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New Vitrinite Reflectance Data for the Bighorn Basin, North-Central Wyoming and South-Central Montana

Open-File Report 2007-1246

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By Thomas M. Finn, and Mark J. Pawlewicz

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Introduction

The Bighorn Basin is a large Laramide (Late Cretaceous through Eocene) structural and sedimentary basin that encompasses about 10,400 mi^2 in north-central Wyoming and south-central Montana (fig. 1). Important conventional oil and gas resources have been discovered and produced from reservoirs ranging in age from Cambrian through Tertiary (Fox and Dolton, 1989, 1996a, b; De Bruin, 1993). In addition, a potential unconventional basin-centered gas accumulation may be present in Cretaceous reservoirs (Johnson and Finn, 1998; Johnson and others, 1999). The purpose of this report is to present new vitrinite reflectance data to be used in support of the U.S Geological Survey's assessment of undiscovered oil and gas resources of the Bighorn Basin. These new data supplement previously published data by Nuccio and Finn (1998), and Yin (1997), and lead to a better understanding and characterization of the thermal maturation and burial history of potential source rocks.

Eighty-nine samples of Cretaceous and Tertiary strata (fig. 2) were collected and analyzed—15 samples were from outcrops around the margins of the basin and 74 samples were well cuttings (fig. 1). Forty-one of the samples were shale, two were carbonaceous shale, and the remainder from coal.

All samples were analyzed by vitrinite reflectance to determine levels of thermal maturation. Preparation of samples for reflectance analysis required (1) crushing the larger pieces into 0.25-to 1-mm pieces, (2) casting the pieces with epoxy in pre-cut and drilled plugs, and (3) curing the samples overnight. Subsequently, a four-step grinding and polishing process was implemented that included sanding with progressively finer sandpaper (60 and 600 grit) followed with a two-step polishing process (0.3 and 0.05 micron). Vitrinite reflectance measurements were determined at 500 X magnification using plane-polarized incident white light and a 546-nm monochromatic filter in immersion oil. For samples containing sufficiently high quality vitrinite, at least 25 measurements were recorded. For samples of poorer quality, either due to a poor polish or to the presence of mineral or other inorganic material, fewer measurements were recorded. Analytical results are given in tables 1 and 2.

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p no.	API	Operator	Well name	Tnsp.	Rng.	Sec.	Sample type	Lith.	Top depth	Bottom depth	Formation	%R_o	n
1	4902920489	American Quasar	1 Sellers Draw	48N	98W	21	cuttings	shale	16,500	16,550	Cody	1.40	4
1	4902920489	American Quasar	1 Sellers Draw	48N	98W	21	cuttings	shale	17,000	17,050	Cody	1.73	5
1	4902920489	American Quasar	1 Sellers Draw	48N	98W	21	cuttings	shale	17,500	17,550	Cody	1.00	7
1	4902920489	American Quasar	1 Sellers Draw	48N	98W	21	cuttings	shale	18,000	18,050	Cody	1.17	8
1	4902920489	American Quasar	1 Sellers Draw	48N	98W	21	cuttings	shale	18,500	18,550	Cody	1.53	15
1	4902920489	American Quasar	1 Sellers Draw	48N	98W	21	cuttings	shale	19,000	19,050	Frontier	1.68	13
1	4902920489	American Quasar	1 Sellers Draw	48N	98W	21	cuttings	shale	19,520	19,540	Mowry	1.72	9
1	4902920489	American Quasar	1 Sellers Draw	48N	98W	21	cuttings	shale	19,740	19,770	Cloverly	1.24	15
1	4902920489	American Quasar	1 Sellers Draw	48N	98W	21	cuttings	shale	20,000	20,040	Cloverly	1.60	10
2	4900320574	Santa Fe Energy	1-20 Tatman Mtn.	49N	96W	20	cuttings	shale	12,800	12,850	Cody	1.43	3
2	4900320574	Santa Fe Energy	1-20 Tatman Mtn.	49N	96W	20	cuttings	shale	13,000	13,050	Cody	1.31	9
2	4900320574	Santa Fe Energy	1-20 Tatman Mtn.	49N	96W	20	cuttings	shale	13,500	13,550	Cody	1.38	2
2	4900320574	Santa Fe Energy	1-20 Tatman Mtn.	49N	96W	20	cuttings	shale	14,000	14,050	Cody	1.60	7
2	4900320574	Santa Fe Energy	1-20 Tatman Mtn.	49N	96W	20	cuttings	shale	14,500	14,550	Cody	1.68	15
2	4900320574	Santa Fe Energy	1-20 Tatman Mtn.	49N	96W	20	cuttings	shale	14,710	14,760	Frontier	1.68	10
2	4900320574	Santa Fe Energy	1-20 Tatman Mtn.	49N	96W	20	cuttings	shale	15,000	15,050	Frontier	1.75	7
2	4900320574	Santa Fe Energy	1-20 Tatman Mtn.	49N	96W	20	cuttings	shale	15,500	15,550	Mowry	1.67	8
2	4900320574	Santa Fe Energy	1-20 Tatman Mtn.	49N	96W	20	cuttings	shale	15,900	15,940	Cloverly	1.82	11
3	4902921064	Forest Oil	1 Emblem Bench	51N	98W	2	cuttings	shale	15,000	15,040	Cody	0.82	3
3	4902921064	Forest Oil	1 Emblem Bench	51N	98W	2	cuttings	shale	15,500	15,550	Cody	0.94	6
3	4902921064	Forest Oil	1 Emblem Bench	51N	98W	2	cuttings	shale	16,000	16,050	Cody	1.22	8
3	4902921064	Forest Oil	1 Emblem Bench	51N	98W	2	cuttings	shale	16,500	16,550	Cody	1.20	6
3	4902921064	Forest Oil	1 Emblem Bench	51N	98W	2	cuttings	shale	17,000	17,050	Frontier	1.51	8
3	4902921064	Forest Oil	1 Emblem Bench	51N	98W	2	cuttings	shale	17,450	17,480	Frontier	1.19	7
3	4902921064	Forest Oil	1 Emblem Bench	51N	98W	2	cuttings	shale	18,000	18,050	Mowry	1.53	13
3	4902921064	Forest Oil	1 Emblem Bench	51N	98W	2	cuttings	shale	18,270	18,320	Cloverly	1.69	16
4	4902920532	Texas Pacific	Red Point II Unit 1	53N	98W	30	cuttings	coal	4,680	4,780	Willwood (?)	0.59	25
4	4902920532	Texas Pacific	Red Point II Unit 1	53N	98W	30	cuttings	coal	5,540	5,600	Fort Union	0.56	25
4	4902920532	Texas Pacific	Red Point II Unit 1	53N	98W	30	cuttings	coal	7,410	7,480	Fort Union	0.63	25
4	4902920532	Texas Pacific	Red Point II Unit 1	53N	98W	30	cuttings	coal	9,120	9,220	Fort Union	0.56	25
4	4902920532	Texas Pacific	Red Point II Unit 1	53N	98W	30	cuttings	coal	10,900	10,960	Fort Union	0.70	27
4	4902920532	Texas Pacific	Red Point II Unit 1	53N	98W	30	cuttings	coal	11,380	11,430	Fort Union	0.74	25
4	4902920532	Texas Pacific	Red Point II Unit 1	53N	98W	30	cuttings	coal	11,770	11,790	Fort Union	0.76	25
4	4902920532	Texas Pacific	Red Point II Unit 1	53N	98W	30	cuttings	coal	11,940	12,000	Lance	0.79	25
4	4902920532	Texas Pacific	Red Point II Unit 1	53N	98W	30	cuttings	coal	13,600	13,640	Lance	0.97	25
4	4902920532	Texas Pacific	Red Point II Unit 1	53N	98W	30	cuttings	coal	13,800	13,840	Meeteetse	1.00	15
4	4902920532	Texas Pacific	Red Point II Unit 1	53N	98W	30	cuttings	coal	14,890	14,960	Mesaverde	1.14	19
4	4902920532	Texas Pacific	Red Point II Unit 1	53N	98W	30	cuttings	coal	15,480	15,520	Mesaverde	1.28	19
4	4902920532	Texas Pacific	Red Point II Unit 1	53N	98W	30	cuttings	shale	15,960	16,060	Cody	1.48	4
4	4902920532	Texas Pacific	Red Point II Unit 1	53N	98W	30	cuttings	shale	16,500	16,580	Cody	1.63	13
4	4902920532	Texas Pacific	Red Point II Unit 1	53N	98W	30	cuttings	shale	17,000	17,080	Cody	1.69	21
4	4902920532	Texas Pacific	Red Point II Unit 1	53N	98W	30	cuttings	shale	17,500	17,550	Cody	1.74	15
4	4902920532	Texas Pacific	Red Point II Unit 1	53N	98W	30	cuttings	shale	17,810	17,870	Frontier	1.77	13

1. Vitrinite reflectance (Ro) data and locations for cuttings samples from wells drilled for oil and gas exploration and production in the Bighorn Basin, north-central Wyoming and south-central ana. Map no. refers to numbers plotted in figure 1.—Continued

well number assigned by American Petroleum Institute; Tsp., township; Rng., range; Sec., section; Lith., lithology; n, number of readings per sample. Queried (?) where uncertain. Depth is in feet.]

p no.	API	Operator	Well name	Tnsp.	Rng.	Sec.	Sample type	Lith.	Top depth	Bottom depth	Formation	%R_o	n
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	5,430	5,550	Fort Union	0.52	25
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	6,870	6,960	Fort Union	0.62	25
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	7,350	7,470	Fort Union	0.61	25
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	8,070	8,110	Fort Union	0.63	27
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	8,150	8,190	Fort Union	0.64	25
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	8,510	8,550	Fort Union	0.59	25
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	8,830	8,910	Fort Union	0.72	25
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	9,360	9,430	Fort Union	0.70	25
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	9,760	9,840	Fort Union	0.62	29
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	10,000	10,070	Fort Union	0.69	25
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	10,720	10,780	Fort Union	0.81	25
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	11,060	11,140	Fort Union	0.74	25
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	11,580	11,620	Fort Union	0.74	25
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	12,120	12,170	Fort Union	0.82	25
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	12,600	12,630	Lance	0.79	25
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	12,880	12,950	Lance	0.65	17
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	13,470	13,560	Lance	0.64	25
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	13,730	13,780	Lance	0.99	25
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	14,000	14,050	Meeteetse	1.05	15
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	14,440	14,520	Meeteetse	0.75	15
5	4902920787	Husky Oil	14-25 Unit	53N	99W	25	cuttings	coal	15,480	15,540	Mesaverde	1.12	25
6	4902920475	CIG Exploration	1McCulloch Peak	54N	101W	10	cuttings	shale	11,660	11,690	Cody	0.75	7
6	4902920475	CIG Exploration	1McCulloch Peak	54N	101W	10	cuttings	shale	12,000	12,050	Cody	1.10	12
6	4902920475	CIG Exploration	1McCulloch Peak	54N	101W	10	cuttings	shale	12,500	12,550	Cody	0.99	9
6	4902920475	CIG Exploration	1McCulloch Peak	54N	101W	10	cuttings	shale	13,000	13,050	Cody	1.12	8
6	4902920475	CIG Exploration	1McCulloch Peak	54N	101W	10	cuttings	shale	13,500	13,550	Cody	1.07	18
6	4902920475	CIG Exploration	1McCulloch Peak	54N	101W	10	cuttings	shale	14,170	14,190	Frontier	1.18	9
6	4902920475	CIG Exploration	1McCulloch Peak	54N	101W	10	cuttings	shale	15,200	15,225	Cloverly	1.31	21

Table 2. Vitrinite reflectance (Ro) data and locations for samples collected from outcrops in the Bighorn Basin, north-central Wyoming and south-central Montana.

[Map no. refers to numbers plotted in figure 1. Lith., lithology; n, number of readings per sample. Queried (?) where uncertain.]

Map no.	Latitude	Longitude	Sample type	Lith.	Formation	$\%R_o$	n
1	43.84427	-107.53406	outcrop	coal	Fort Union	0.37	28
2	44.11637	-108.78875	outcrop	coal	Meeteetse	0.36	25
3	44.46481	-109.03073	outcrop	shale	Frontier(?)	0.56	5
4	44.30424	-108.92427	outcrop	coal	Meeteetse	0.36	26
5	44.27300	-108.87899	outcrop	coal	Fort Union	0.36	26
6	44.06968	-108.75522	outcrop	carb shale	Mesaverde	0.27	2
7	43.99319	-108.63836	outcrop	carb shale	Meeteetse(?)	0.69	8
8	43.91672	-108.52686	outcrop	coal	Meeteetse(?)	0.35	22
9	43.84570	-108.35965	outcrop	coal	Meeteetse(?)	0.38	26
10	43.79930	-108.29036	outcrop	coal	Mesaverde	0.42	22
11	44.27370	-107.87090	outcrop	coal	Meeteetse(?)	0.37	22
12	44.59260	-108.20030	outcrop	coal	Fort Union	0.96	18
13	44.78702	-108.64310	outcrop	coal	Lance	0.35	32
14	45.15844	-109.18591	outcrop	coal	Fort Union	0.42	26
15	44.72590	-109.21809	outcrop	coal	Mesaverde	0.34	26

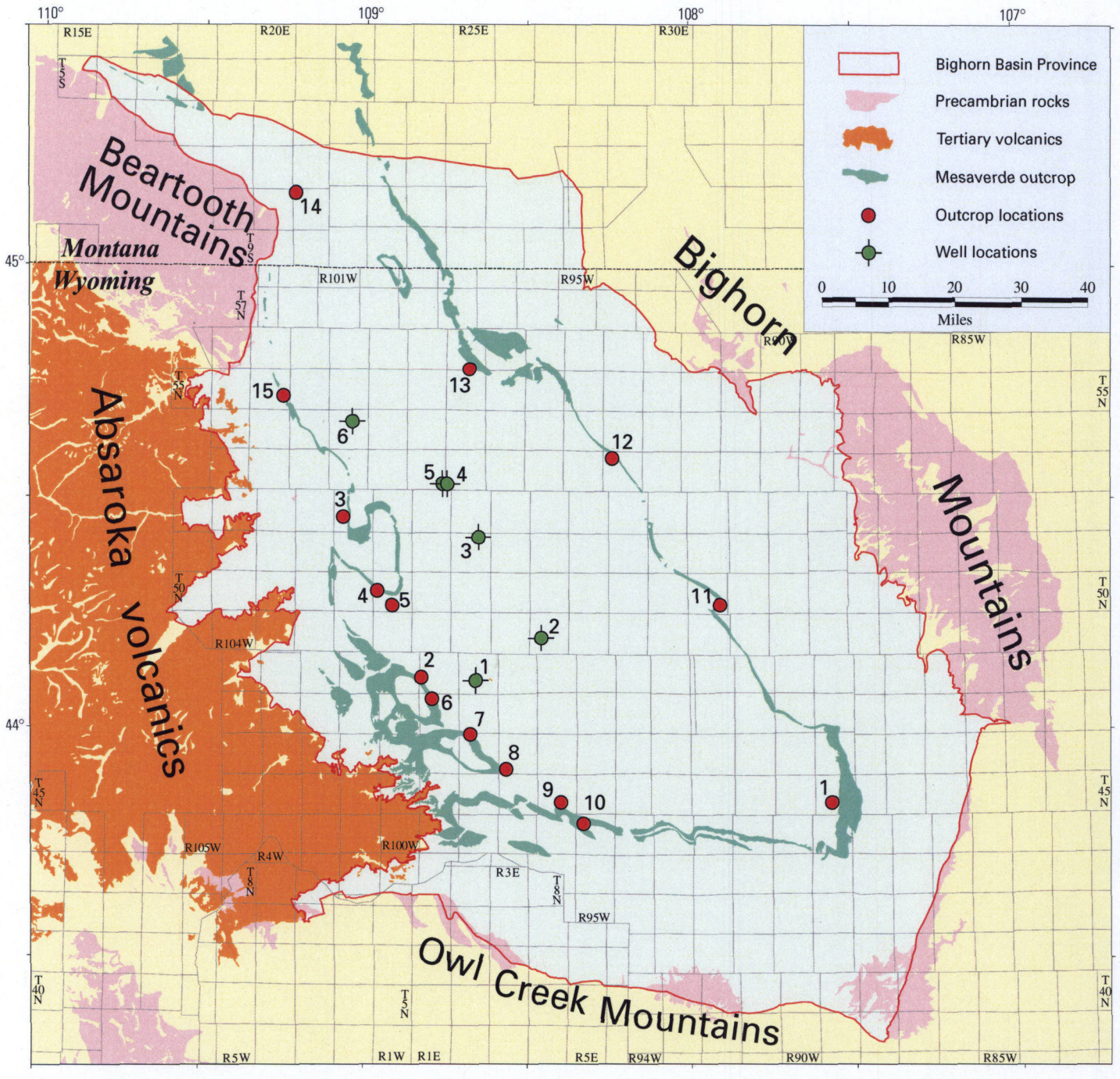

Figure 1. Map showing general outline of the Bighorn Basin, bordering mountain ranges, distribution of major rock units, and sample localities. Numbers refer to column 1 (map no.) in tables 1 and 2.

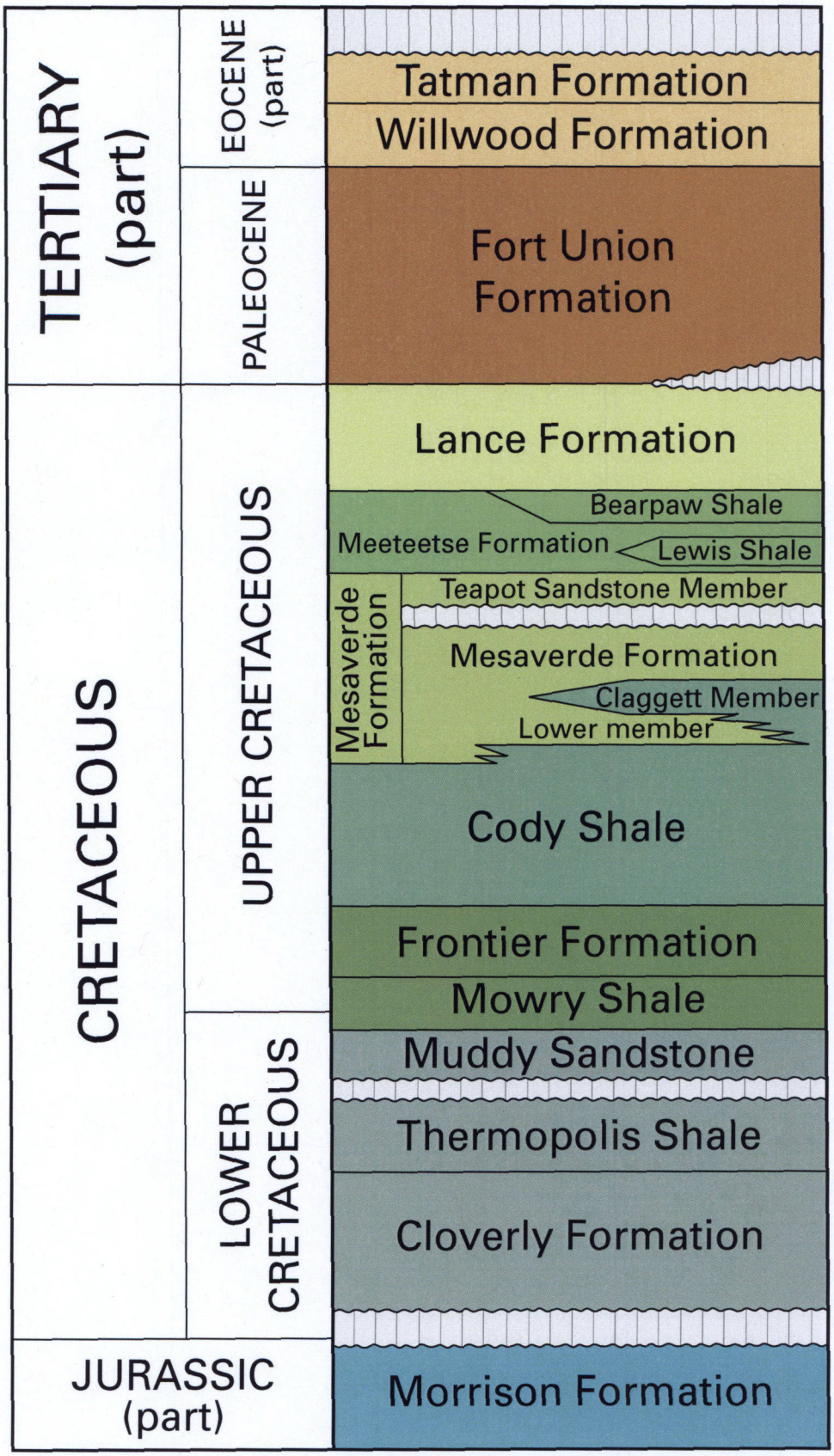

Figure 2. Generalized stratigraphic chart of uppermost Jurassic, Cretaceous and lower Tertiary rocks in the Bighorn Basin.