Datashare 85

Sedimentology, facies architecture, and sequence stratigraphy of a Mississippian black mudstone succession—The upper member of the Bakken Formation, North Dakota, United States

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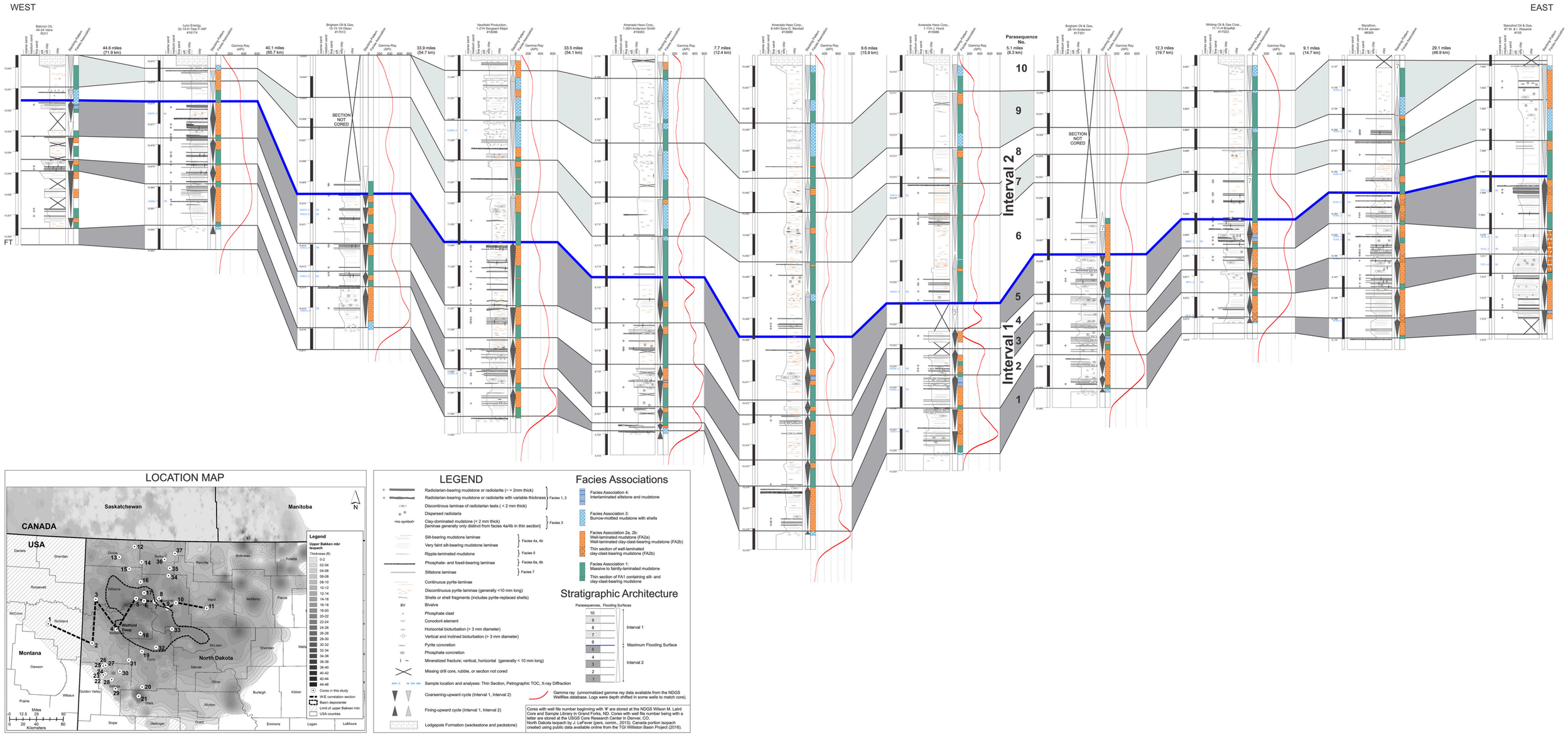
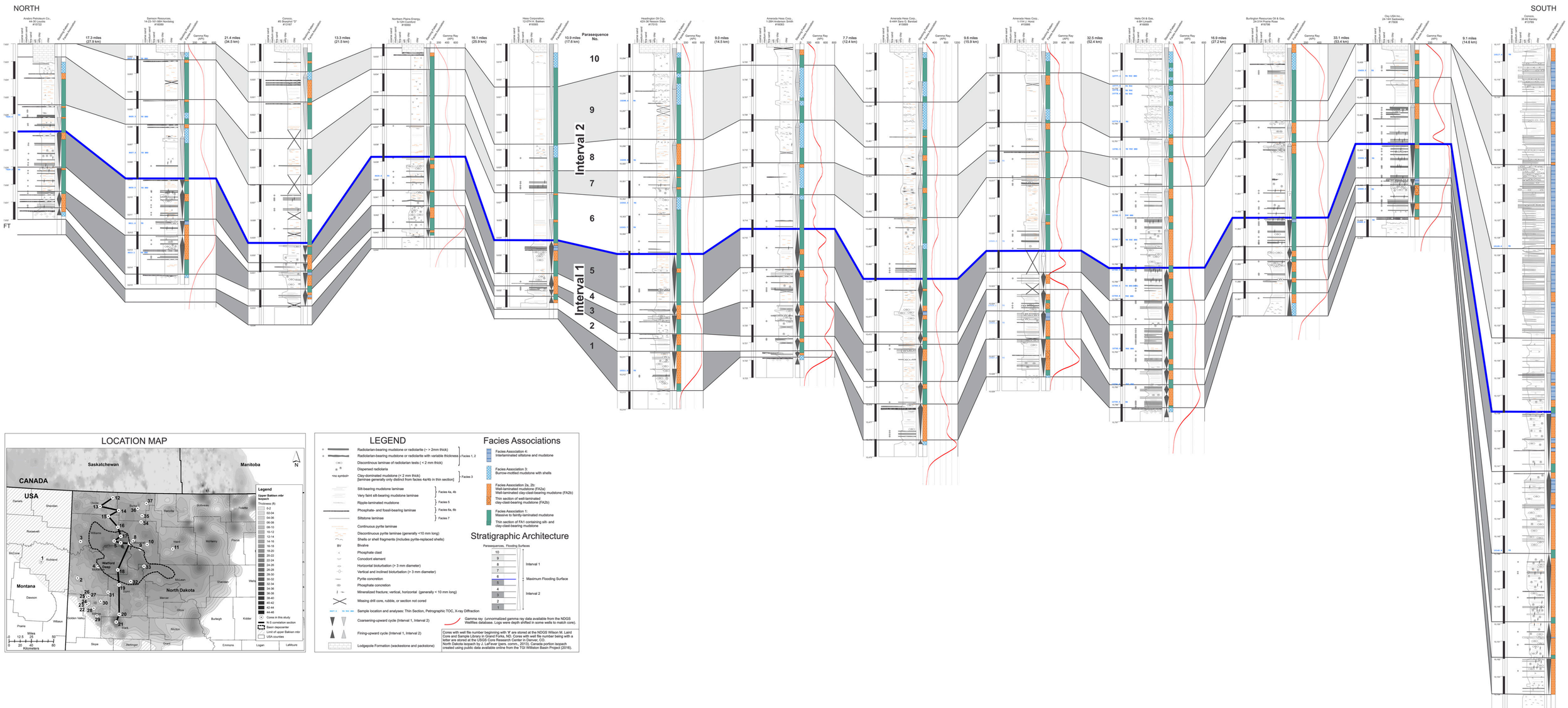


Appendix 1. West–east correlation section from eastern Montana to central North Dakota through the upper Bakken member of the Bakken Formation, Williston Basin



LOCATION MAP

LEGEND

- Radiolarian-bearing mudstone or radiolarite (~ > 2mm thick)
- Radiolarian-bearing mudstone or radiolarite with variable thickness } Facies 1, 2
- Discontinuous laminae of radiolarian tests (< 2 mm thick)
- Dispersed radiolaria
- Clay-dominated mudstone (< 2 mm thick) [laminae generally only distinct from facies 4a/4b in thin section] } Facies 3
- Silt-bearing mudstone laminae
- Very faint silt-bearing mudstone laminae } Facies 4a, 4b
- Ripple-laminated mudstone } Facies 5
- Phosphate- and fossil-bearing laminae } Facies 6a, 6b
- Siltstone laminae } Facies 7
- Continuous pyrite laminae
- Discontinuous pyrite laminae (generally <10 mm long)
- Shells or shell fragments (includes pyrite-replaced shells)
- BV Bivalve
- Phosphate clast
- Conodont element
- Horizontal bioturbation (> 3 mm diameter)
- Vertical and inclined bioturbation (> 3 mm diameter)
- Pyrite concretion
- Phosphate concretion
- Mineralized fracture; vertical, horizontal (generally < 10 mm long)
- Missing drill core, rubble, or section not cored
- Sample location and analyses: Thin Section, Petrographic TOC, X-ray Diffraction
- Coarsening-upward cycle (Interval 1, Interval 2)
- Fining-upward cycle (Interval 1, Interval 2)
- Lodgepole Formation (wackestone and packstone)

Gamma ray (unnormalized gamma ray data available from the NDGS WellRes database. Logs were depth shifted in some wells to match cores).

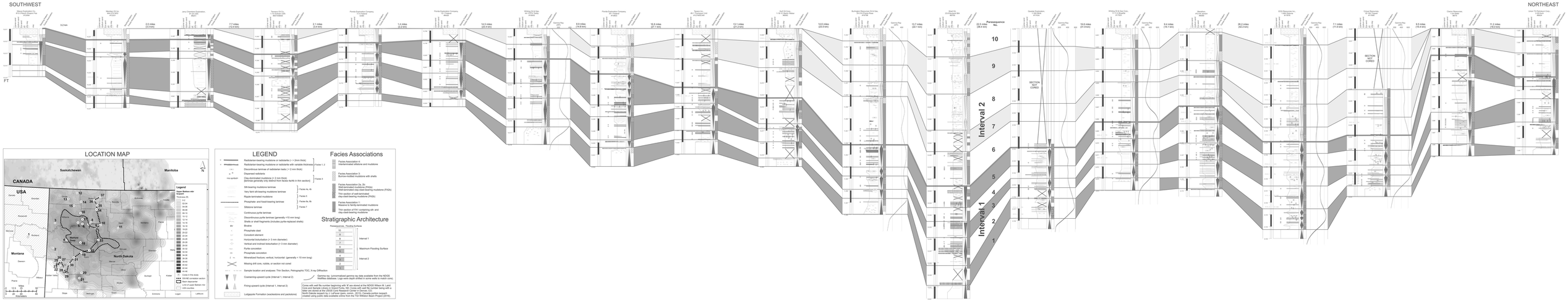
Cores with well file number beginning with 'F' are stored at the NDGS Wilson M. Laird Core and Sample Library in Grand Forks, ND. Cores with well file number being with a '1' are stored at the NDGS Subsurface Geology Core Library in North Dakota lasjarch by J. LeFever (pers. comm., 2013). Canada portion lacjeach created using public data available online from the TGI Williston Basin Project (2016).

Facies Associations

- Facies Association 4: Interlaminated siltstone and mudstone
- Facies Association 3: Burrow-mottled mudstone with shells
- Facies Association 2a, 2b: Well-laminated mudstone (FA2a) Well-laminated clay-clast-bearing mudstone (FA2b)
- Thin section of well-laminated clay-clast-bearing mudstone (FA2b)
- Facies Association 1: Massive to faintly-laminated mudstone
- Thin section of FA1 containing silt- and clay-clast-bearing mudstone

Stratigraphic Architecture

Appendix 2. North–south correlation section through the North Dakota portion of the upper Bakken member, Bakken Formation, Williston Basin



Appendix 3. Southwest–northeast correlation section through the North Dakota portion of the upper Bakken member, Bakken Formation

Appendix 4. X-Ray Diffraction Analyses for Samples from the Upper Shale Member of the Bakken Formation Grouped by Rock Type

Well Name	Well File No. (NDGS/CRC)	Sample No.	Approx. Depth (ft)	Facies Association or Facies	Quartz (wt %)	K-Feldspar (wt %)	Albite (wt %)	Calcite (wt %)	Dolomite (wt %)	Total Carb	Siderite (wt %)	Pyrite (wt %)	Sphalerite (wt %)	1M Illite R>3 (wt %)	Fe-Chlorite (wt %)	2M1 Illite / Muscovite (wt %)	Total (wt %)
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048B-1	11048.2	FA2a	60	10	2	1	6	6	0	3	0	8	3	8	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048B-6	11048.27	FA2a	55	15	2	1	5	5	0	2	0	14	0	6	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048B-7	11048.3	FA2a	62	10	2	0	4	4	0	3	0	10	2	7	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048(C) 1 #1	11048.35	FA2a	62	11	2	0	4	4	0	2	0	10	1	9	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048C(1)-2	11048.5	FA2a	51	13	2	0	6	6	0	3	1	16	1	10	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048C(1)-3	11048.52	FA2a	57	12	2	0	6	6	0	1	1	12	1	9	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048D #1	11048.6	FA2a	59	10	1	1	4	4	0	3	0	12	1	9	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048D #8	11048.77	FA2a	64	9	1	0	5	5	0	2	0	9	0	8	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11049B-2	11049.4	FA2a	73	6	1	0	3	3	0	2	0	10	3	2	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11049C-1	11049.5	FA2a	39	15	1	1	5	6	0	6	0	16	4	12	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11049C-2	11049.55	FA2a	47	5	1	1	3	4	0	22	0	11	2	8	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11049C-5	11049.7	FA2a	41	14	1	1	4	5	0	7	0	16	3	12	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11049C-6	11049.8	FA2a	35	14	2	1	5	6	0	4	0	21	6	11	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	1.10E+03	11049.9	FA2a	46	13	1	1	4	5	0	3	0	17	5	9	100
WHITING OIL AND GAS CORP., 1-23 BN	B832	10352A #1	uncertain	FA2a	22	14	2	0	9	9	1	5	0	21	13	12	100
WHITING OIL AND GAS CORP., 1-23 BN	B832	10354E(1) #2	uncertain	FA2a	52	9	0	1	4	5	0	2	16	11	4	2	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048B-2	11048.2	RBM	63	7	1	2	4	6	0	10	0	8	1	4	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048B-5	11048.24	RBM	62	11	2	1	4	4	0	3	1	12	0	6	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048(C) 2 #1	11048.4	RBM	61	9	1	2	3	6	0	6	1	8	2	6	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048(C) 3	11048.42	RBM	62	6	2	1	3	3	0	4	10	8	0	5	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048C-5	11048.46	RBM	70	12	2	0	3	3	0	0	1	11	1	0	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048C-6	11048.48	RBM	73	7	1	1	4	4	0	2	1	7	0	4	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048C(2)-1	11048.54	RBM	54	12	1	3	3	6	0	5	3	11	1	6	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048C(2)-3	11048.56	RBM	58	8	1	1	4	5	0	0	9	11	3	5	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048C(2)-6	11048.58	RBM	75	8	1	2	2	4	0	0	2	8	0	2	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048D #2	11048.62	RBM	67	8	1	1	3	4	0	7	2	8	0	4	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048D #7	11048.74	RBM	71	6	1	0	3	3	0	5	1	8	0	5	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	1.10E+03	11048.8	RBM	63	10	2	1	3	4	0	0	1	14	0	5	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	1.10E+02	11048.81	RBM	76	7	1	0	2	3	0	0	1	10	0	2	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	1.10E-01	11048.85	RBM	63	11	2	2	3	5	0	0	3	10	2	4	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	1.10E-02	11048.87	RBM	66	11	2	0	3	4	0	1	1	11	0	5	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	1.10E-03	11048.9	RBM	75	7	1	0	2	2	0	2	0	6	1	6	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11049B-3	11049.45	RBM	70	5	1	0	4	4	0	3	0	10	4	2	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11049C-3	11049.6	RBM	62	4	0	0	2	3	0	18	0	8	0	5	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11049C-4	11049.65	RBM	61	7	0	1	2	3	0	15	0	8	0	5	100
WHITING OIL AND GAS CORP., 1-23 BN	B832	10352D #1	uncertain	RBM	76	4	1	0	2	2	0	2	10	6	0	0	100
WHITING OIL AND GAS CORP., 1-23 BN	B832	10352D #2	uncertain	RBM	75	5	0	0	2	2	0	1	4	8	4	0	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048B-3	11048.3	RAD	77	4	1	0	3	3	0	2	0	7	0	4	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048B-4	11048.22	RAD	81	4	1	0	3	3	0	2	0	6	0	3	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048C-4	11048.44	RAD	76	6	1	5	2	6	0	1	6	3	0	1	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048D #3	11048.64	RAD	88	3	1	2	1	3	0	1	0	3	0	1	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048D #4	11048.66	RAD	84	6	1	5	1	6	0	0	0	4	0	0	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048D #5	11048.68	RAD	90	2	0	4	1	5	0	1	0	1	0	0	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048D #6	11048.7	RAD	84	6	1	0	1	2	0	0	1	7	0	0	100
TEXACO INC., #5 THOMPSON UNIT	12748 / E349	11048E	11048.83	RAD	83	3	1	0	2	2	0	1	2	5	0	3	100

Detrital quartz and carbonate determined by visual estimations from petrographic analysis.
Abbreviations: Fe = iron; RAD = radiolarite; RBM = radiolarian-bearing mudstone; wt %, weight percent.

Appendix 5. X-Ray Diffraction Analyses for Samples from the Upper Shale Member of the Bakken Formation, Grouped by Well Name

#16089, Samson Resources, 14-23-161-98H Nordstog

Sample name:	Depth (ft)	Facies Association or Facies	NON-CLAYS	Quartz	Chert (13.1 nm)	Total Quartz	Kspar (intermediate microcline)	Kspar (sanidine)	Plagioclase (albite, var. cleavelandite)	Total Feldspar	Calcite	Dolomite	Ankerite	Total Carbonate	Pyrite	Gypsum	Bassanite	Gypsum	Total non-clays	CLAYS	Kaolinite (disordered)	Illite (1Md)	Illite (2M1; SG4)	Chlorite (Fe-rich; Tuscaloosa Formation)	Total clays	TOTAL
16089-8602.3	8602.3	FA1		4.39	19.82	24.21	8.68	4.94	2.06	15.68	1.82	2.26	2.98	7.06	4.13	0.28	1.16	1.42	52.52		1.26	32.72	9.30	4.20	47.48	100.00
16089-8605.5	8605.5	FA1		6.53	17.17	23.69	7.25	4.67	1.76	13.68	0.10	1.60	2.36	4.06	7.05	0.43	1.17	1.57	50.08		1.76	33.13	9.41	5.62	49.92	100.00
16089-8607.5	8607.5	FA1		10.37	22.76	33.13	5.93	4.93	2.29	13.15	1.81	2.68	2.74	7.23	11.35	0.76	0.79	1.53	66.42		1.22	22.48	5.14	4.74	33.58	100.00
16089-8609.5	8609.5	FA1		7.51	29.82	37.34	6.68	4.55	2.22	13.46	0.00	1.15	2.33	3.48	6.13	0.24	1.19	1.41	61.84		1.16	24.67	6.31	6.02	38.16	100.00
16089-8613.1	8613.2	FA1		3.81	26.80	30.61	7.55	5.58	1.73	14.86	0.00	1.53	1.76	3.29	7.33	0.68	1.18	1.84	57.95		1.91	29.40	4.57	6.17	42.05	100.00

#16689, Helis Oil & Gas, 4-8H Linseth

Sample name:			NON-CLAYS	Quartz	Chert (13.1 nm)	Total Quartz	Kspar (intermediate microcline)	Kspar (sanidine)	Plagioclase (albite, var. cleavelandite)	Total Feldspar	Calcite	Dolomite	Ankerite	Total Carbonate	Pyrite	Gypsum	Bassanite	Gypsum	Total non-clays	CLAYS	Kaolinite (disordered)	Illite (1Md)	Illite (2M1; SG4)	Chlorite (Fe-rich; Tuscaloosa Formation)	Total clays	TOTAL
16689-10777.3	10777.3	FA1		12.57	14.30	26.87	6.66	2.91	1.92	11.49	4.46	5.10	4.39	13.95	2.87	0.29	1.12	1.39	56.57		0.82	28.16	8.59	5.87	43.43	100.00
16689-10781.5	10781.5	FA1		9.85	17.87	27.72	5.14	1.61	1.96	8.72	0.73	3.03	2.55	6.31	8.62	0.75	0.67	1.41	52.78		0.71	27.45	11.96	7.09	47.22	100.00
16689-10785.3	10785.3	FA1		12.71	29.58	42.29	3.74	2.67	2.12	8.52	0.00	1.38	1.74	3.12	4.78	0.21	0.94	1.13	59.87		2.04	26.85	7.62	3.62	40.13	100.00
16689-10789.8	10789.8	FA1		15.14	34.60	49.73	4.87	2.90	1.95	9.72	0.00	1.28	1.32	2.60	4.52	0.49	0.78	1.26	67.84		1.71	21.60	4.65	4.20	32.16	100.00
16689-10792.8	10792.8	FA1		19.07	38.88	57.95	4.06	3.13	1.43	8.62	0.00	2.22	0.80	3.02	5.06	0.30	0.69	0.98	75.64		1.10	16.20	4.21	2.86	24.36	100.00
16689-10794.9	10794.9	FA1		9.27	25.05	34.31	5.38	3.90	1.73	11.02	1.02	2.70	2.10	5.82	12.26	0.69	0.77	1.44	64.86		0.87	20.94	7.88	5.45	35.14	100.00
16689-10786.7	10786.7	FA2a		26.69	43.41	70.10	3.62	1.17	1.00	5.78	0.95	1.39	2.70	5.04	3.44	0.11	0.52	0.63	85.01		1.25	11.67	1.08	0.99	14.99	100.00
16689-10788.3	10788.3	Facies 2		16.12	38.43	54.55	4.93	1.87	1.67	8.47	0.25	1.08	1.03	2.36	10.20	0.74	0.41	1.14	76.73		1.26	14.70	5.25	2.06	23.27	100.00
16689-10789.3	10789.3	Facies 1		11.84	1.79	13.63	5.44	0.56	1.11	7.12	0.09	0.67	0.32	1.08	63.94	1.53	0.54	2.06	87.85		2.03	6.70	0.00	3.42	12.15	100.00

#17676, EOG, 1-06H Sidonia

Sample name:			NON-CLAYS	Quartz	Chert (13.1 nm)	Total Quartz	Kspar (intermediate microcline)	Kspar (sanidine)	Plagioclase (albite, var. cleavelandite)	Total Feldspar	Calcite	Dolomite	Ankerite	Total Carbonate	Pyrite	Gypsum	Bassanite	Gypsum	Total non-clays	CLAYS	Kaolinite (disordered)	Illite (1Md)	Illite (2M1; SG4)	Chlorite (Fe-rich; Tuscaloosa Formation)	Total clays	TOTAL
17676-8718.7	8718.7	FA1		4.64	16.59	21.23	6.44	4.84	2.54	13.83	1.81	1.45	3.45	6.71	7.12	0.78	1.69	2.44	51.35		2.72	34.06	6.32	5.55	48.65	100.00
17676-8720.4	8720.4	FA1		9.15	22.04	31.19	6.69	5.01	2.27	13.97	0.01	0.67	1.56	2.24	7.58	0.93	1.25	2.15	57.15		2.39	30.82	4.60	5.04	42.85	100.00
17676-8723.4	8723.4	FA1		13.58	45.50	59.08	4.07	4.93	1.45	10.45	0.37	0.63	1.03	2.04	3.61	0.31	0.67	0.97	76.16		1.27	17.46	3.35	1.76	23.84	100.00
17676-8725.8	8725.8	FA1		9.21	37.86	47.06	5.07	3.37	1.96	10.41	0.21	0.92	0.53	1.66	4.15	0.50	1.84	2.31	65.62		2.12	24.14	2.76	5.35	34.38	100.00
17676-8728.8	8728.8	FA1		12.76	36.41	49.17	4.53	3.68	1.92	10.12	0.07	0.81	1.21	2.09	5.03	0.74	0.68	1.41	67.84		1.59	21.23	5.85	3.49	32.16	100.00
17676-8732.4	8732.4	FA1		10.56	43.63	54.19	4.33	2.94	1.81	9.08	0.86	2.25	1.33	4.44	5.06	0.52	1.64	2.13	74.93		2.03	20.25	0.00	2.79	25.07	100.00
17676-8777.7	dup (8718.7)			4.63	17.34	21.98	6.86	4.22	2.41	13.49	1.57	1.86	2.73	6.16	6.90	0.79	1.43	2.20	50.75		2.54	33.71	6.56	6.45	49.25	100.00
17676-8731.4	8731.4	FA2b		9.50	44.97	54.47	5.15	3.87	1.64	10.66	0.00	2.44	1.62	4.05	4.61	0.66	0.65	1.29	75.11		1.51	16.82	4.12	2.44	24.89	100.00

Abbreviations: FA1 = massive to faintly laminated mudstone; FA2a = well-laminated mudstone; FA2b = well-laminated, clay-clast-bearing mudstone.

Appendix 6. Petrographic Total Organic Carbon, Rock-Eval Pyrolysis and Whole-Rock Vitrinite Reflectance Analyses Analysis by Weatherford Laboratories, Shenandoah, Texas

Helis Oil & Gas, 4-8H Linseth															
NDGS Well File No.	Depth (ft)	Facies Association or Facies	TOC (wt %)	S1	S2	S3	Tmax	Measured Petrographic % R0	HI	OI	S2/S3	S1/TOC x100	PI
16689	10777.3	FA1	7.21										
16689	10777.8	FA3	5.11	5.63	9.80	0.41	446.00	0.81	191.67	8.02	23.90	110.11	0.36
16689	10778.1	FA3	7.44										
16689	10778.4	FA1	7.99										
16689	10785.3	FA1	9.52										
16689	10781.5	FA1	9.90										
16689	10788.3	RBM	9.44										
16689	10786.7	FA2a	8.64										
16689	10789.3	RAD	3.09										
16689	10789.8	FA1	11.10										
16689	10792.8	FA1	10.60										
16689	10794.9	FA1	11.45										
16689	10799.9	Duplicate of 10785.3	9.51										

Abbreviations: FA1 = massive to faintly laminated mudstone; FA2a = well-laminated mudstone; FA3 = burrow-mottled mudstone with shells; RAD = Radiolarite (facies 1); RBM = Radiolarian-bearing mudstone (facies 2).