U.S. National Museum, and W. A. Cobban, U.S. Geological Survey.

		Feet	Meters
Mesaverde Group:			
Iles Formation:			
48.	Trout Creek Sandstone Member: Sandstone, silty near base, light-gray (N7), uniformly fine grained, well-sorted, subrounded, cherty, very thin bedded (2 cm), flat-bedded to very low angle crossbedded; a few *Ophiomorpha*	25.0	7.6
47.	Mostly covered; probably carbonaceous shale	18.0	5.5
46.	Sandstone, silty, very fine to fine-grained, ripple-laminated	13.0	4.0
45.	Mostly covered; claystone, light-gray (N7)	5.0	1.5
44.	Sandstone, light-gray (N7), very fine to fine-grained (fining upward), thin-bedded; weathers massive	26.0	7.9
43.	Covered; probably mostly claystone	55.0	16.8
42.	Sandstone, light-gray (N7), very fine to fine-grained (fining upward), well-sorted; laminated to very thin bedded (0.5-2 cm); trough crossbedded in lower half, medium-scale foresets (locally thick bedded, 30 cm) at top; contorted bedding near base	30.0	9.1
41.	Claystone, light-gray (N7), and interbedded thin lenticular sandstones	50.0	15.2
40.	Sandstone, silty, light-gray (N7) to dark-yellowish-orange (10YR 6/6), fine-grained; claystone pebbles (up to 3 cm diameter); contorted bedding; weathers massive	48.0	14.6
39.	Sandstone, grayish-yellow (5Y 8/4); similar to unit 40	11.0	3.4
38.	Claystone, light-gray (N7); interbedded siltstones	30.0	9.1

DECEPTION CREEK SECTION-(cont.)

Mesaverde Group-(cont.)		Feet	Meters
Iles Formation-(cont.)			
37.	Poorly exposed; sandstone, light-gray (N7) to dark-yellowish-orange (10YR 6/6), very fine-grained; carbonaceous plant debris and plant impressions on sandstone	12.0	3.7
36.	Claystone, light-gray	5.0	1.5
35.	Siltstone, dark-yellowish-orange (10YR 6/6); wood imprints at top; weathers massive	10.0	3.0
34.	Sandstone, silty, light-gray (N7) to yellowish-orange (at top), very fine grained; plant debris at top; interbedded light-gray claystone; gradational lower contact	25.0	7.6
33.	Sandstone, very fine to medium-grained biotite mica, chert; weathers massive flat bedded to ripple bedded; clay pebbles	37.0	11.3
32.	Poorly exposed; claystone; interbedded siltstones	15.0	4.6
31.	Sandstone, silty, light-gray, very light gray (N8) weathering, very fine grained, medium-scale (up to 2 ft, 0.6 m) trough crossbedded; ironstone concretions near base	3.0	0.9
30.	Poorly exposed; siltstone, light-gray (N7); interbedded claystone, medium-gray (N5), carbonaceous	20.0	6.0
29.	Sandstone, yellowish-gray (5Y 7/2) to dark-yellowish-orange (10YR 6/6); ripple laminated, some low angle crossbedding; clay pebbles; sharp scour base	30.0	9.1
28.	Claystone, gray; interbedded thin coal, sandstone, and carbonaceous shale	52.0	15.8
27.	In part covered; claystone; interbedded sandstone, fine- to medium-grained; abundant chert; contorted; weathers massive	25.0	7.6

DECEPTION CREEK SECTION-(cont.)

Mesaverde Group-(cont.)		Feet	Meters
Iles Formation-(cont.)			
26.	Sandstone, yellowish-gray (5Y 7/2) to dark-yellowish-orange (10YR 6/6), fine- to medium-grained, friable, ripple-laminated; clay pebbles; sharp scour base	5.0	1.5
25.	Claystone, medium light-gray (N6), carbonaceous debris; interbedded siltstone, yellowish-gray (5Y 7/2); large ironstone concretions in claystone	30.0	9.1
24.	Sandstone, light-gray (N7), fine-grained, moderately well sorted, thin-bedded; trough crossbedding, cuspate rippled at tops of beds; clay pebbles	41.0	12.5
23.	Covered; probably claystone	20.0	6.1
22.	Sandstone, yellowish-gray (5Y 7/2), very fine to fine-grained, cherty, moderately well sorted; medium-scale foreset bedding and some ripple bedding	26.0	7.9
21,	Claystone, light-gray (N7); interbedded carbonaceous shale, coal (2 ft, 0.6 m thick) and minor sandstone; ironstone concretions	40.0	12.2
20.	Sandstone, yellowish-gray (5Y 7/2), dark-yellowish-orange-weathering (10YR 6/6), very fine to fine-grained; "bleached" white at top; trough crossbedded and ripple laminated; contorted bedding; carbonaceous plant debris at top	26.0	7.9
19.	Covered; claystone, light-gray	20.0	6.1
18.	Sandstone, yellowish-gray (5Y 7/2), fine-grained; small-scale trough crossbedded; carbonaceous debris; sharp scour base	2.0	0.6
17.	Shale, medium-gray (N5) and dark-yellowish-orange (10YR 6/6), slightly fissile; ironstone concretions; carbonaceous debris	16.0	4.8
16.	Sandstone, silty, light-gray, fine-grained, well-sorted, well-rounded; trough crossbedded; sharp scour base; siltstone interbeds near base; Toredolithus at base	30.0	9.1

DECEPTION CREEK SECTION-(cont.)

Mesaverde Group-(cont.)		Feet	Meters
Iles Formation-(cont.)			
15.	Claystone, medium-gray; interbedded carbonaceous shale ----------	7.0	2.1
14.	Sandstone, very fine to fine-grained, well-sorted; medium scale trough crossbeds (festoon); sharp scour base ----------	30-35.0	9.1-10.6
13.	Sandstone, light-gray (N7); thinly interbedded claystone, medium-gray (N5). Sandstone, silty, very fine-grained, very well sorted; predominantly ripple bedded with broken clay clasts and rounded clay pebbles on bedding surfaces; *Scolithus* ----------	16.0	4.9
12.	Coal ----------	0.25	0.07
11.	Claystone, brownish-gray, carbonaceous ----------	6.5	2.0
10.	Sandstone, silty interbedded claystone. Sandstone entirely medium scale trough crossbedded ----------	21.5	6.5
9.	Sandstone, light-gray (N7) fine-grained, quartz, some chert; weathers "bleached" white at top, medium-scale (up to 2 ft, 0.6 m) trough crossbeds; sharp scour base over thin sandstone or thinly interbedded shale and sandstone ----------	44.0	13.4
8.	Shale; thinly interbedded sandstone ----------	21.5	6.6
7.	Sandstone, light-gray (N7) to yellowish-gray (5Y 7/2), very fine grained laminated to very thinly bedded (1 cm) horizontally bedded; long straight crested, very shallow ripples at top; basal contact sharp (hummocky surface); *Ophiomorpha*, *Ostrea* (disarticulated), on upper surface, bioturbation structures -------	10.0	3.0

DECEPTION CREEK SECTION (cont.)

Mesaverde Group-(cont.)

Iles Formation-(cont.)

6. Shale; thinly interbedded sandstones and siltstones at 35 ft (10.7 m) above base. Sandstone (up to 1 ft (0.3 m) thick); long sinuous crested ripples on tops of sandstones; tracks, trails, and burrows include *Gyrochorte* (biserial trails), *Crossopodia* (central furrow with "segments" forming a broad dense fringe on either side), *Nereites?* (meandering feeding trails with central axis and laterally spaced leaf-or lobe-shaped protrusions), starfish resting trace, and *Planolites* (meandering sand- and silt-filled, smooth walled, deposit feeding burrows) ------ 70.0 21.3

Ostracode:
Haplocytheridea

Foraminifera:
Haplophragmoides excavatus Cushman and Waters

5. I-1 sandstone; Sandstone, light-gray (N7 to yellowish-gray (5Y 7/2), fine- to medium-grained, moderately well sorted; well-rounded grains, quartz, chert, mica; friable; flat bedded to very low angle crossbedded (tangential bases), some current ripple bedding (asymmetric); *Ophiomorpha* (more concentrated near top), *Thallasinoides* on upper surfaces; shell coquina *(Ostrea)*-filled scoured trough at top ---------- 50.0 15.2

Bivalvia:
Crassostrea sp. aff. *C. subtrigonalis* (Evans and Shumard); rare boring by *Clione*; wood frags.

Total thickness Iles Formation ---------- ±1,056.25 ± 321.9

Mancos Shale:

Buck Tongue, upper part:

4. Mudstone, medium-dark-gray (N4) ---------- 43.3 13.1

Total tickness Buck Tongue, upper part------- 43.0 13.1

DECEPTION CREEK SECTION-(cont.)

Mancos Shale-(cont.)	Feet	Meters
3. Loyd sandstone bed: Sandstone, yellowish-gray (5Y 7/2) to grayish-yellow (5Y 8/4), very fine grained, silty ("sugary"); weathers massive; *Ophiomorpha* ----------	25.0	7.6
Bivalvia: cf. *Veniella* sp. (poor external mold) *Clisocolus* n. sp. aff. *C. dubius* and aff. *C. transversa* (Whitfield)		
Buck Tongue, lower part:		
2. Mudstone, silty, light-olive-gray (5Y 61) ----------	77.0	23.5
Foraminfera: *Spiroplectommanina semicomplanata* (Carsey) *Haplofragmoides excavatus* Cushman and Waters		
Total thickness Buck Tongue, lower part------	77.0	23.5
Unnamed sandstone of B. *asperiformis* range age:		
1. Sandstone, pale-greenish-yellow (10Y 8/2), fine-grained, well-rounded, moderately well sorted, friable; large-scale foreset bedding, medium-scale troughs; *Chondrites?*, *Ophiomorpha* mostly concentrated near top -------	34.0	10.4
Total thickness Mancos Shale (part) --------	179.0	54.6

MORGAN GULCH SECTION, NE1/4 sec. 5, T. 5 N., R. 93 W., Horse Gulch 7.5 min. Quadrangle, Moffat County, Colorado
Section measured with Jacob Staff and tape by L. W. Kiteley and N. Noreen, July 1978. Pollen and spores identified by Fred May; megafauna identified by E. G. Kauffman, U.S. National Museum.

Mesaverde Group:	Feet	Meters
Iles Formation:		
18. Sandstone, yellowish-gray, very fine to fine-grained; trough crossbedded; clay pebbles; sharp scour base over underlying shale	23.0	7.0
17. Shale, medium dark-gray, carbonaceous	15.0	4.6
16. Sandstone, light-gray to dark yellowish-orange, very fine grained to silt-sized, ripple-laminated; carbonaceous plant debris and carbonaceous woody fragments	5.0	1.5
15. Shale, similar to unit 17	50.0	15.2
14. I-2 sandstone, equivalent: Sandstone, lenticular, light-gray, fine- to medium-grained, moderate to well-sorted, well-rounded; trough crossbedded; clay pebbles; abundant plant debris and carbonaceous woody fragments	8.0	2.4
13. Shale, similar to unit 17	12.0	3.7
12. Siltstone, mottled light-gray to dark-gray, carbonaceous; plant rootlets; plant debris	3.0	0.9
11. Shale, medium-gray, carbonaceous	20.0	6.1
10. Shale, light-gray, medium- to large-scale trough-crossbedded; claystone pebbles; *Toredolithus* at base; sharp scour base (includes low-angle flat bedded marine? sandstone in lower third)	100.0	30.5
9. Claystone; interbedded siltstone, thinly laminated; small-scale trough crossbedding to low-angle flat bedding	7.0	2.1
8. Coal	3.0	0.9

MORGAN GULCH SECTION-(cont.)	Feet	Meters
Mesaverde Group-(cont.)		
Iles Formation-(cont.)		
7. Claystone, thinly laminated	6.0	1.8
6. Coal	15.0	4.6
5. I-1 sandstone: Sandstone, grayish-yellow (5Y 8/4), very fine to fine-grained (silt sized near base). Dominantly low angle flat-bedded (a few small-scale trough crossbeds) in lower half with sharp basal contact; *Ophiomorpha* (large) near base and concentrated in a zone at +30 ft (9 m) above base. Upper half flat bedded to low angle crossbedded; "white" weathering in uppermost 16 ft (5 m)	56.0	17.1
Total thickness Iles Formation (part)	329.0	98.8
Mancos Shale:		
4. Claystone; interbedded thin tabular siltstones, especially at top	155.0	47.2
3. Siltstone, light-gray to grayish-orange, thinly horizontally laminated; forms concretions	1.0	0.3
2. Shale, medium-gray	81.0	24.7
1. First Mancos Ss of Konishi (1959a): Sandstone, light-gray to grayish-orange, fine-grained, moderately well sorted, rounded to angular; ironstone concretions and rounded pebbles on bedding surfaces; *Ophiomorpha, Gyrochorte,* oysters, sharks teeth on bedding surfaces; excellent porosity	9.0	2.7
Total thickness Mancos Shale (part)	245.0	74.7

DUFFY MOUNTAIN SECTION, C sec. 25, T. 5 N., R. 93 W.; NW1/4 sec. 30, E1/2 sec. 19, SE1/4 sec. 18, SW1/4 sec. 17, T. 5 N., R. 92 W., Axial, Horse Gulch, and Round Bottom 7.5 min. Quadrangles, Moffat County, Colorado Section measured with Jacob Staff and tape by L. W. Kiteley and J. R. Peterson, July 1977.

Mesaverde Group:	Feet	Meters
Iles Formation:		
38. Trout Creek Sandstone Member: Sandstone, "whitish" weathering, low-angle cross-bedded to horizontally bedded; *Ophiomorpha*; weathers in rounded masses	64.5	19.7
37. Shale, light-olive-gray, and interbedded sandstone, light-yellowish gray; *Inoceramus*	116.0	35.4
36. Sandstone, lenticular, very fine to medium grained; sharp scour base; interbedded silty shale, medium-gray (N5) to medium dark-gray; carbonaceous shale; weathers pale brown (5YR 5/2) to grayish-brown (5YR 3/2); thin coal beds. Contact at top of unit is sharp between coal bed and overlying marine shale	24.0	7.3
35. Sandstone, yellowish-gray to light-gray, fine- to medium-grained, fair-sorted, cherty, slightly friable; large-scale trough crossbedded and small-scale low-angle crossbedding	19.0	5.8
34. Covered	10.0	3.0
33. Sandstone, similar to Unit 35	24.5	7.5
32. Poorly exposed; mudstone; interbedded sandstone	25.0	7.6
31. Poorly exposed; sandstone	15.0	4.6
30. Poorly exposed; claystone, light-gray; interbedded sandstone. Basal 20 ft (6.0 m) consists of locally thickened sandstone interval of underlying unit	63.0	19.2

DUFFY MOUNTAIN SECTION (cont.)

Mesaverde Group-(cont.)

Iles Formation-(cont.)

29.	Sandstone, yellowish-gray (5Y 7/2) to grayish-orange (10YR 7/4), very fine to medium-grained, poorly sorted; large-scale crossbedding; sharp scour base ----------	20.0	6.1
28.	Claystone, gray; interbedded thin (up to 3 ft, 0.9 m) lenticular sandstone, massive-bedded ----------	30.0	9.1
27.	Sandstone, massive-bedded ----------	5.0	1.5
26.	Claystone, gray, carbonaceous; interbedded carbonaceous shale (1-2 ft, 0.3-0.6 m, at top of unit) ----------	10.0	3.0
25.	Sandstone, light-yellowish-gray to grayish-orange, very fine to medium-grained, poorly sorted, friable; large scale trough crossbedded, dominantly unidirectional; sharp scour base. ----------	13.5	4.1
24.	Mostly covered; probably shale, gray, and interbedded thin sandstone, similar to unit 22 ----------	15.0	4.6
23.	Sandstone, light-yellowish-gray, gray-orange-weathering (10YR 7/4), very fine- to medium-grained, friable; ironstone concretions at base, and thin interbedded clay "drapes"; medium-scale trough crossbeds (festoon) and rippled beds; unit thins and thickens and contains pebble lags ----------	15.0	4.6
22.	Poorly exposed; shale, medium-gray (N5), slightly carbonaceous; ironstone concretions; interbedded thin (1 ft, 0.3 m) silty sandstone, very fine to fine-grained, poorly sorted, clay pebbles; ripple laminated; root traces (basal 6 ft, 1.8 m) ----------	21.0	6.4

DUFFY MOUNTAIN SECTION (cont.)

Mesaverde Group-(cont.)	Feet	Meters
Iles Formation-(cont.)		
21. Claystone, medium-gray (N5), slightly carbonaceous (basal 13 ft); overlain by sandstone, lenticular, light-yellowish-gray, grayish-orange-weathering (10YR 7/4, low-angle-crossbedded and current-rippled ----------	15.0	4.6
20. Covered in upper 9 ft (2.7 m); sandstone, light-gray (N7), olive-gray (5Y 3/2) where case hardened; weathers light brown (5YR 5/6) to moderate brown (5YR 4/4); very fine to fine grained; thinly laminated to thin bedded (4 cm); medium-scale festoon crossbedded ----------	19.0	5.8
19. Claystone, light-gray (N7) to yellowish-gray (5Y 8/1); coaly and abundant carbonaceous woody fragments; interbedded thin siltstones and very fine grained sandstones; poorly exposed; ironstone concretions weathering out ----------	73.0	22.3
18. Sandstone, yellowish-gray (5Y 7/2) to dusky-yellow (5Y 6/4), very fine- to fine-grained, cherty, moderately well sorted, thin- to medium-bedded (up to 15 cm), low-angle-crossbedded; contains large (up to 11 cm) ironstone concretions; contorted in places; weathers in rounded masses ----------	15.0	4.6
17. Predominantly covered. At 16.6 ft (5 m) above base, sandstone, silty, yellowish-gray (5Y 7/2) to dusky-yellow (5Y 6/4), very fine to fine-grained; poorly sorted chert; thin bedded (4 cm); trough crossbedded; weathers massive; small (2 cm) ironstone concretions weathering out. At 23 ft (7 m) siltstone and thin-bedded sandstone, very fine to fine-grained ----------	49.6	15.1

DUFFY MOUNTAIN SECTION (cont.)

Mesaverde Group-(cont.)	Feet	Meters
Iles Formation-(cont.)		
(Cross over Milk Creek, units 17-38 measured on north side.)		
16. Sandstone, yellowish-gray (5Y 7/2) to dusky-yellow (5Y 6/4), very fine to fine-grained, moderately well sorted, very thinly laminated to laminated (0.5 cm); medium-scale foreset bedding, local climbing ripples; claystone "drapes"; contorted and brecciated in places with claystone clasts up to 30 cm long; rounded ironstone concretions (up to 10 cm) in brecciated claystones and sandstones; base scoured into underlying shale and undulatory; unit thins and thickens ----------	29.9	9.1
15. Mudstone, silty, dark-gray (N3); contains possible charophyte vegetative parts ----------	15.0	4.6
14. Sandstone, fine-grained, micaceous, poorly sorted; interbedded siltstone; medium-scale trough crossbedded to ripple bedded at tops of troughs; large claystone pebbles ----------	18.9	5.8
13. Shale, carbonaceous, interbedded coal and thin sandstones (up to 2 ft, 0.6 m), and siltstones. Sandstone, light-gray, very fine to fine-grained; very thin (2 cm) flat bedded clay pebbles; contorted bedding in places ----------	75.0	22.9
12. Claystone, gray; interbedded carbonaceous shale, coal, siltstone, and sandstone. Sandstones, lenticular (up to 4 ft, 1.2 m), light-gray, very fine grained, flat-bedded to wedge planar crossbedded, contorted. Siltstones (up to 4 ft, 1.2 m thick), very low angle crossbedded; weathers massive. Thick coal beds containing ironstone concretions at 45-50 ft (14-15 m) and 55-60 ft(17-18 m) above base ----------	100.0	30.5

DUFFY MOUNTAIN SECTION (cont.)

Mesaverde Group-(cont.)	Feet	Meters
Iles Formation-(cont.)		
11. Sandstone, grayish-yellow (5Y 8/4) to very light gray (N8), very pale orange (10YR 8/2) to grayish-brown (5YR 3/2) weathering, very fine to medium-grained; unit thins and thickens (>100 ft, 30 m) along strike; and small- and medium-scale trough crossbedding in thin parts, medium to large-scale troughs in thickened parts; claystone "drapes" and clay pebbles; abundant woody debris (logs and stems) at base (*Toredolithus* borings numerous); carbonaceous debris throughout ----------	91.0	27.7
10. Shale, carbonaceous, moderate-brown (5YR 4/4) to dark-yellowish-orange (10YR 6/6); interbedded sandstones, lenticular (up to 4 cm), pale-yellowish-orange (10YR 8/6) to grayish-orange (10YR 7/4), very fine to fine-grained, ripple-laminated; rounded clay clasts; woody plant impressions ----------	120.0	36.6
9. I-2 sandstone: Sandstone, grayish-orange (10YR 7/4) in lower half to yellowish-gray (5Y 8/1) in upper half, very fine to fine-grained (coarsening upward); quartz, chert; dominantly flat bedded, some trough cross bedding; sharp basal contact; root traces at top; *Ophiomorpha* abundant in lower half, few in number in upper half; broken *Inoceramus* shells form fossil hash --------	33.4	10.2
8. Poorly exposed; alternating shale and thin (1-2 ft, 0.3-0.6 m), lenticular sandstones. Sandstones are rippled in basal 10 ft (3 m); compound foresets crossbedded upper 65 ft ----------	75.0	22.9

DUFFY MOUNTAIN SECTION (cont.)

Mesaverde Group-(cont.)	Feet	Meters
Iles Formation-(cont.)		
7. Coal, black (N1), hard ----------	2.0	0.6
6. Shale, carbonaceous, moderate-brown (5YR 4/4) to dark-yellowish-orange (10YR 6/6) ----------	3.0	0.9
Pollen and spores: *Laevigatosporites*, *Cyathidites*, *Alnipollenites*, *Betulaepollenites*, *Proteacidites*, *Ephedrapites*		
5. Sandstone I-1: Sandstone; grayish orange (10YR 7/4) in lower half to yellowish-gray (5Y 8/1) in upper half, very fine to fine grained (coarsening upward); quartz, feldspar, chert; trough cross-bedded (lower half) to low-angle flat bedded (upper half); root traces at top; *Ophiomorpha* abundant in lower half, few in number in upper half; chevron burrow Bivalve: *Inoceramus* (s. l.) sp. aff. *I. Barabini* Morton (worn adult valve) ----	42.1	12.8
Total thickness Iles Formation ----------	1,267.4	386.3

DUFFY MOUNTAIN SECTION (cont.)

Mesaverde Group-(cont.)	Feet	Meters
Mancos Shale (part):		
Buck Tongue of Mancos Shale, upper part:		
4. Shale, olive-gray (5Y 3/2 ----------	105.0	32.0
Total thickness Buck Tongue, upper part--	105.0	32.0

Pollen and spores:
Deflandrea victoriensis
Trithyrodinium robustum
Aquilapollenites
Palaeohystrichophora infusorioides
Proteacidites

3. Loyd Sandstone Bed: Sandstone, clayey, grayish-orange (10YR 7/4), very fine grained; weathers massive, in rounded masses; *Ophiomorpha* (small to large), *Thalassinoides*, and small smooth-walled burrows *(Planolites?)* ----------	25.0	7.6

Bivalvia:
Cymbophora subtilis Stephenson
Cymella n. sp. aff. *C. montanensis* Henderson
Pinna sp. (fragment indet.)
Mytilus (Mytilus) n. sp. cf. *M. quadratus* Gabb
Phelopteria linguaeformis (Evans and Shumard)
Ostrea (Ostrea) sp. indet. (fragments only)
Large disc-like bivalve, cf. *Cyprimeria* sp.

DUFFY MOUNTAIN SECTION (cont.)

Mancos Shale (part)-(cont.)	Feet	Meters
3. Loyd Sandstone Bed-(cont.) cf. *Panopea* sp. indet. *Dosiniopsis deweyi* (Meek & Hayden) *Oxytoma (Hypoxytoma)* n. sp. cf. O. (H.) *nebrascana* (Evans and Shumard) *Thyasira* sp. aff. *T. becca* Kauffman (worn) Small indet. bivalves, one is phosphatized, the rest not, suggesting that there may be some reworked, or remanie, specimens. Disconformity near here? Ammonite: *Baculites* sp. (small juvenile and adult segments) indet.		
2. In part covered; dominantly claystone, silty, olive-gray (5Y 3/2) ----------	190.0	57.9
1. First Mancos Sandstone of Konishi (1959a): Sandstone, yellowish-gray (5Y 7/2) to grayish-orange (10YR 7/4), very fine to fine-grained (coarsening upward), poorly sorted; chert and mica; tabular planar crossbedding with rippled tops; rounded clay clasts on bedding surfaces; upward curving smooth-walled burrows *(Asterosoma?)*, bioturbation especially at tops of bed sets ----------	20.0	6.1
Bivalvia: *Inoceramus* (s.l.) (fragment) cf. *I. proximus* Toumey Ammonite: *Baculites* sp. indet.		
Total thickness Mancos Shale (part) -------	340.0	103.6

KONISHI SECTION (Type section of the LOYD SANDSTONE MEMBER), NE1/4 sec. 31, T. 5 N., R. 92 W., Monument Butte 15 min. Quadrangle, Moffat County, Colorado Section measured by D. A. Beattie, B. G. Kerr, K. Konishi, and G. Venable, July and September 1957 (Konishi 1959b), and remeasured and annotated by L. W. Kiteley, July 1978. Numbers of units are those of Konishi, (1959b). Notes, in parentheses, are by Kiteley. Megafauna identified by W. A. Cobban.

Mesaverde Group:	Feet	Meters
Iles Formation (part):		
113. I-2 sandstone: Sandstone, white on top, brown on bottom, very fine grained, well-sorted; subangular grains, slightly calcareous; massive except basal portion (27 ft, 8.2 m) merging into sandy shale. Basal 27 ft (8.2 m) consists of siltstone and very fine grained sandstone in beds up to 4 ft (1.2 m) and interbedded thin (up to 1 ft, 0.3 m) bioturbated and rippled silty claystone; some low-angle crossbedding and medium-scale symmetrically filled troughs in sandstone interbeds; *Ophiomorpha*; ironstone concretions and iron boxwork structure.) Upper 85 ft (25.9 m) weathers rounded and is good ledge-former ("Rim Rock" of Hancock, 1925) ----------	112.0	34.1
114. Shale, silty, gray to light-black, calcareous, and thin tabular siltstones (up to 3 ft (0.9 m) thick; very thinly bedded (2 cm); horizontally bedded to low angle crossbedded; horizontal burrows, thin rounded sand-filled smooth tubes *(Planolites?)* (up to 4 cm length) ----------	63.0	19.2
115. I-1 sandstone: Sandstone, silty, pale-greenish-brown, very fine grained, medium to poorly sorted, subangular grains, very calcareous, slightly friable. Basal 17 ft (5.18 m) is thin bedded and merges into underlying claystone; large *Ophiomorpha* near top; *Inoceramus convexsus* -	59.0	18.0
Total thickness Iles Formation (part) —	234.0	71.3

KONISHI SECTION-(cont.)

Mancos Shale (part):	Feet	Meters
Buck Tongue, upper part:		
116. Mostly concealed; shale ----------	57.0	17.4
Total thickness Buck Tongue, upper part -	57.0	17.4
117. Loyd Sandstone Bed: Sandstone, silty, green to greenish-gray (grayish-yellow-green, 5GY 7/2), fine- to medium(?)-grained, well-sorted, extremely calcareous, friable; subrounded grains (laminated, horizontally bedded to low angle crossbedded in places); concretionary at certain horizons with nuclei of fossils; weathers massive; a few burrows to none ----------	104.0	31.7
Bivalvia: *I. subcompressus* Ammonite: *Baculites* sp.		
Total thickness Mancos Shale (part) -------	161.0	49.1

UTE GULCH SECTION, SW NE sec. 17, T. 5 N., R. 91 W., Castor Gulch 7.5 min. Quadrangle, Moffat County, Colorado Section measured with Jacob Staff and tape by N. Noreen and L. W. Kiteley.

Mesaverde Group:	Feet	Meters
Iles Formation (part):		
9. Sandstone, light-gray to yellowish-gray, very fine to fine-grained, trough crossbedded; ironstone concretions; overlies coal and clinker	14.0	4.3
8. Poorly exposed; coal at top and at 40 ft (12.2 m) above base; siltstone at 55 ft (16.8 m) above base	59.0	18.0
7. I-4 sandstone: Sandstone, siltstone, and thin interbedded claystone and coal. Upper 38 ft (11.6 m) consists of sandstone, grayish-orange, very fine to fine-grained, massive-weathering; 4 ft (1.2 m) iron-stained band 15 ft (1.5 m) below top; *Toredolithus* at base. Basal 15 ft (4.6 m) consists of siltstone interbedded with claystone, dark-red-stained (burned); ironstone concretions in basal few feet; sharp scour base over coal bed and thin interbedded rippled siltsone	±75.0	±22.9
6. Shale, very carbonaceous, medium-gray to brownish, coaly (clinker near top); interbedded thin siltstone, ripple-bedded, and coal; weathers to light bluish gray and brick red (burned)	5.0	1.5
5. Shale, very carbonaceous, medium-gray to brownish, coaly; interbedded siltstone, yellowish-gray, ripple-bedded, and thin coal beds; roots(?) or smooth-walled burrows(?)	31.0	9.5
4. Sandstone, yellowish-gray, very fine to fine-grained, noncalcareous; wedge planar crossbedded (wedge sets); contorted bedding above which are climbing ripples at top of sets; woody debris, carbonaceous shale, carbonaceous debris in basal 1-2 ft (0.3-0.6 m)	12.0	3.7

UTE GULCH SECTION-(cont.)

Mesaverde Group-(cont.)	Feet	Meters
Iles Formation (part)-(cont.)		
3. Shale, carbonaceous; interbedded 3-ft (0.9-m) coal at top ----------	13.0	4.0
2. I-3 sandstone: Sandstone, yellowish-gray, very fine grained; low-angle crossbedding (probable trough cross-beds?); rounded claystone and iron-stone concretions; a few *Ophiomorpha* ------	30.0	9.1
1. Poorly exposed; probably claystone siltstone, and coal ----------	50.0	15.2
Total thickness Iles Formation (part) ---	289.0	88.1

CASTOR GULCH SECTION, NW1/4 NW1/4 sec. 21, T. 5 N., R. 91 W., Castor Gulch 7.5 min. Quadrangle, Moffat County, Colorado
Section measured with Jacob Staff and tape by L. W. Kiteley and N. Noreen, June 1978.

Mesaverde Group:	Feet	Meters
Iles Formation (part):		
16. Sandstone, very silty, yellowish-gray, very iron stained, very fine grained; bedding indistinct; weathers rounded	20.0	6.0
15. Siltstone, light-gray; interbedded medium-dark-gray silty claystone, carbonaceous	55.0	16.7
14. Sandstone, light-gray to dark-yellowish-orange, very fine grained; root traces; thinly interbedded carbonaceous shale	2.0	0.6
13. Covered	13.0	4.0
12. I-3 sandstone: Sandstone, light-gray fine-grained, well-sorted, well-rounded, nonargillaceous; moderately good porosity. Upper 38 ft (11.6 m): Sandstone, lenticular, trough cross-bedded to rippled in uppermost 19 ft (5.8 m); low angle crossbedded in basal 19 ft (5.8 m). Lower 5 ft (1.5 m): gradational into underlying claystones	43.0	13.1
11. Covered	17.0	5.2
10. Sandstone, light-gray, very fine to fine-grained, poorly sorted, subrounded, noncalcareous, dominantly horizontally bedded; erosional surface (up to 2.5 ft, 0.8 m thick) filled with shell hash at top	18.0	5.5
9. Poorly exposed; siltstone, carbonaceous shale, and coal. Siltstone (1 ft, 0.3 m) at 42 ft (12.8 m) above base; siltstone, thinly laminated; contains plant impressions; overlies coal; at 40 ft (12.1 m) above base	66.0	20.1

CASTOR GULCH SECTION-(cont.)

Mesaverde Group-(cont.)	Feet	Metters
Iles Formation (part)-(cont.)		
8. Sandstone, very fine to fine-grained, poorly sorted, argillaceous; medium scale trough crossbedded with ripples at tops of troughs; claystone pebbles; coaly, carbonaceous plant debris and iron boxwork structure at base; sharp scour base over carbonaceous shale with thin coal stringers ----------	12.0	3.7
7. Shale, carbonaceous; interbedded siltstones, lenticular, and coal; marine bivalve shells in float ----------	50.0	15.2
6. I-2 sandstone: Sandstone, siltstone, and claystone (coarsening upward). Upper 70-75 ft (21-22.9 m): Sandstone, very fine to fine-grained; low-angle crossbedded to horizontally flatbedded in upper 15 ft (4.6 m) where appears "white" in color; massive appearing in lower 55-60 ft (17-18 m); *Ophiomorpha* in zone at 15 ft (4.6 m) above base, none in upper part; minor contorted bedding near base and iron boxwork structure. Basal 10-15 ft (3.0-4.5 m): Claystone, pale-greenish (5GY 7/2); comminuted carbonaceous plant debris; interbedded siltstones and carbonaceous shale. Siltstones at top are lenticular and form medium-scale trough crossbeds that are wide and shallow (1-2 ft x 6-8 ft, 0.3-0.6 x 1.8-2.4 m), thinly laminated and symmetrically filled; carbonaceous shale in upper several cm; claystone pebbles in siltstone. Basal several feet consists of siltstone and sandstone in thin beds that are horizontal to low angle crossbedded and contain horizontal smooth-walled burrows *(Planolites?)*; interbedded pale-greenish (5GY 7/2) to olive-gray mudstone ----------	85.0	25.9

CASTOR GULCH SECTION-(cont.)

Mesaverde Group-(cont.)	Feet	Meters
Iles Formation (part)-(cont.)		
5. Mudstone, olive-gray ----------	9.0	2.7
4. Mudstone, similar to unit 5, but includes two thin (1 ft, 0.3 m) lenticular sandstones, very fine grained, horizontal flat to low-angle crossbedded; horizontal smooth-walled burrows *(Planolites?)* -------	15.0	4.6
3. Sandstone, very fine grained, horizontal flat to low-angle crossbedded; horizontal smooth-walled burrows *(Planolites?)* ----------	5.0	1.5
2. Mudstone, olive-gray ----------	50.0	15.2
1. I-1 sandstone: Sandstone, light-gray, very fine-grained, slightly argillaceous, slightly calcareous; horizontally bedded to low-angle crossbedded; *Ostrea* (disarticulated) and shell "hash" in upper one-quarter; *Ophiomorpha, Thallasinoides,* and smooth-walled horizontal burrows *(Planolites?)* ----------	16.0	4.9
Total thickness Iles Formation (part) -	386.0	117.7

HAMILTON STORE SECTION, NE1/4 sec. 21, T. 5 N., R. 91 W., Hamilton 7.5 min. Quadrangle, Moffat County, Colorado
Section measured with Jacob Staff by L. W. Kiteley and N. Noreen, June 1978.

Mesaverde Group:	Feet	Meters
Iles Formation (part):		
11. I-2 sandstone: Sandstone and siltstone (coarsening upward). Upper half: Sandstone, yellowish-gray, fine- to medium-grained, poorly sorted, highly quartzose; small and medium scale trough crossbedded; claystone pebbles and ironstone concretions; *Toredolithus* at sharp scour base; iron boxwork structure. Lower half: Sandstone, light-yellowish-gray, "white"-weathering near top, very fine grained; low angle crossbedded near base to horizontal flat bedded at top; *Ophiomorpha* in upper one-third	49.0	15.0
10. Claystone, silty, olive-gray (5Y 4/1)	18.0	5.5
9. Sandstone, silty, very fine grained; interbedded claystone halfway up from base. Sandstone, horizontally bedded to low-angle crossbedded; horizontal smooth-walled burrows *(Planolites?)*	7.0	2.1
8. Claystone, silty, olive-gray	54.5	16.6
7. I-1 sandstone: Sandstone, very fine to fine-grained, slightly argillaceous, slightly calcareous; interbedded claystone at 8 ft (2.4 m) above base, bioturbated to slightly rippled; horizontally bedded to low angle crossbedded near base to horizontally bedded near top; *Ophiomorpha* concentrated at top	25.0	7.6
Total thickness Iles Formation (part)	153.5	46.5

HAMILTON STORE SECTION-(cont.)

Mancos Shale:	Feet	Meters
Buck Tongue, upper part:		
6. Claystone, silty, olive-gray	15.0	4.6
5. Sandstone, lenticular, very fine grained; horizontally bedded	1.0	3.0
4. Claystone, silty, olive-gray	12.5	3.8
3. Sandstone, similar to Unit 5	2.5	0.8
2. Claystone, silty, olive-gray	57.2	17.4
Total thickness Buck Tongue, upper part	88.2	29.6
1. Loyd Sandstone Bed (part): Sandstone, grayish-yellow-green (5GY 7/2), very fine grained; thin-bedded, horizontally bedded and trough-crossbedded; *Ophiomorpha*	26.0	7.9
Total thickness Mancos Shale (part)	114.2	37.5

'BELLERING COW' SECTION, SE1/4 sec. 22, T. 5 N., R. 91 W., Hamilton 7.5 min. Quadrangle, Moffat County, Colorado
Section measured with Jacob Staff and tape by L. W. Kiteley and N. Noreen, July 1978.

Mesaverde Group:	Feet	Meters
Iles Formation (part):		
19. I-4 sandstone: Sandstone, grayish-orange; "white" at top, very fine to fine grained (coarsening upward), poorly sorted, slightly calcareous, horizontally bedded; ironstone concretions and iron boxwork structure; *Ophiomorpha* especially in a zone at about 25 ft (7.6 m) above base. Thin lenticular fine-grained sandstone with small-scale trough cross-bedding and ironstone concretions in upper few feet	30.0	9.1
18. Shale, carbonaceous; interbedded coal; large oysters in float	75.0	22.9
17. I-3 sandstone: Sandstone, dark-yellowish-orange; "white" in upper half; horizontal flat bedded to low angle crossbedded; *Ophiomorpha*	32.0	9.8
16. Shale, carbonaceous; interbedded coal; olive-gray shale in upper part; large oysters in float	55.0	16.8
15. Sandstone, dark-yellowish-orange, very fine grained (fining upward), medium-scale trough-crossbedded; interbedded claystone "drapes", rippled; sharp scour base over coal bed	30.0	9.1
14. Poorly exposed; claystone; interbedded coal (some clinker)	44.0	13.4
13. Shale, carbonaceous; interbedded thin siltstones	2.0	0.6
12. Claystone, medium-dark-gray; interbedded carbonaceous shale and coal	5.0	1.5

'BELLERING COW' SECTION-(cont.)

Mesaverde Group-(cont.)	Feet	Meters
Iles Formation (part)-(cont.)		
11. Sandstone, yellowish-gray, very fine grained, calcareous, trough-cross-bedded; ironstone concretions and rounded clay pebbles; carbonaceous plant debris and wood in basal part; sharp scour base	4.0	1.2
10. Claystone, medium-dark-gray; interbedded carbonaceous shale, coal, and thin tabular sandstones, very fine-grained	23.0	7.0
9. I-2 sandstone: Sandstone, siltstone, and claystone. Upper 35 ft (10.7 m): Sandstone, banded light-gray to dark-yellowish-gray; upper 10 ft (3.0 m) appears "white"; very fine grained, noncalcareous; dominantly horizontally thin bedded to massive appearing; ironstone concretions; *Ophiomorpha* to within 5 ft (1.5 m) of top; *Ostrea* (disarticulated) and shell hash at 5 ft (1.5 m) below top. Lower 30 ft (9.1 m): Siltstone; interbedded claystones, grayish-orange, small-scale trough-crossbedded; ironstone concretions and iron boxwork structure in uppermost part; a few *Ophiomorpha* increasing in number upward; finely ribbed bivalve on uppermost bedding surface	65.0	19.9
8. Claystone, olive-gray; thinly interbedded siltstone at 60 ft (18.2 m) above base	82.0	25.0
7. I-1 sandstone: Sandstone, silty, grayish-orange (10YR 7/4), calcareous, horizontally thick bedded (up to 3 ft, 1 m) and medium-scale trough crossbedded (1 x 9 ft, 0.3 x 3 m); ironstone concretions and claystone pebbles; iron boxwork structure	12.0	3.7
Total thickness Iles Formation (part) -	459.0	139.9

'BELLERING COW' SECTION-(cont.)

Mancos Shale:	Feet	Meters
Buck Tongue, upper part:		
6. Claystone, olive-gray	11.0	3.4
5. Siltstone, yellowish-gray calcareous, thin-bedded; horizontally bedded to low-angle crossbedded; contorted in place	3.0	0.9
4. Claystone, olive-gray	6.0	1.8
3. Siltstone, similar to unit 5	3.0	0.9
2. Claystone, olive-gray	65.0	19.9
Total thickness Buck Tongue, uper part	98.0	26.9
1. Loyd Sandstone Bed: Sandstone, silty, grayish-green, very fine grained; horizontal bedding to low-angle crossbedded; concretionary with fossils forming nuclei of concretions; weathers rounded ("lumpy"); *Ophiomorpha*, mud-filled cylindrical horizontal burrows *(Planolites?)*	35.0	10.7
Total thickness Manco Shale (part)	123.0	37.5

STOCK PASS GULCH, NE1/4 sec. 23, T. 5 N., R. 91 W., Hamilton and Castor Gulch 7.5 min. Quadrangles, Moffat County, Colorado. Section measured with Jacob Staff by N. Noreen, and L. W. Kiteley, July 1978.

Mesaverde Group:	Feet	Meters
Iles Formation (part):		
11. Shale, carbonaceous, brownish-black; 1-ft (0.3 m) oyster bed at top; dark red stained (burned) ----------	6.0	1.8
10. Sandstone, very silty, yellowish-orangish-gray, very fine to fine-grained, noncalcareous, horizontally bedded; *Inoceramus* fragments and *Ostrea* (disarticulated) throughout ----------	11.0	3.4
9. Shale, carbonaceous, brownish-black; interbedded coal at 5 ft (1.5 m) above base; oysters in float ----------	10.0	3.0
8. Siltstone, lenticular; ripple-bedded; interbedded carbonaceous shale at top ----------	7.0	2.1
7. I-4 sandstone: Sandstone, yellowish-gray; uppermost 16 ft (4.9 m) appears white, fine grained; horizontally bedded to crossbedded; *Ophiomorpha*, large, and iron boxwork structure in basal 25 ft (7.6 m) ----------	41.0	12.5
6. Poorly exposed; claystone, brownish-gray, platy; interbedded 3-4 ft (0.9-1.2 m) coal at 20 ft (6.1 m) above base; thin-bedded siltstone at top[1/] ----------	56.0	17.0
5. Siltstone, thin-bedded, ripple-bedded[1/] ----	5.0	1.5
4. Poorly exposed; probably claystone; interbedded coal at 5 ft (1.5 m) above base[1/] ----------	25.0	7.6

[1/] Note: Local development of lenticular, very silty, crossbedded sandstone overlies I-3 sandstone (unit 3) in NE1/4 SW1/4 sec. 23, T. 5 N., R. 91 W. Measured thickness ------- 43.0 13.1

STOCK PASS GULCH-(cont.)

Mesaverde Group-(cont.)	Feet	Meters
Iles Formation (part)-(cont.)		
3. I-3 sandstone: Sandstone, orangish-gray; "white" in upper part, very fine to fine grained, noncalcareous; tabular crossbedded to horizontally bedded near top, *Ophiomorpha* in basal 3 ft (0.9 m) and at 20 ft (6.1 m) above base; good porosity	36.0	11.0
2. Shale, carbonaceous, brownish-black; interbedded coal, olive-gray claystone, platy, at about 40 ft (12.2 m) above base	80.0	24.0
1. Sandstone, orangish-gray, very fine to fine-grained fining upward to siltsized; sharp basal contact. Thin ripple-bedded siltstone in basal 3 ft (0.9 m)	14.0	4.3
Total thickness Iles Formation (part) -	291.0	88.7

MEASURED SECTIONS

HORSE GULCH SECTION, SW1/4 NW1/4 sec. 24, and E1/2 SW1/4 sec. 13, T. 5 N., R. 91 W., Hamilton and Castor Gulch 7.5 min. Quadrangles, Moffat County, Colorado. Section measured by C. D. Masters, and R. K. Bambach, July 1963 (Masters, 1966), and by L. W. Kiteley and N. Noreen, with Jacob Staff and tape, June and July 1978. Details of coal beds from Hancock (1925). Megafauna identified by E. G. Kauffman, U.S. National Museum, and W. A. Cobban, U.S. Geological Survey.

Mesaverde Group:	Feet	Meters
Iles Formation:		
11. I-4 sandstone: Upper 50 ft (15.2 m): Sandstone, lenticular, yellowish-gray, very fine to fine-grained, poorly sorted, trough crossbedded; clay pebbles and ironstone concretions along bedding planes at base of troughs. Lower 20 ft (6.1 m): Sandstone, light-gray to "white" at top, very fine to fine-grained (coarsening upward); a few *Ophiomorpha* in lower half ----------	70.0	21.3
10. Poorly exposed; probably claystone; carbonaceous plant debris; *Ostrea* shells (disarticulated) in float ----------	35.0	10.7
9. I-3 sandstone: Sandstone, siltstone and interbedded claystone, from top to base: Uppermost 45.0 ft (13.7 m): Sandstone, light-gray to orangish-gray, fine- to medium-grained; poorly sorted, noncalcareous, medium-scale wedge planar cross-bedded; claystone pebbles and ironstone concretions along bedding planes; sharp scour base; *Toredolithus* at base; excellent porosity. Middle 0.5 ft (0.15 m): Shale, carbonaceous, coaly. Lower 23.5 ft (7.1 m): Sandstone, "white" at top, very fine to fine-grained, poorly sorted; massive appearance; a few *Ophiomorpha*; moderately good porosity. Basal 6 ft (1.8 m): Siltstone and claystone. Upper 3 ft (0.9 m) consists of thinly interbedded medium-gray claystone and siltstone with horizontal smooth-walled burrows *(Planolites?)*. Lower 3 ft (0.9 m) massive-appearing siltstone with a slightly undulatory upper contact ---	75.0	22.9

HORSE GULCH SECTION-(cont.)

Mesaverde Group-(cont.)	Feet	Meters
Iles Formation-(cont.)		
8. Claystone, medium-dark-gray; comminuted plant fragments; interbedded siltstone with small horizontal smooth tubes *(Planolites?)*, finely ribbed bivalves(?), and broken *Inoceramus* shells ----------	35.0	10.7
7. Siltstone; interbedded claystone and coal. Siltstone is ripple laminated and contains comminuted plant debris. Claystone, fissile, ripple-laminated ------	25.0	7.6
6. Claystone, medium-dark-gray; interbedded carbonaceous shale and coal --------	65.0	19.8
5. Sandstone, siltstone and interbedded claystone. Upper 25 ft (7.6 m): Sandstone, fine- to medium-grained (fining upward), medium-scale wedge planar crossbedded, ripple bedded at tops of sets; some contorted bedding; claystone pebbles along bedding planes; rafted carbonaceous and coaly debris throughout; *Toredolithus* at bases of crossbedded units. Lower 40 ft (12.1 m): Siltstone and interbedded claystone; horizontally bedded to medium scale trough crossbedded in siltstone (lower three-fourths) to ripple bedded (upper one-quarter); iron boxwork structure and ironstained claystone concretions; *Ophiomorpha* in lower part, smooth-walled cylindrical burrows (U-in-U) in upper thin bedded rippled siltstones ----------	65.0	19.8
4. Sandstone, silty, very fine grained, thin bedded (5 cm), horizontally bedded and small-scale trough cross-bedded to rippled; interbedded shale, grayish-olive (10Y 4/2) to dusky-yellow (5Y 6/4); comminuted plant fragments; horizontal small smooth tubes *(Planolites?)* ----------	70.0	21.3

HORSE GULCH SECTION-(cont.)

Mesaverde Group-(cont.)	Feet	Meters
Iles Formation-(cont.)		
3. I-1 sandstone: upper part: Sandstone, grayish-orange (10YR 7/4), very fine grained, subrounded, slightly calcareous, horizontally bedded; current ripple bedded locally; ironstone concretions along bedding surfaces. Lower part: claystone interbedded and siltstone; bioturbated in claystone to nonbioturbated in siltstone; *Thallasinoides* ----------	31.0	9.4
Total thickness Iles Formation (part)--	471.0	143.5
Mancos Shale (part):		
Buck Tongue, upper part:		
2. Poorly exposed; probably claystone ----------	68.0	20.7
Total thickness Buck Tongue of Mancos Shale, upper part ----------	68.0	20.7
1. Loyd Sandstone Bed: Sandstone, silty, greenish-gray (5GY 8/1), fine grained, medium-scale crossbedded; interbedded siltstone, thinly laminated; small sandstone concretions in siltstone contain fossils as nuclei; *Ophiomorpha*, clay-filled in sandstone concretions (1.2 cm diameter) ----------	15.0	4.6
Total thickness Mancos Shale (part) ---	83.0	25.3

Ammonites:
Baculites perplexus Cobban

Bivalvia:
Corbula sp. juv.
"Corbula" sp.
Granocardium (Ethmocardium) white; (Dall)
G. n. sp.
Oxytuma (Hypoxytoma) nebrascana (Evans and Schumard)
Phelopteria linguaeformis (Evans and Shumard)
Thryacia? sp.
Pinna sp. (fragment)
Synclonema sp. cf. *S. dall;* (Gabb)
Dosiniopsis sp. aff. *D. dewey;* (Meek and Hayden)
Cymbophora sp. cf. *C. warrenana* (Meek and Hayden)
Thyasira? sp.
Crassostrea? frags.

POVERTY GULCH SECTION, NE1/4 sec. 19, T. 5 N., R. 90 W., Hamilton and Castor Gulch 7.5 min. Quadrangles, Moffat County, Colorado
Section measured with Jacob Staff and tape by L. W. Kiteley and N. Noreen, July 1978. Megafauna identified by E. G. Kauffman, U.S. National Museum.

Mesaverde Group:	Feet	Meters
Iles Formation:		
27. I-7 sandstone: Sandstone, clayey. Upper part; sandstone, dark-yellowish-gray, "white" at top, very fine to fine-grained, poorly sorted, non-calcareous. Basal 2-3 feet: sandstone, light-gray, medium-grained, horizontally bedded to low-angle crossbedded; iron boxwork structure; *Ophiomorpha* ----------	25.0	7.6
26. Covered ----------	15.0	4.6
25. I-6 sandstone: Sandstone, light-gray fine-grained, subrounded; chert, clay (possibly kaolinite), calcareous; horizontally bedded ----------	10.0	3.0
24. Covered ----------	5.0	1.5
23. Sandstone, silty; orangish-gray to dark-yellowish-orange with iron streaks, very fine to fine grained; contorted bedding; ironstone concretions; sharp scour base ----------	15.0	4.6
22. Poorly exposed; probably carbonaceous shale -	3.0	0.9
21. I-5 sandstone: Sandstone, very silty, orangish-gray, subrounded, slightly calcareous, high-angle crossbedded to massive appearing; large ironstone concretions; coaly fragments, *Ostrea* shells, and broken *Inoceramus* shells in a zone 4 ft (1.2 m) above base; top is marked by a distinct erosional surface containing a 1.5-ft (0.46-m) shell lag deposit ----------	9.0	2.7
Fish scales *Crassostrea* frags. *Inoceramus* frags. *Pseudoptera subtortuosa* (Meek and Hayden)		

POVERTY GULCH SECTION (cont.)

Mesaverde Group-(cont.)	Feet	Meters
Iles Formation-(cont.)		
Granocardium sp. cf. *Dosiniopsis* cf. *Phelopteria* sp. *Thracia* n. sp. (large form) naticid gastropod *Turritella* sp. inoceramid cf. *Endocostea typica* (Whitfield) many other indet. bivalves		
20. Poorly exposed; shale, carbonaceous; interbedded lenticular sandstone, 4 ft (1.2 m) thick at 17 ft (5.1 m) above base ----------	46.0	14.0
Bivalvia: *"Inoceramus" (Endocostea?) barabini* (Morton)		
19. I-3 sandstone: Sandstone and siltstone. Upper 35 ft (10.7 m): Sandstone, orangish-gray; white in upper 10 ft (3 m); massive. Basal 4 ft (1.2 m): Siltstone, thin-bedded; interbedded light-gray silty claystone ----------	39.0	11.9
18. Claystone, gray; interbedded thin siltstone ----------	23.0	7.0
17. Siltstone, thin-bedded, low-angle crossbedded ----------	3.0	0.9
16. Coal, shale, carbonaceous; interbedded coal ----------	22.0	6.7
15. Sandstone, orangish-gray, very fine grained, medium-scale trough cross bedded; contorted near base; ironstone concretions and claystone pebbles; sharp scour base; *Toredolithus* 18 ft (5.5 m) above base in 3 ft (0.9 m) claystone bed which forms break between two sandstone units ----------	57.0	17.3

POVERTY GULCH SECTION-(cont.)

Mesaverde Group-(cont.)	Feet	Meters
Iles Formation-(cont.)		
14. Shale, carbonaceous; interbedded light-gray claystone; coal at 15 ft (4.5 m) above base and at top	33.0	10.0
13. Sandstone, yellowish-gray, fine- to medium-grained, noncalcareous, trough-crossbedded; ironstone concretions and clay pebbles; sharp scour base	23.0	7.0
12. Shale, carbonaceous; transitional into 3-ft (0.9-m) coal bed at top	5.0	1.5
11. Siltstone, ripple-bedded	4.0	1.2
10. Poorly exposed; probably carbonaceous shale	8.0	2.4
9. I-2 sandstone: Sandstone, yellowish-gray, fine- to medium-grained (coarsening upward), subangular to subrounded, poorly sorted, calcareous; claystone pebbles, ironstone concretions and iron boxwork structure in lower part; contorted bedding; broken shell fragments at 25 ft (7.6 m) above base; good porosity	55.0	16.8
8. Siltstone, thin-bedded; interbedded gray claystone	14.0	4.3
7. Sandstone, light-yellowish-gray, very fine grained, calcareous, trough-crossbedded; claystone pebbles, ironstone concretions; distinct flat-bedded siltstone break at base	5.0	1.5
6. Sandstone, very fine to fine-grained; (coarsening up), grayish-orange to dark-yellowish-orange, noncalcareous; scattered *Ophiomorpha* in lower part	30.0	9.0

POVERTY GULCH SECTION-(cont.)

Mesaverde Group-(cont.)	Feet	Meters
Iles Formation-(cont.)		
5. Siltstone; interbedded claystones, medium-gray; medium scale trough crossbedded in siltstone; a few *Ophiomorpha* burrows, vertical smooth-walled tubes *(Scolithus)*, upward-curving smooth tubes *(Asterosoma)* ----------	20.0	6.1
4. Mudstone, silty, light-olive-gray to yellowish-gray, noncalcareous ----------	70.0	21.3
3 I-1 sandstone: Siltstone; interbedded mudstone, medium-gray, noncalcareous, thin horizontally bedded to low-angle crossbedded; nonburrowed in siltstone to bioturbated in mudstone and claystone; a few *Ophiomorpha* near top; broken *Inoceramus* in float ----------	54.0	16.5
Total thickness Iles Formation (part)--	593.0	180.7
Mancos Shale (part):		
Buck Tongue (part):		
2. Claystone, olive-gray ----------	51.0	15.5
Total thickness Buck Tongue of Mancos Shale upper part	51.0	15.5
1. Loyd Sandstone Beds: Sandstone, grayish-green, very fine grained ("sugary") some low-angle crossbedding; weathers rounded; *Ophiomorpha*; other fossils (no collection) ----------	52.0	15.8
Total thickness Mancos Shale (part)----	103.0	31.3

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