MEASURED SECTIONS OF THE PENNSYLVANIAN TENSLEEP SANDSTONE, PRYOR AND BIG HORN MOUNTAINS, MONTANA

D.A. Lopez, S.W. VanDelinder, M.L. Hendricks, Shawn Reddish-Kuzara,
C.W. Schwartz, and D.C. Bear Claw

Montana Bureau of Mines and Geology
Open-File Report 553

2007

Abstract

Thirteen stratigraphic sections of the Tensleep Sandstone in the Pryor and Bighorn Mountains of south-central Montana were measured and described to help understand the genesis of this regionally important oil and gas reservoir horizon. Dramatic stratigraphic changes occur in the Tensleep across south-central Montana. The upper contact is unconformable, showing topographic relief of as much as 50 ft due to a combination of erosion and the preservation of dunes at the top of the Tensleep. In the west, both upper and lower Tensleep sections are present. The lower is characterized by repeated cycles of marine sandstone, tens of feet thick, capped by very limy to dolomitic sandstone beds 1 to 5 ft thick. The upper Tensleep is characterized by cycles of eolian dune sandstone capped by marine limy to dolomitic sandstone. Dune sandstones can be as thick as 60 ft. The total Tensleep thickness in the western part of the area can be as much as 250 ft. In the east and central parts of the area the upper Tensleep is absent, and dune sandstones develop in the lower Tensleep. Vertical cycles are genetically similar to those in the western part of the region. As little as 25 ft of Tensleep is present on the east side of the Bighorn Mountains.

Introduction

The Permo-Pennsylvanian section in the Big Horn and Powder River Basins is the most prolific oil-producing system in the central Rocky Mountains, having produced more than 2 billion barrels of oil in the Bighorn Basin and 525 million barrels of oil in the Powder River Basin. The Permo-Pennsylvanian Petroleum System includes the Permian Phosphoria Formation, which is the oil source rock, and the Pennsylvanian Tensleep Sandstone, which is the main reservoir rock.

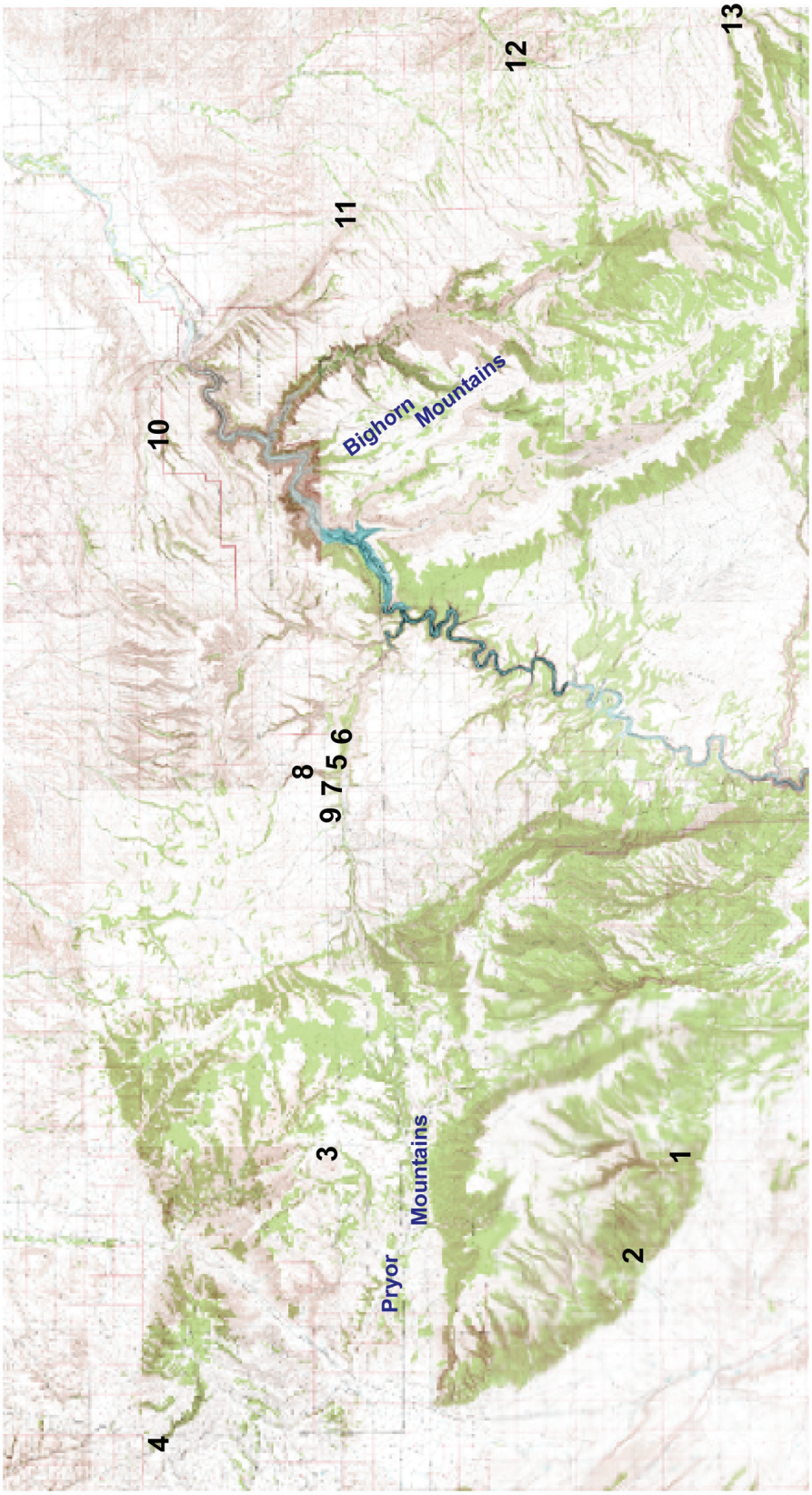
Dramatic stratigraphic changes in the Tensleep occur across south-central Montana. To better understand these stratigraphic changes, 13 surface sections were measured and described in the Pryor and Bighorn Mountains. The results are summarized in the following conclusions: (1) The upper Tensleep contact is unconformable, showing topographic relief of as much as 50 ft due to a combination of erosion and the presence or absence of dunes. (2) In the west, both upper and lower Tensleep sections are present. The lower is characterized by repeated cycles of marine sandstone, tens of feet thick, capped by very limy to dolomitic sandstone beds 1 to 5 ft thick. The upper Tensleep is characterized by cycles of eolian dune sandstone capped by marine limy to dolomitic sandstone. Dune sandstones can be as thick as 60 ft. The total Tensleep thickness in the western part of the area can be as much as 250 ft. (3) In the east and central parts of the area the upper Tensleep is absent and dune sandstones develop in the lower Tensleep. The vertical cycles are similar to the ones in the west. On the east side of the Bighorn Mountains the Tensleep thins to as little as 25 ft.

Most of the exposures of the Tensleep occur on the Crow Indian Reservation; the Crow Tribe gave permission to access their lands and cooperated in the project. Without their help the project could not have been undertaken.

The thirteen sections that follow were measured and described in the summer of 2005 at locali-

ties shown in figure 1. Relative thicknesses are shown diagrammatically in figure 2. Petrographic descriptions of samples, taken from several localities noted in the measured sections, were done by Hendricks and Associates, Inc. Color notations used in the descriptions are from the Rock Color Chart, 1975, Geological Society of America.

Figure 1
Locations of Measured Sections



1: Bear Canyon
2: Stockman Trail
3: Crown Butte
4: Five Mile Creek
5: Dry Head #1
6: Dry Head #2
7: Dry Head #3
8: Dry Head #4
9: Spring Creek
10: Grapevine Canyon
11: Soap Creek
12: Rotten Grass Creek
13: Lodge Grass Creek

Figure 1. Location index map of measured sections.

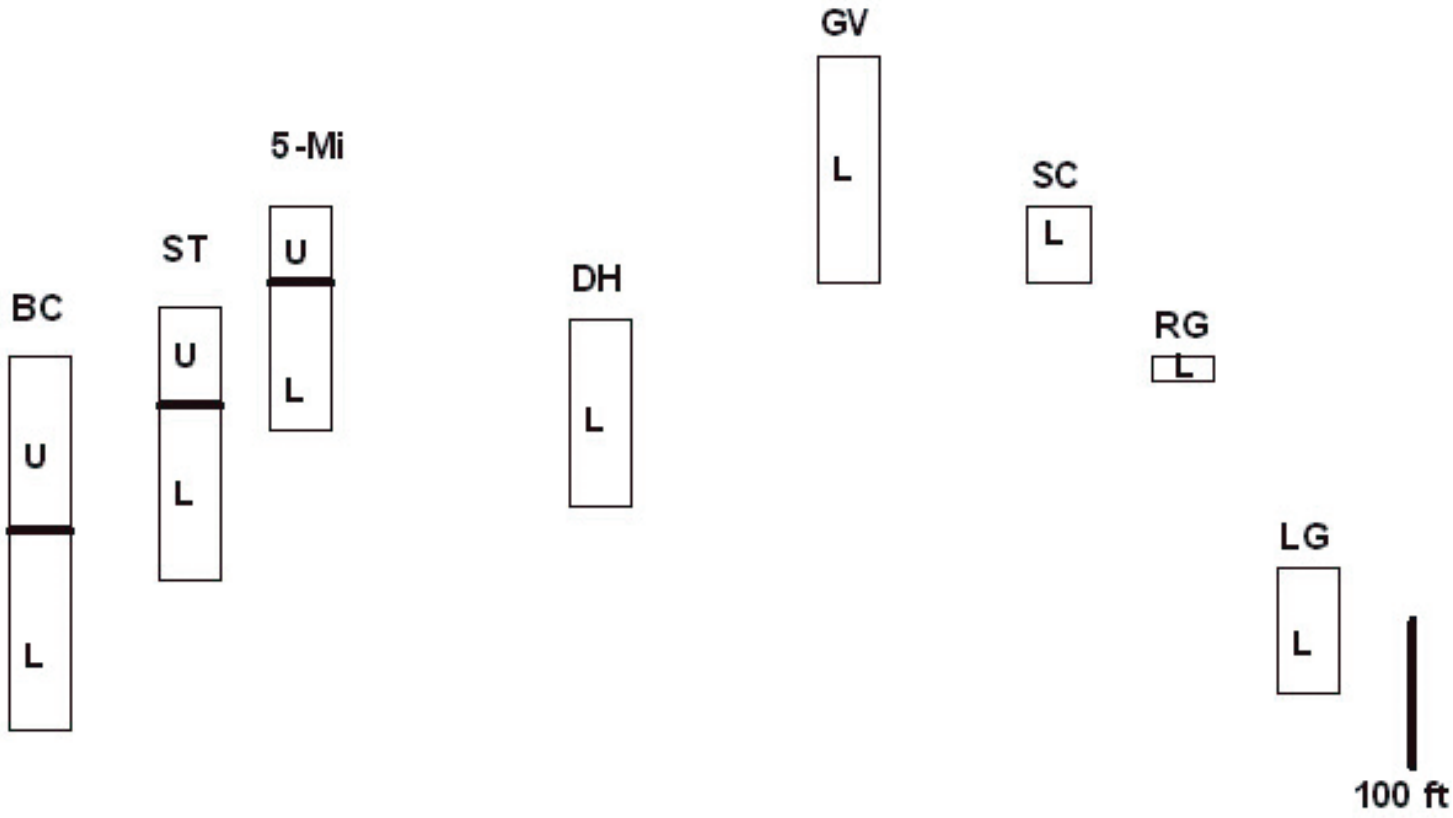


Figure 2. Thickness changes of Tensleep Sandstone across the project area shown diagrammatically. West is on the right, east on the left. BC, Bear Canyon; ST, Stockman Trail; 5-Mi, Five Mile Creek; DH, Dry Head Canyon; GV, Grapevine Canyon; SC, Soap Creek; RG, Rotten Grass Creek; LG, Lodge Grass Creek.

Bear Canyon
Location of Measured Section: SE¼ SW¼ Section 3, T. 9 S., R. 26 E.

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
5	5	10R6/2; pale red						**Base Phosphoria Formation**, mostly covered, pale red to light gray limestone with red, brown and yellow chert		
5	5	5YR8/1; pinkish gray				none	parallel laminated	**Top Upper Tensleep Sandstone**; sandy dolomite, vuggy		
15	10	N8; very light gray	fine	w	non-calcareous	none	high-angle trough cross bedding	light gray, cross-bedded dune sandstone		
20	5	5R8/2; grayish pink						thin-bedded dolomite		
23	3	5R8/2; grayish pink	v fine			bioturbated		sandy dolomite, thick-bedded		
35	12	N8; very light gray	fine	w	non-calcareous	vertical	high-angle trough cross bedding	light gray, cross-bedded dune sandstone; burrowed in upper 2 ft related to overlying marine incursion		
37	2	5R8/2; grayish pink	v fine	w	calcareous	none	parallel laminated	limy sandstone capping dune cycle		
50	13	5Y8/1;pale yellowish gray	fine	w	non-calcareous	none	high-angle trough cross bedding	light gray, cross-bedded dune sandstone		
72	22	N8; very light gray	v fine	w	non-calcareous	vertical upper 3 ft	high-angle trough cross bedding	**Base Upper Tensleep**; light gray, cross-bedded dune sandstone; burrowed in upper 3 ft		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
83	11	5R8/2; grayish pink						**Top Lower Tensleep**; pale grayish pink sandy dolomite with abundant yellow brown chert nodules and thin beds (2–3 in)		
85	2	5Y8/1; pale yellowish gray						hard, light yellowish gray limestone		
95	10	N8; very light gray	fine	w	calcareous	none	low-angle tabular cross bedding	light gray, cross-bedded, limy sandstone		
98	3	5Y8/1; pale yellowish gray	v fine	w	v calcareous	none	low-angle tabular cross bedding	light gray, cross-bedded, limy sandstone to sandy limestone, lithic limestone grains		
102	4	5Y8/1; pale yellowish gray						sandy dolomite, thick-bedded, abundant chert nodules throughout bed		
104	2	5Y8/1; pale yellowish gray	v fine	w	calcareous	none	parallel laminated	light gray, limy sandstone		
109	5	N8; very light gray	v fine	w	calcareous	none	low-angle tabular cross bedding	light gray cross-bedded, limy sandstone		
113	4	N8; very light gray	v fine	w	calcareous	none	parallel laminated	light gray, limy sandstone, friable		
128	15	5Y8/1; pale yellowish gray	fine	w	calcareous	bioturbated	massive	limy sandstone, bioturbated		
130	2	N8; very light gray	v fine	w	calcareous	none	parallel laminated	light gray, limy sandstone, friable; platy argillaceous siltsone and sandstone at top, dolomitic		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
133	3	5Y8/1;pale yellowish gray	fine	w	calcareous	none	low-angle trough cross bedding	pale yellowish gray cross-bedded sandstone		
136	3	N8; very light gray	fine	w	calcareous	bioturbated	bioturbated	light gray, bioturbated, limy sandstone		
142	6	5Y8/1;pale yellowish gray	fine	w	v calcareous	vertical	parallel laminated	very limy sandstone, limonitic nodules on bedding planes (1–2cm); burrowed upper half	BC-1	very fine to fine-grained, slightly calcareous quartz sandstone, angular to subrounded, poor to fair sorting; micritic matrix dolomitized and recrystallized, trace orthoclase, porosity ~15%.
157	15	5Y8/1;pale yellowish gray	fine	w	calcareous	none	cut and fill, ripple cross laminated	light yellowish gray, lenticular, limy sandstone; bed sets 1–2 ft thick		
168	11	N8; very light gray	v fine	w	calcareous	none	low-angle, tabular cross bedding	light gray cross-bedded, limy sandstone; bed sets 3 in to 1 ft thick		
175	7	N8; very light gray	v fine	w	calcareous	none	parallel laminated	light gray, thin-bedded limy sandstone		
176	1	N8; very light gray	v fine	w	v calcareous	none	brecciated	light gray, brecciated, limy sandstone		
180	4	N8; very light gray	fine	w	calcareous	none	low-angle trough cross bedding	light gray cross-bedded, limy sandstone, poorly exposed		
184	4	N8; very light gray	fine	w	calcareous	none	low-angle trough cross bedding	light gray cross-bedded, limy sandstone		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
187	3	N8; very light gray	fine	w	calcareous	none	parallel laminated	light gray, thin-bedded limy sandstone, sharp basal contact, quartz grains frosted		
188	1	10YR7/4; grayish orange	v fine	w	calcareous	none	parallel laminated	friable, yellowish sandstone capped by greenish gray clay drape followed by reddish and white paleosol; clays leached out in paleosols		
189	1	N8; very light gray	v fine	w	siliceous	none	parallel laminated	light gray siliceous sandstone		
190	1	5GY7/2; grayish yellow-green	silt				parallel laminated	light greenish gray siltstone with very thin cherty sandstone (1-2 inches)		
195	5	5Y8/1;pale yellowish gray	v fine	w	calcareous	none	parallel laminated	pale yellowish gray sandstone, thin greenish gray siltstone and dolomite (1 ft) at top		
197	2	5B8/1; very light bluish gray	v fine	w	calcareous	bioturbated	bioturbated	**Base Tensleep Sandstone**; pale bluish gray, bioturbated, limy sandstone		
14	14	10R4/6; reddish brown						**Top Amsden Formation**; reddish brown mudstone interbedded with yellowish gray and pinkish gray limestone and limestone breccia; limestone beds 1–2 ft thick		

Bear Canyon 2
Location of Measured Section: NW¼ SW¼ Section 3, T. 9 S., R. 26 E.

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments
3	3	5Y8/1						**Base Phosphoria Formation**; light yellowish gray limestone with red chert nodules
13	13	5R8/2; grayish pink	v fine	w	dolomite	bioturbated	bioturbated	**Top Tensleep Sandstone**; very dolomitic sandstone; caps dune cycle
15	2	5Y8/1; pale yellowish gray	v fine	w	calcareous	bioturbated	bioturbated	light gray clean sandstone bioturbated top of dune below
72	57	5Y8/1; pale yellowish gray	v fine	w	calcareous	none	high-angle trough cross bedding	light gray, cross-bedded sandstone, dune facies
108	36	N8; very light gray	fine	w	calcareous	none	high-angle trough cross bedding	light gray, cross-bedded sandstone, dune facies; thin marine reworked parallel laminated zone at top (6 in)
114	6	5Y8/1; pale yellowish gray	v fine	w	v calcareous	bioturbated	massive appearing, bioturbated	light gray, limy sandstone; bioturbated causing massive appearance
125	11	N8; very light gray	fine	w	non-calcareous	none	high-angle planar cross bedding	**Base Upper Tensleep Sandstone**; light gray, cross-bedded sandstone, dune facies
134	9	5R8/2; grayish pink						**Top Lower Tensleep**; pale grayish pink sandy dolomite with abundant yellow brown chert nodules and thin beds (2–3 in)

Crown Butte
Location of Measured Section: N½ Section 10, T. 7 S., R. 26 E.

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
		N8						**Base Phosphoria Formation**; light gray cherty limestone (reddish brown chert nodules)		
18	18	10YR7/4, grayish orange	fine	w	v calcareous	none	parallel bedded, nodular bioturbated,	**Top Tensleep Sandstone**; cherty, sandy limestone (top lower Tensleep)		
23	5	5Y8/1, yellowish gray	fine	w	v calcareous	bioturbated	bedding destroyed	yellowish gray, limy sandstone		
25	2	5YR8/1, pinkish gray	fine	m	v calcareous	bioturbated	bioturbated, bedding destroyed	pinkish gray, very limy sandstone to sandy limestone, clastic limestone grains, stained brown from bitumen	CB-1	very fine to fine-grained, slightly calcareous sandstone, angular to subrounded, poor to fair sorting; micritic matrix dolomitized and recrystallized, residual dead oil, porosity ~20%
37	12	5Y8/1, yellowish gray	fine	w	non-calcareous	none	planar steep cross beds	light yellowish gray, cross-bedded sandstone (dune facies)		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
65	28	10YR8/2 - 5Y8/1, v pale orange-yellowish gray	fine	w	calcareous	none	flat parallel	yellowish gray sandstone **mostly covered**		
67	2	10YR7/4, grayish orange	fine	w	v calcareous	vertical	trough cross bedding, contorted bedding	calcite-cemented nodules ~0.25–0.5 in, limy sandstone		
74	7	10YR8/2, very pale orange	fine	w	v calcareous	vertical	flat parallel, thick bedded	parallel bedded limy sandstone		
89	15	10YR7/4, grayish orange	fine	w	v calcareous	bioturbated	bioturbated; rip-up clasts at base, calcite-cemented nodules	very calcareous, grayish orange bioturbated sandstone		
92	3	10YR8/2, very pale orange	fine	w	calcareous	none	parallel bedded, flat	pale orange-gray, limy sandstone		
96	4	10YR7/4, grayish orange	fine	w	v calcareous	vertical	bioturbated top, flat parallel bedded	rip-up clasts basal 0.5 ft, small calcite cemented nodules, limy sandstone		
107	11	5Y8/1, yellowish gray	fine	w	v calcareous	none	flat, parallel laminated,	yellowish gray, limy sandstone, calcite-cemented nodules		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
108	1	10YR6/2, pale yellowish brown	v fine–fine	m	calcareous	none	flat, parallel laminated	very cherty, calcareous sandstone		
109	1	10YR8/2-10YR7/4, v pale orange-gray orange	fine	w	calcareous	none	trough cross bedding, low angle	calcareous sandstone with spherical calcite-cemented nodules ~0.25–0.5 in		
								Covered, **base of Tensleep not exposed** but Amsdent float occurs about 20–30 ft lower.		

Dry Head Section 1
Location of Measured Section: NW¼ Ne¼ Section 11, T. 7 S., R. 28 E.

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments
								Base Phosphoria Formation, pink cherty limestone, covered, float only; chert brownish red and yellowish brown
5	5	5R8/2; grayish pink	v fine	w	v calcareous	none	parallel laminated	**Top Tensleep Sandstone**; cherty very limy sandstone; weathering produces abundant "pinpoint" vugs
35	30	N8; very light gray 10YR7/4;	v fine	w	non-calcareous	none	high-angle trough cross bedding, rippled at top	very light gray cross-bedded dune sandstone, excellent porosity, bed sets 4 to 6 ft. Rippled at top, possibly marine reworking
36	1	grayish orange 10YR7/4;	v fine	w	v calcareous	none	parallel laminated	sandy dolomite, micritic matrix
37	1	grayish orange 10YR7/4;	v fine	w	v calcareous	none	ripple laminated	very fine limey sandstone, fines upward into siltstone
40	3	grayish orange	v fine	w	v calcareous	small vertical	low-angle trough cross bedding	very limy sandstone
54	14	N8; very light gray 10YR7/4;	v fine to fine	mod	calcareous	vertical top	high-angle trough cross bedding, burrowed at top 6 ft	light gray, cross-bedded dune sandstone, upper 6 ft burrowed (ophiomorpha)
56	2	grayish orange	v fine	w	v calcareous	none	wavy parallel laminated	very limy sandstone

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments
58	2	N8; very light gray	v fine to fine	mod	calcareous	none	high-angle trough cross bedding, burrowed at top 6 ft	light gray, cross-bedded dune sandstone
63	5	10YR7/4; grayish orange	fine	w	v calcareous	none	low-angle trough cross bedding and parallel laminate at top	very limy sandstone, thin sandy dolomite at the top (3 in)
78	15	10YR7/4; grayish orange	fine	w	v calcareous	none	low-angle trough cross bedding	very limy sandstone, friable, mostly covered
82	4	N8; very light gray	v fine	w	calcareous	none	high-angle trough cross bedding	clean, cross-bedded sandstone, light gray
88	6	10R8/2; grayish orange-pink to light gray					parallel laminated to wavy laminated	sandy limestone grading upward into sandy dolomite
110	22	N8; very light gray	fine	w	calcareous	none	high-angle planar cross beds, thick bedded	light gray, clean, cross-bedded sandstone in bed sets 4–6 ft thick, silt drapes on bed sets.
112	2	10YR7/4; grayish orange	fine	w	v calcareous	none	parallel laminated	very limy sandstone
117	5	N8; very light gray	v fine	w	calcareous	none	high-angle trough cross beds	clean, cross-bedded sandstone, light gray

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments
124	7	10YR7/4; grayish orange	v fine	w	v calcareous	none	wavy parallel laminated and ripple cross laminated	yellowish gray, very limy sandstone
126	2	N8; very light gray	v fine	w	calcareous	none	parallel, flat laminated and ripple laminated	light gray sandstone, contains clasts of dolomite breccia
138	12	10R6/2; pale red	v fine	w	calcareous	none	low-angle trough cross bedding	**Base Tensleep Sandstone**; pale reddish-gray, limy sandstone, brecciated at base and stained darker red at base
135	135	10R4/6-10R5/4; mod-pale red-brown						**Ranchester Member, Amsden Formation**; reddish mudstone with thin interbedded light gray to mottled reddish and gray limestone; some limestones contain abundant red chert, minor amount of dolomite
50	50	10R3/4; dark reddish brown						**Horseshoe Member, Amsden Formation**; mostly red mudstone with thin siltstone beds and thin yellowish muddy sandstone
		N7; light gray						**Top Madison Limestone**, vuggy to brecciated limestone

Dry Head Section 2
Location of Measured Section: NE¼ NE¼ Section 12, T. 7 S., R. 28 E.

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
3	3	N8, very light gray						light gray to light bluish gray, gypsiferous, cherty sandstone		
24	21	10R6/6; mod reddish orange						**Base Chugwater Formation**; reddish mudstone and thin interbedded red sandstone		
3	3	10R6/2; pale red						**Phosphoria Foramtion**; pale red, sandy, cherty limestone, brecciated in part		
8	8	N8, very light gray	v fine	w	v calcareous	none	low-angle trough cross bedding to wavy parallel laminated	**Top Tensleep Sandstone**; light gray to pale yellowish gray limy sandstone, thin bedded		
20	12	10R6/2; pale red						pale red cherty dolomite		
25	5	10YR7/4; grayish orange	v fine	w	v calcareous	vertical	wavy parallel bedded to mega-rippled	grayish orange limy sandstone, burrowed in upper half		
31	6	10R6/2; pale red						pale red, sandy, silty, cherty dolomite		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
33	2	10YR7/4; grayish orange	fine	w	v calcareous	bioturbated	planar, parallel bedded	limy sandstone, lithic limestone and quartz grains, matrix limy mud		
35	2	N8, very light gray	v fine	w	non-calcareous	none	wavy parallel bedded to low-angle trough cross-bedded	clean cross-bedded sandstone, beds 6 in to 1 ft		
39	4	10YR7/4; grayish orange	v fine	w	v calcareous	bioturbated	parallel flat bedded	limy sandstone, lithic limestone and quartz grains, matrix limy mud	DH2-1	very fine to fine-grained, slightly calcareous quartz sandstone, angular to subrounded, poor to fair sorting; micritic matix dolomitized and recrystallized, trace orthoclase, porosity ~14%
48	9	N8, very light gray	fine	w	non-calcareous	vertical at top only	high-angle trough cross bedding	clean, cross-bedded dune sandstone, burrowed in upper 3 ft related to overlying marine incursion		
58	10	N8, very light gray	silt to v fine	mod	v calcareous	none	rippled to wavy bedded	light gray to greenish gray friable, silty sandstone, contains lithic limestone grains, poorly exposed		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
61	3	10YR8/2; very pale orange						cherty, sandy dolomite; chert in nodules and in 1–3 in beds, chert gray to yellowish gray		
63	2	10YR7/4; grayish orange	silt to v fine	mod	calcareous	none	ripple laminated	thin sandstone–siltsone couplets, very thin bedded		
64	1	N8, very light gray					flat parallel laminate	sandy dolomite		
67	3	10YR7/4; grayish orange	v fine to fine	mod	v calcareous	none	wavy bedded and low-angle trough cross bedding	very limy sandstone bedsets 1–6 in		
68	1	N8, very light gray	v fine	w	v calcareous	bioturbated	wavy laminated to bioturbated	very light gray, nodular, limy, bioturbated sandstone		
69	1	10YR7/4; grayish orange					flat parallel laminate	sandy limestone		
74	5	N8, very light gray	v fine	w	v calcareous	none	low-angle trough cross bedding ripple laminated at top	cross-bedded limy sandstone, ripple laminated in upper 1 ft		
78	4	10YR8/2; very pale orange	v fine	w	v calcareous	none	parallel laminated to ripple laminated	pale yellow limy sandstone		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
88	10	10YR7/4; grayish orange	v fine	w	v calcareous	none		friable, poorly exposed yellowish to orange gray sandstone		
93	5	N8, very light gray	v fine	w	v calcareous	none	low-angle trough cross bedding	light gray cross-bedded limy sandstone		
97	4	10YR7/4; grayish orange	v fine	w	v calcareous	none		limy sandstone, mostly covered		
102	5	N8, very light gray	v fine	w	v calcareous	none	low-angle trough cross bedding	light gray cross-bedded limy sandstone		
105	3	10YR7/4; grayish orange	v fine	w	v calcareous	none	wavy, parallel laminated	limy sandstone, mostly covered		
107	2	N8, very light gray	v fine	w	v calcareous	none	low-angle trough cross bedding	limy sandstone, lithic limestone and quartz grains, matrix limy mud		
111	4	10YR7/4; grayish orange	v fine	w	v calcareous	none	wavy, parallel laminated	limy sandstone, mostly covered		
113	2	N8, very light gray	v fine	w	v calcareous	none	low-angle trough cross bedding	limy sandstone, lithic limestone and quartz grains, matrix limy mud; poorly exposed		
125	12	10YR7/4; grayish orange	v fine	w	v calcareous	none	wavy, parallel laminated	**Base Tensleep Sandstone**; limy sandstone, mostly covered		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
10	10	5RP6/2						**Top Amsden Formation**; pale red and purple mudstone, interbedded thin limestone and limestone breccia		

Dry Head Section 3
Location of Measured Section: NE¼ NE¼ Section 10, T. 7 S., R. 28 E.

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments
								Base Phosphoria Formation; sandy dolomitic limestone, cherty (reddish gray, pink, gray)
11	11	10YR7/4; grayish orange	fine	w	v calcareous	vertical, upper 2 ft	flat parallel bedding	**Top Tensleep Sandstone**; beds 1–2 ft thick, limy sandstone
12	1	N8, very light gray	v fine	w	calcareous	none	trough cross bedding	toe of dune build up, thickens dramatically to west
22	10	10YR7/4; grayish orange	fine	w	v calcareous	vertical	trough cross bedding	limy cross-bedded sandstone, fining upward
26	4	10YR7/4; grayish orange	v fine	w	v calcareous	bioturbated	bioturbated	limy bioturbated sandstone
61	35	N8, very light gray	fine	w	non-calcareous	vertical, upper 2 ft	high-angle trough cross bedding	cross-bedded dune sandstone, contorted bedding from compaction and down depositional slope slumping, burrowed in upper 2 ft related to overlying marine incursion
64	3	10YR7/4; grayish orange	fine	w	calcareous	bioturbated	bitoturbated	very light gray to grayish orange mottled sandstone, marine
87	23	N8, very light gray	fine	w	non-calcareous	vertical, upper 2 ft	high-angle trough cross bedding	cross-bedded dune sandstone, burrowed in upper 2 ft related to overlying marine incursion

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments
93	6	10YR7/4; grayish orange	v fine	w	calcareous	none	parallel laminated, ripple cross laminated	limy sandstone, marine
98	5	10YR7/4; grayish orange	v fine	w	calcareous	none	low-angle trough cross bedding	limy cross-bedded sandstone, fining upward, rippled at top
99	1	10R8/2; grayish orange pink					parallel, flat bedded	slightly sandy dolomite
104	5	N8 to 10YR7/4, lt gray to gray orange	v fine	w	calcareous	none	low-angle trough cross bedding	mottled limy, cross-bedded sandstone
109	5	N8, very light gray	silt		calcareous		platy	light gray to greenish gray siltstone
110	1	N8, very light gray	v fine	w	calcareous	none	ripple laminated	light gray ripple cross-laminated sandstone
111	1	10YR7/4; grayish orange						sandy mudstone
116	5	10YR7/4; grayish orange	v fine	w	calcareous	none	low-angle planar cross bedding	limy, thin bedded sandstone

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments
118	2	10YR7/4; grayish orange					flat parallel bedding	sandy, cherty limestone; 2 in purple-gray hematitic calcareous sandstone at base
123	5	10R6/2-N8; pale red to v lt gray	fine	w	v calcareous	none	planar, low-angle cross bedding	limy sandstone, marine; stained reddish at base and light gray upward.
126	3	10YR7/4; grayish orange	v fine	w	v calcareous	none	flat parallel bedding	**Base Tensleep Sandstone**; limy quartz sandstone and sandy limestone; lithic limestone grains
								Top Amsden Formation; pale purple mudstone and interbedded limestone and limestone breccia

Dry Head Section 4
Location of Measured Section: NE¼ NW¼ Section 10, T. 7 S., R. 28 E.

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
		10R5/6, reddish brown	clay-silt					**Base Chugwater Formation;** reddish brown mudstone		
9	9	10YR7/4, grayish orange	fine	w	v calcareous	none	parallel, flat, brecciated	**Top Tensleep Sandstone**; light grayish orange, very limy sandstone, iron (reddish brown) stain at the top.		
17	8	10YR7/4, grayish orange	v fine	w			bioturbated	sandy limestone, quartz grains and limestone clasts in micritic matrix		
25	8	N8, very light gray	v fine	w	slightly calcareous	vertical, upper few ft	high-angle trough cross bedding	light gray dune sandstone, burrowed top from marine incursion above		
26	1	10YR7/4, grayish orange	v fine	w	calcareous	vertical	ripple cross-laminated to bioturbated	marine sandstone cut across top of underlying dune ss		
32	6	N8, very light gray	v fine	w	slightly calcareous	vertical, upper few ft	high-angle trough cross bedding	light gray dune sandstone, burrowed top from marine incursion above		
33	1	10YR7/4, grayish orange	v fine	w	calcareous	vertical	ripple cross-laminated to bioturbated	marine sandstone cut across top of underlying dune ss		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
37	4	N8, very light gray	v fine	w	slightly calcareous	vertical, burrowed whole thickness	high-angle trough cross bedding	light gray dune sandstone, burrowed top from marine incursion above		
38	1	10YR7/4, grayish orange	v fine	w	v calcareous	vertical	ripple cross-laminated to bioturbated	marine sandstone cut across top of underlying dune ss		
42	4	N8, very light gray	v fine	w	slightly calcareous	vertical, burrowed whole thickness	high-angle trough cross bedding	light gray dune sandstone, burrowed top from marine incursion above		
46	4	10R5/4, pale reddish brown				bioturbated top		sandy dolomite, pale pink at base and darkens upward	DH4-8	very fine crystalline dolomite, original micrite dolomitized and recrystallized, porosity 0–1%
66	20	N8, very light gray	v fine	w	non-calcareous	burrowed upper 4 ft	high-angle trough cross bedding	dune ss, light gray to light grayish orange in upper few ft. Upper few ft burrowed below overlying marine incursion may be marine reworked at top	DH4-6&7	very fine to fine-grained, dolomitic quartz sandstone, angular to subrounded, poor to fair sorting; micritic matix dolomitized and recrystallized, trace orthoclase, porosity 0–22%

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
76	10	10YR7/4, grayish orange	v fine	w	v calcareous	none	parallel laminated to rippled	clay-rich sandstone grading upward into coarser, very calcareous sandstone containing limestone grains (4 cycles)		
78	2	N8, very light gray	v fine	w	v calcareous	none	low-angle trough cross beds	toe of dune sandstone build up		
85	7	10YR7/4, grayish orange	v fine	w	v calcareous	vertical	parallel laminated to bioturbated	very calcareous sandstone burrows 4–7 ft deep	DH4-5	very fine to fine-grained, dolomitic quartz sandstone, angular to subrounded, poor to fair sorting; micritic matix dolomitized and recrystallized, trace orthoclase, porosity 0–10%
86	1	N8, very light gray	v fine	w	calcareous	none	planar, high-angle cross bedding	very light gray cross-bedded sandstone		
90	4	10YR7/4, grayish orange	v fine	w	calcareous	vertical	parallel laminated to bioturbated	nodular, mottled calcareous sandstone minor thin interbedded claystone		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
104	14	N8, very light gray	v fine	w	non-calcareous	none	high angle planar cross bedding	light gray dune sandstone	DH4-4	very fine to fine-grained, dolomitic quartz sandstone, angular to subrounded, poor to fair sorting; micritic matix dolomitized and recrystallized, trace orthoclase, porosity ~24%
106	2	10YR7/4, grayish orange	v fine	w	calcareous	none	low-angle planar cross beds	cherty, yellowish gray to gray-orange cross-bedded sandstone, appears to grade upward into dune ss above	DH4-3	very fine to fine-grained, dolomitic quartz sandstone, angular to subrounded, poor to fair sorting; micritic matix dolomitized and recrystallized, trace orthoclase, porosity 0–4%
118	12	10YR7/4 to N8; gray-orange to v light gray	fine	w	calcareous	none	planar and trough cross bedding, rippled at base	dune sandstone, light gray, some contorted beds and collapsed breccia	DH4-2	very fine to fine-grained, dolomitic quartz sandstone, angular to subrounded, poor to fair sorting; micritic matrix dolomitized and recrystallized, trace orthoclase, porosity 0–20%
124	6	N8, very light gray	fine	w	calcareous	none	planar, flat bedding	light gray sandstone parallel bedded		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
131	7	10YR7/4 to N8; gray-orange to v light gray	fine	w	calcareous	none	low-angle trough cross beds	light gray cross-bedded sandstone	DH4-1	very fine to fine-grained, dolomitic quartz sandstone, angular to subrounded, poor to fair sorting; micritic matrix dolomitized and recrystallized, trace orthoclase, porosity 0–20%
136	5	10YR7/4 to N8; gray-orange to v light gray	v fine to fine	w	calcareous	none	low-angle trough cross beds	light gray cross-bedded sandstone		
								Approximate Base Tensleep Sandstone, not exposed		

Five Mile Creek
Location of Measured Section: Center Section 6, T. 6 S., R. 25 E.

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
		5R5/4, mod red						**Base Chugwater Formation**: red mudstone		
4	4	N8, v light gray						**Top Phosphoria**; light gray limestone		
9	5	10R7/4, mod orange, pink						pink mudstone		
11	2	10R8/2, grayish pink						**Base Phosphoria Formation**; clastic limestone to limestone breccia, some greenish rip-up clasts		
14	14	5YR7/4, mod yellowish gray	v fine	w	v calcareous	vertical	bioturbated, beds 1 to 2 ft thick	**Top Tensleep Formation**		
17	3	5YR7/4, mod yellowish gray	v fine	w	sandy limestone	none		cherty, sandy limestone		
28	11	N8-5YR7/1, v light gray to pale yellow gray	v fine	w	v calcareous	none	platy, thin bedded	thin bedded sandstone, limy		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
36	8	5YR6/1, lt brownish gray	v fine	w	v calcareous	vertical upper 1 ft	planar and trough cross bedding	contorted beds, cross bed sets show evidence of downslope sliding	5-mi #6	very fine to fine-grained, dolomitic quartz sandstone, angular to subrounded, poor to fair sorting; micritic matrix dolomitized and recrystallized, trace orthoclase, porosity ~22%
42	6	5YR7/4, mod yellowish gray	v fine	w	v calcareous	none	parallel	limy sandstone to sandy limestone, cherty		
58	16	5YR7/1, pale yellow gray	v fine to fine	w	calcareous	vertical upper 1 ft	low-angle trough cross bedding, bi-directional (dip directions reverse through the interval)	thin bedded sandstone, bed thickness 1–4 ft, some contorted beds, looks marine	5-mi #5	very fine to fine-grained, dolomitic quatrz sandstone, angular to subrounded, poor to fair sorting; micritic matrix dolomitized and recrystallized, trace orthoclase, porosity ~24%
65	7	5YR7/1, pale yellow gray	v fine	w	v calcareous	horizontal & vertical	low-angle trough cross bedding, partly bioturbated	thin bedded calcareous sandstone		
68	3	5YR7/1, pale yellow gray	v fine	w	v calcareous	vertical	bioturbated	limy, bioturbated sandstone		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
75	7	5YR7/4, mod yellowish gray	v fine	w	calcareous	none	low-angle planar cross bedding, thick bedded	yellowish gray limy sandstone, marine		
79	4	5YR6/1, light brownish gray	silt to clay					light brownish gray silty to sandy mudstone		
81	2	N8, v light gray	v fine	w	v calcareous	none	ripple laminated in part and parallel laminated, some climbing ripples	light gray calcareous sandstone		
83	2	5YR7/1, pale yellow gray	v fine	w	v calcareous	none	planar high angle cross bedding	yellowish gray limy sandstone, some clastic limestone grains		
87	4	5YR7/1, pale yellow gray	v fine	w	calcareous	vertical	wavy parallel laminated	yellowish gray limy sandstone, burrowed		
88	1	N8	v fine	w	siliceous	none	flat parallel laminated	light gray silicified sandstone		
98	10	5YR7/1, pale yellow gray	v fine to fine	w	calcareous	none	low-angle trough cross bedding	yellowish gray sandstone, some limestone clastic grains		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
100	2	5YR7/1, pale yellow gray	v fine	w	v calcareous	none	parallel, flat	very fine to fine-grained quartz sandstone grading to lithic sandstone with abundant limestone grains.	5-mi #4	very fine to fine-grained, dolomitic quartz sandstone, angular to subrounded, poor to fair sorting; micritic matrix dolomitized and recrystallized, trace orthoclase, porosity ~22%
103	3	10YR7/4, mod grayish brown	v fine	w	v calcareous	none	ripple laminated, thin bedded	grayish brown limy sandstone		
107	4	10YR7/4, mod grayish brown	v fine	w	v calcareous	none	planar high-angle cross bedding	grayish brown, cross-bedded, limy sandstone	5-mi #1, #2, and #3	very fine to fine-grained, dolomitic quartz sandstone, angular to subrounded, poor to fair sorting; micritic matrix dolomitized and recrystallized, trace orthoclase, porosity 0–15%
113	6	N8, v light gray	v fine to fine	w	v calcareous	vertical	low-angle planar cross bedding	light gray calcareous sandstone		
125	12							covered		
127	2	N8	fine	w	dolomitic	none	parallel, flat	sugary light gray dolomitic sandstone		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
141	14	5YR7/1, pale yellow gray	v fine	w	v calcareous	none	parallel, flat	**Base Tensleep Sandstone;** light yellowish gray, limy sandstone, beds 1.5–2 ft thick		
13	13	5YR6/1, light brownish gray						**Top Amsden Fm, Ranchester Member;** light brownish gray, cherty limestone, thin to medium bedded		
23	10	N8 - 5YR6/1, v lt gray to lt brnish gray						limestone, dolomitic sandy limestone, and limestone breccia, thin bedded		
28	5	5R6/6-5RP4/2, pale red--grayish red purple						pink to pale purple mudstone and siltstone		
31	3	N8						light gray dolomite		
46	15	5R6/6-5RP4/2, pale red--grayish red purple						pink to pale purple mudstone and siltstone, interbedded with thin light gray and pale pink limestone and limestone breccia		
61	15	5R6/6, pale red						**Base Ranchester Member**; mudstone with very minor beds of limestone.		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
67	6	10R4/6, mod reddish brown						red mudstone		
75	8	covered						**Base Amsden Fomation, Horseshoe Member**; covered, reddish brown soil		
	0							**Top Madison Group**; medium gray limestone		

Grape Vine Canyon
Location of Measured Section: N½ Secton 2, S½ Section 11, T. 6 S., R. 30 E.

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments
		10R6/2, pale red						**Phosphoria (?) and Chugwater Formation:** reddish cherty limestone overlain by red mudstone
13	13	5Y8/4, grayish yellow	fine	w	non-calcareous	none	trough cross bedding and contorted bedding	**Top Tensleep Sandstone**; pale yellow gray fine-grained dune (?) sandstone
17	4	10R6/2, pale red	fine	w	v calcareous	none	flat parallel laminated	interbedded reddish mudstone and very limy, cherty, pink-gray sandstone
20	3	5R8/2, pale pink-gray	fine	w	v calcareous	vertical upper ft	flat parallel laminated	pale pinkish gray, cherty, very limy sandstone
27	7	5R4/2, grayish red purple	fine	w	calcareous	none	platy	muddy sandstone, platy, beds about 0.25 in
92	55	5Y8/1, yellowish gray	fine to v fine	w	calcareous	vertical, upper 2–3 ft	trough cross bed (low-angle) sets 10–12 ft thick with thin muddy sandstone partings	cross-bedded calcareous sandstone
97	5	5Y7/2, yellowish gray	fine	w	calcareous	none	parallel laminated and low-angle trough cross beds, bed sets 1–2 ft thick	thin bedded, cross-bedded calcareous sandstone

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments
98	1	5P5/2, grayish purple	clay–silt					pale purple mudstone
100	2	N8, light gray						mottle, micritic limestone
102	2	10YR7/4, grayish orange					flat parallel laminated	sandy limestone
117	15	10YR7/4, grayish orange	clay - silt				platy	sandy mudstone and mudstone
127	10	5YR7/2 to N8, gray orange to light gray	f	w	v calcareous	none	low-angle trough cross bedding calcite-cemented nodules ~0.25 in	cross-bedded limy sandstone
135	8	5YR7/2, grayish orange	f	w	v calcareous	none	low-angle trough cross bedding, cut and fill at base, rip-up clasts	cross-bedded limy sandstone, tidal channel (?)
142	7	5YR7/2 to N8, gray orange to light gray						mottled brecciated limestone at base and brecciated (collapse) sandy limestone at top
147	5	10YR7/4, grayish orange	clay - silt					mudstone

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments
150	3	N8, light gray	v fine	w			brecciated	mottled brecciated limy, cherty sandstone
153	3	N8-5YR7/2, light gray to gray orange	f	w	v calcareous	none	planar cross beds in flat bed sets 1–2 ft thick	very limy cross-bedded sandstone
157	4	10YR7/4, grayish orange	clay - silt					mudstone
159	2	5YR7/2 gray orange	fine to coarse	p	v calcareous	bioturbated top 1 ft	brecciated, rip up clasts	coarse sand with rip-up clasts at base, then thinnly laminated muddy sandstone, overlain by reddish gray ss and bioturbated ss at top
161	2	5YR7/2 to N8, gray orange to light gray	fine	w	calcareous	none	low-angle trough cross bedding	mottled limy sandstone, light gray with reddish to pale purple
163	2	5R7/2 reddish gray						reddish gray sandy nodular limestone
166	3	5YR7/2 to N8, gray orange to light gray	fine	w	v calcareous	none	low-angle trough cross bedding	grayish orange limy cross-bedded sandstone
167	1	N8						micritic limestone
178	11	10YR7/4, grayish orange						mudstone with thin interbedded limestones (6 in or less)

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments
179	1	N8						micritic limestone
180	1	N8	fine	w	v calcareous	none	flat parallel laminated	light gray very limy sandstone
181	1	5YR8/1, pinkish gray					parallel bedded	bedded, nodular chert
184	3	5YR8/1-N8, pinkish gray to light gray	fine	w	calcareous	none	low-angle trough cross bedding	**Base Tensleep Sandstone**; light gray, limy, cross-bedded sandstone
14	14	10R7/4 - 10R6/4,v pale to pale red brown	clay–silt					**Top Amsden Fm, Ranchester Limestone Member**; mudstone interbedded with gray siltstone and limestone and minor grayish purple siltstone
21	7	5YR8/1, pinkish gray						pinkish gray limestone with reddish brown chert nodules
31	10	5YR8/1, pinkish gray						mudstone, with nodular limestone near top
33	2	5YR8/1, pinkish gray						mottle micritic limestone
82	49	10R7/4 - 10R6/4,v pale to pale red brown						mudstone with thin interbedded limestones (6 in or less) and limestone breccia.

Lodge Grass Creek
Location of Measured Section: Center Section 20, T. 9 S., R. 33 E.

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
		10R7/4	silt to clay					**Base Chugwater Formation**; red mudstone		
4	4	N8, light gray	v fine	w	v calcareous	vertical	trough cross bedding	**Top Tensleep Sandstone**; light gray, limy sandstone		very fine to fine-grained, dolomitic quartz sandstone, angular to subrounded, poor to fair sorting; micritic matrix dolomitized and recrystallized, trace orthoclase, porosity 0–6%
6	2	5YR7/1, pale brownish gray	v fine	w	sandy limestone	none	parallel laminated and ripple laminated	light brownish gray, very limy sandstone to sandy limestone	LG-3	
11	5	N8, light gray	v fine	w	v calcareous	vertical in upper 1 ft	low-angle trough cross bedding	light gray, limy sandstone		
12	1	10YR6/4, light yellowish brown	v fine	w	v calcareous	none	ripple laminated	light brown, very limy sandstone to sandy limestone		
15	3	N8, light gray	v fine	w	calcareous	vertical	sparsely burrowed, trough cross bedding	light gray friable sandstone; possible toe of dune sandstone		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
17	2	5YR7/1, pale brownish gray	v fine		dolomite	none	parallel bedded	sandy dolomite pale brownish gray to grayish pink		
24	7	N8, light gray	v fine	w	v calcareous	none	flat, planar to wavy bedding, beds 1 in to 8 in	light gray, calcareous sandstone		
25	1	N8, light gray	v fine	w	v calcareous	none	ripple to parallel laminated	light gray, calcareous sandstone with silty clay drapes and lenses of brownish gray limestone		
32	7	N8, light gray	v fine	w	non-calcareous	vertical	trough cross bedding	light gray, non-calcareous sandstone, burrowed in upper 2 ft, probable dune facies	LG-2	very fine to fine-grained, dolomitic quartz sandstone, angular to subrounded, poor to fair sorting; micritic matrix dolomitized and recrystallized, trace orthoclase, porosity 0–24%
87	55	N8, light gray	v fine	w	v calcareous	none	parallel laminated and trough cross	Base Tensleep Sandstone; mostly covered interval, calcite-cemented spherical nodules about 0.25–0.5 in. diameter, cross bed sets thin (3 in to 1 ft); appears from float that there are some interbedded thin mudstones and siltstones		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
18	18	10R5/4, pale reddish brown	silt to clay					**Top Amsden Formation, Ranchester Limestone Member**; red mudstone		
83	65	10R5/4, pale reddish brown	silt to clay					mostly covered, float indicates probably interbedded red mudstone and thin limestone beds.		
86	3	5YR7/1, pale brownish gray						light brownish gray to grayish pink, cherty limestone		
101	15	10R5/4, pale reddish brown	silt to clay					covered, reddish mudstone		
111	10	5YR7/1, pale brownish gray						brownish gray to grayish pink, mottled, cherty, dolomitic limestone; vuggy, brecciated in part		
115	4	10R5/4, pale reddish brown	silt to clay					red mudstone		
116	1	5YR7/1, pale brownish gray						mottled, sandy limestone		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
129	13	10R5/4, pale reddish brown	silt to clay					red mudstone with interbedded thin medium gray limestone		
134	5	5YR7/1, pale brownish gray						mottled limestone breccia		
140	6	10R5/4, pale reddish brown	silt to clay					red mudstone, mostly covered		
155	15	N8, light gray						limestone, basal 5 ft massive then remainder pale grayish pink to light gray mottled brecciated limestone, vuggy	LG-1	very fine crystalline dolomite, original micrite dolomitized and recrystallized, contains fine to coarse detrital quartz and orthoclase, porosity 0–7%
167	12	10R5/4, pale reddish brown	silt to clay					red mudstone		
171	4	5YR7/1, pale brownish gray						**Base Ranchester Member**; brownish gray dolomite		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
196	25	5R4/6, moderate red						**Base Amsden Formation, Horseshoe Member**; red mudstone		
								Top Madison Group Limestone; medium gray, karsted, vuggy limestone		

Rotten Grass Creek
Location of Measured Section: NE¼ SE¼ Section 22, T. 8 S., R. 32 E.

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments
		5R5/4, mod red						**Triassic Chugwater Formation**: red mudstone
0	2	N8, v light gray				none	flat, parallel laminated, med bedded	**Top Tensleep Sandstone**: sandy limestone, cycle cap
25	23	N8, v light gray	very fine	well	calcareous	vertical, upper 1 ft	platy, basal 1 ft; then remainder trough cross-bedded	
10	10	5R5/4-10R5/4 mod red to pale red brown						**Amsden Formation, Ranchester Member:** red mudstone and interbedded thin micritic limestone

Soap Creek
Location of Measured Section: N½ Section 33, T. 7 S., R. 32 E.

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments
		5R5/4,mod red						**Base Chugwater Formation:** red mudstone
1	1	N8; v light gray	v fine	w	v calcareous	none	flat, parallel	**Top Tensleep Sandstone**; limy sandstone, cycle top
15	14	N8; v light gray	v fine	w	slightly calcareous	vertical, upper 2 ft	high-angle trough cross-bedded	oil-stained sandstone (dead oil); this dune interval pinches out laterally in about 100 yards in each direction, where Chugwater rests directly on next underlying unit
21	6	5YR6/1, light brownish gray	v fine	w	v calcareous	none	wavy, parallel laminated	limy sandstone to sandy limestone, top of cycle
22	1	10YR8/2, v pale orange	v fine	w	v calcareous	none	flat, parallel laminated	very limy sandstone
34	12	N8; v light gray	v fine	w	calcareous	vertical, upper 1 ft	high-angle trough cross-bedded	oil-stained, some calcareous cemented nodules as large as 0.5 in. in diameter
43	9	10YR8/2, v pale orange	v fine	w	calcareous to v calcareous	none	parallel, flat	platy sandstone, some lithic carbonate clasts, some sandstone argillaceous and less resistant than calcareous sandstone.
48	5	5YR6/1, light brownish gray	v fine	w	calcareous			**mostly covered**, light brownish gray sandstone float

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments
51	3	N8; v light gray	v fine	w	calcareous	none	platy	**Base Tensleep Sandstone**; limy sandstone, some rip-up clasts
0	2	10R7/2; mod grayish pink						**Top Amsden Formation**; pink mudstone
4	2	5RP7/2; v pale grayish purple						dolomitic nodular limestone
50	46	10R6/2-10R7/2; pale red to mod grayish pink						reddish mudstone interbedded with thin micritic limestone

Spring Creek
Location of Measured Section: NE¼ Section 2, T. 7 S., R. 28 E.

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments
2	2	10YR6/2, pale yellowish brown					parallel laminated	**Top Tensleep Sandstone**; sandy, silty, cherty dolomite
5	3	10YR6/2,pale yellowish brown	v fine	w	v calcareous	vertical & horizontal	ripple laminated	very limy quartz sandstone, 5% lithic limestone grains floating calcareous mud matrix
34	29	N8, very light gray	fine	w	non-calcareous	vertical & horizontal top 1 ft	high-angle trough and planar cross bedding, burrowed upper ft	very light gray, dune sandstone, excellent porosity, some contorted bedding from compaction and down dip slumping, burrowing related to overlying marine incursion
38	4	10YR7/4; grayish orange	v fine					cherty, sandy dolomite
43	5	10YR7/4; grayish orange	v fine	w	v calcareous	bioturbated	parallel, wavy bedding to bioturbated	very limy quartz sandstone, 5% lithic limestone grains floating calcareous mud matrix
47	4	10YR6/2, pale yellowish brown						yellowish brown, cherty, sandy dolomite
49	2	N8, very light gray	v fine	w	calcareous	none	ripple laminated	light gray, silty sandstone

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments
50	1	N8, very light gray						very light gray to pale pink cherty, sandy dolomite
56	6	N8, very light gray			calcareous		rippled to platy	silty to sandy mudstone
57	1	10YR7/4; grayish orange	v fine	w	v calcareous	vertical	wavy bedding and low-angle trough cross bedding	limy, sandstone, marine
61	4	10YR7/4; grayish orange	v fine	w	v calcareous	bioturbated	bioturbated	bioturbated, limy sandstone, some limestone lithic grains
62	1	10YR7/4; grayish orange	fine	w	calcareous	none	parallel laminated	limy, sandstone; chert nodules
65	3	N8, very light gray			calcareous	none	parallel laminated	silty claystone with chert beds 1 to 4 in thick
69	4	N8, very light gray	fine	w	v calcareous	none	parallel laminated	light gray to greenish gray limy sandstone
73	4	N8, very light gray	fine	w	v calcareous	none	trough cross bedding	light gray very limy sandstone; cross bedded
75	2	10YR7/4; grayish orange					parallel, flat bedded	sandy dolomitic limestone

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments
95	20	N8, very light gray	fine	w	calcareous to non-calcareous	none	high-angle trough and planar cross bedding	dune sandstone, very light gray, stained yellowish gray in part (30%), calcareous at base
96	1	10YR7/4; grayish orange	v fine	w	calcareous	none	platy	platy, muddy sandstone
101	5	N8, very light gray	v fine	w	non-calcareous	none	high-angle trough cross bedding	very light gray, cross-bedded dune sandstone
103	2	10YR7/4; grayish orange	v fine to fine	mod	calcareous	none	platy	clay-rich sandstone
112	9	N8, very light gray	v fine	w	calcareous	none	high-angle trough cross bedding	very light gray, cross-bedded dune sandstone
116	4	10YR7/4; grayish orange	v fine	w	calcareous	vertical	parallel laminated basal 1 ft, then trough cross-bedded	grayish orange cross-bedded limy sandstone
127	11	10YR7/4; grayish orange	v fine	w	calcareous	vertical	parallel laminated basal 1 ft, then trough cross-bedded	**Base Tensleep Sandstone**; as above but mostly covered, grayish orange cross-bedded limy sandstone
								Top Amsden Formation; mostly float, purple-gray mudstone

Stockman Trail
Location of Measured Section: SW¼ Section 32, T. 8 S., R. 26 E.

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
								Base Phosphoria Formation; medium gray limestone cherty (reddish brown)		
15	15	N8, very light gray	v fine to fine	w	calcareous	vertical, top 1 ft	high-angle trough cross bedding	**Top Tensleep Sandstone**; light gray, cross-bedded sandstone, dune ss		
25	10	N7, light gray	v fine		limestone	vertical, top 1 ft	parallel flat, partly bioturbated	sandy limestone to very limy sandstone		
67	42	N8, very light gray	v fine to fine	w	calcareous	vertical, top 2 ft	High angle trough and planar cross bedding	light gray, cross-bedded sandstone, dune ss		
73	6	N8, very light gray						light gray limestone, caps cycle		
85	12	N8, very light gray	v fine to fine	w	calcareous	none	high-angle trough cross bedding	light gray, cross-bedded sandstone, dune ss		
89	4	N8, very light gray				none		light gray, sandy, cherty, dolomitic limestone		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
93	4	10YR8/2, very pale orange	v fine to fine	w	v calcareous	vertical	bioturbated	yellowish gray, bioturbated limy sandstone	ST-2	very fine to fine-grained, dolomitic quartz sandstone, angular to subrounded, poor to fair sorting; micritic matrix dolomitized and recrystallized, trace orthoclase, porosity 0–12%
98	5	N8, very light gray	fine	w	calcareous	none	cross-bedded and wavy parallel laminated	light gray, calcareous sandstone		
103	6	N8, very light gray	v fine	w	calcareous	vertical	parallel laminated and partly bioturbated	calcareous, light gray bioturbated sandstone		
112	9	N8, very light gray	v fine	w	v calcareous	vertical & horizontal	parallel laminated and partly bioturbated	light gray, bioturbated limy sandstone		
113	1	N8, very light gray	fine	w	calcareous	none	parallel laminated	light gray calcareous sandstone		
117	4	5Y8/4, grayish yellow	v fine	w			parallel and ripple cross laminated	sandy limestone to very limy sandstone, contains clastic limestone grains		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
121	4	5Y8/4, grayish yellow	v fine	w	calcareous	none	parallel and ripple cross laminated	very limy sandstone		
127	6	5Y8/4, grayish yellow	fine to very fine	w	calcareous	none	trough cross bedding	yellowish gray calcareous sandstone, fine upward grading into overlying bed		
143	15	5Y8/4-N8, gray-yellow to v light gray	fine	w	calcareous	none	high-angle planar cross bedding	yellowish gray to light gray calcareous sandstone, dune (?)		
145	2	N8, very light gray	v fine		dolomite		wavy laminations	sandy dolomite		
155	10	5Y8/4, grayish yellow	v fine to fine	w	calcareous	none	cut and fill structure at base, trough cross bedding, bidirectional	1–3 in bed sets, marine, tidal ss (?)	ST-1	very fine to fine-grained, slightly calcareous quartz sandstone, angular to subrounded, poor to fair sorting, algal fragments present, micritic matrix dolomitized and recrystallized, trace orthoclase, porosity ~17%
164	9	5Y8/4, grayish yellow	v fine	w	limestone to calcareous ss	none	platy, parallel laminated	sandy limestone to v lime sandstone		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
172	8	N8, very light gray	v fine to fine	w	non-calcareous	vertical	planar tabular cross bedding, steep	light gray cross-bedded sandstone grades upward into massive sandstone		
174	2	10R4/6 reddish brown						mudstone, top few inches greenish gray claystone		
186	12	N8, very light gray	fine	w	calcareous	none	climbing ripples	**Base Tensleep Sandstone**; light gray calcareous sandstone, locally stained reddish gray at basal contact, sharp basal contact		
23	23	10R6/2, pale red						**Top Amsden Fm, Ranchester Limestone Member**; reddish gray mudstone interbedded with light gray limestone and limestone breccias in beds 1 ft thick or less, much less abundant than mudstone (20–30%)		
40	17	N8, very light gray						cherty limestone, some chert bedded in 3–6 in beds, reddish gray chert		

Fm Cum. Thick-ness	Interval Thick-ness	Color	Grain Size	Sort-ing	Cement	Burrow Type	Sedimentary Structures	Description/Comments	Sample Number	Petrographic Description of Samples
128	88	10R6/2, pale red						reddish gray mudstone and interbedded limestone breccia and nodular limestone in beds 1–2 ft thick; mudstone about 60–70%		
129	1	N8, very light gray						**Base Ranchester Limestone Member**; light gray limestone		
68	68	10R4/6 reddish brown						**Base Amsden Fm, Horseshoe Member**; reddish brown mudstone and siltstone		
								Top Madison Group; medium gray vuggy to karsted limestone		