Test Results

Paleomagnetic Orientation of Natural Fractures in Ireton, Duvernay, & Majeau Lake Core from COPRC 100 HZ Twock 14-11-63-17

Prepared for
ConocoPhillips Canada

May 2014

APPLIED PALEOMAGNETICS, INC.

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by
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and
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TABLE OF CONTENTS

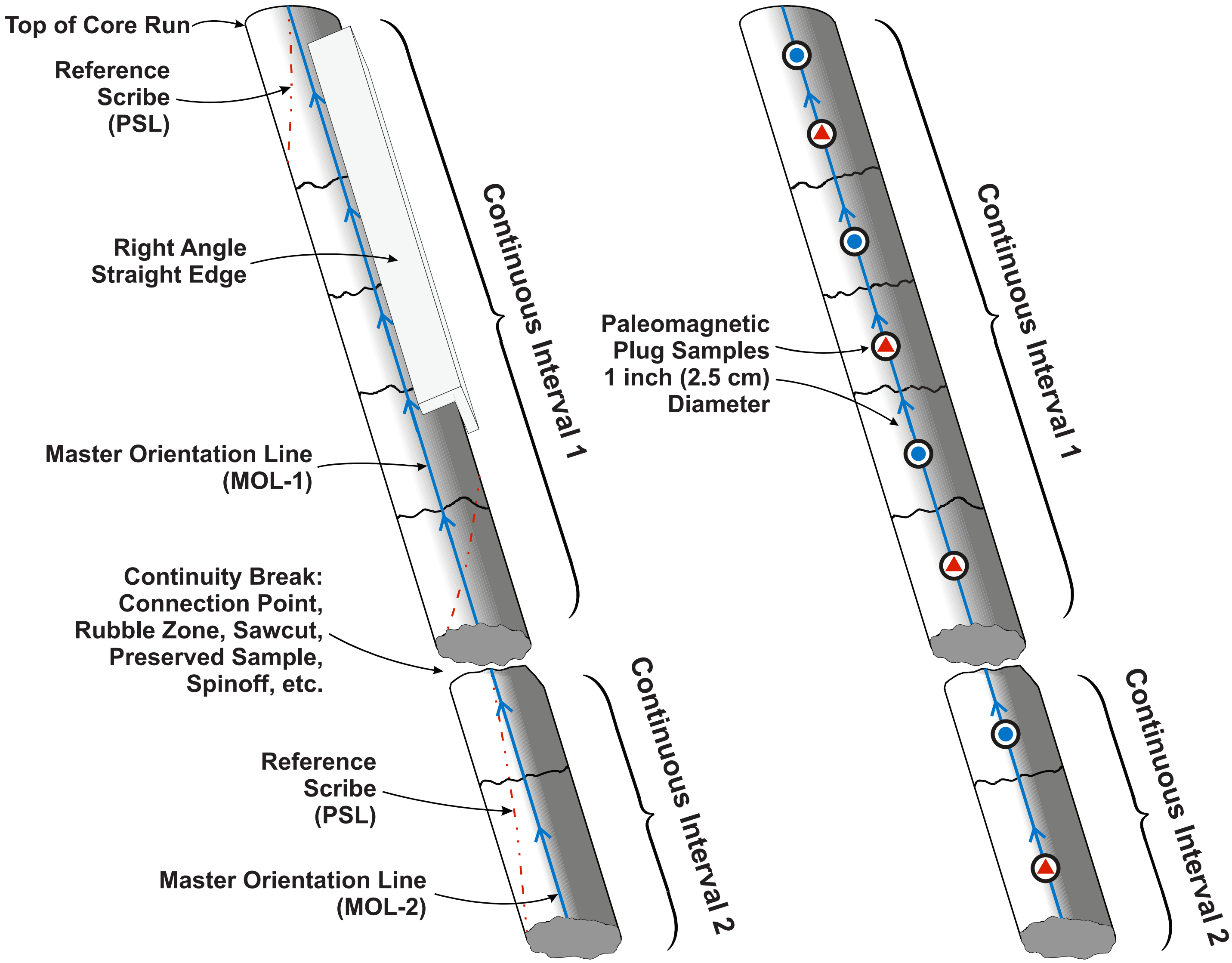
Figure 1: Methodology of the paleomagnetic core-orientation technique.

Figure 2: Combined rose diagram and stereographic projection summarizing paleomagnetic orientations of natural fractures in 6 intervals of Ireton, Duvernay, & Majeau Lake Fm. core from COPRC 100 HZ Twock 14-11-63-17.

Table 1: Paleomagnetic orientation of the Master Orientation Line in the 6 intervals of Ireton, Duvernay, & Majeau Lake core.

Table 2: Paleomagnetic orientations of natural fractures & bedding in the 6 intervals of Ireton, Duvernay, & Majeau Lake core.

Methodology of the Paleomagnetic Core-Orientation Technique

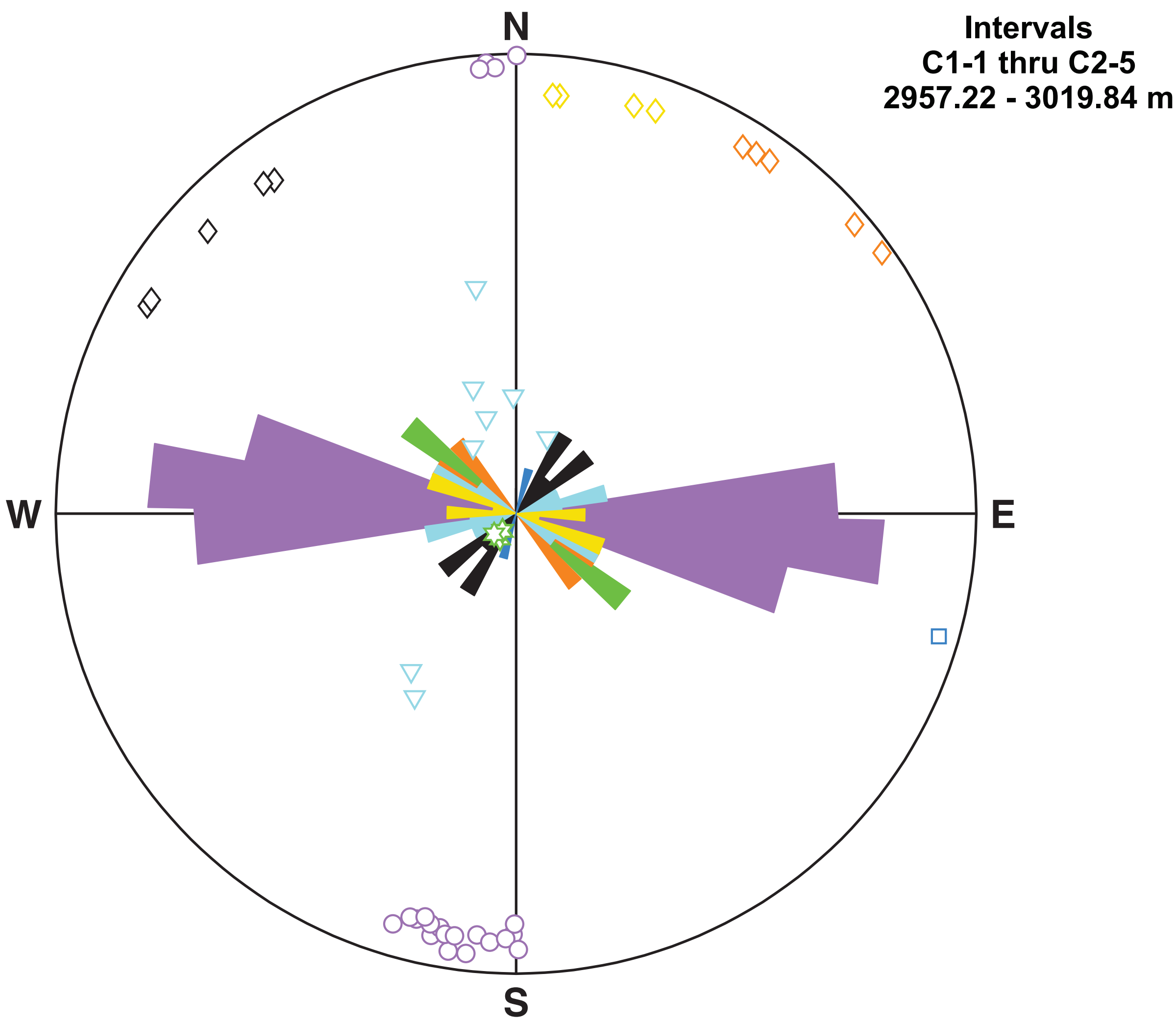


Step 1. Reconstruct the core into "continuous intervals" and mark the "Master Orientation Line" (MOL), which is a known straight line. In contrast, the Principal Scribe Line (PSL) rotates relative to the MOL. The PSL is only present if the core has been scribed and oriented using the downhole "multishot" core-orientation technique.

Step 2. Drill a suite of paleomagnetic plugs using our "antiparallel plug technique." Half the plugs (blue dots) are drilled into the MOL, and the other half of the plugs (red triangles) are drilled opposite the MOL.

Figure 1. Methodology of the paleomagnetic core-orientation technique as developed by Applied Paleomagnetics, Inc. After reconstructing the core into "continuous intervals" and marking the Master Orientation Line (MOL), fracture and bedding orientations are measured relative to the MOL. Next, we drill a suite of 4 to 6 "antiparallel" paleomagnetic plugs per interval, and the plugs are shipped to the Applied Paleomagnetics lab in Santa Cruz, California. At our lab, we use our cryogenic magnetometer to measure magnetic signals recorded in the plugs to determine the orientation of the MOL (Table 1) and fractures and bedding (Table 2) relative to North.

Paleomagnetically Oriented Natural Fractures in Ireton, Duvernay, & Majeau Lake Cores from Twock 14-11-63-17



SYMBOLS: STEREONET

Data points = upper hemisphere poles to:

- □ = Steeply dipping Set 1 extension fracture
- ○ = Steeply dipping Set 2A extension fracture
- ▽ = Shallow dipping Set 2B extension fracture
- ◇ = Cleavage in Duvernay
- ◇ = Cleavage in Majeau Lake
- ✡ = Bed-parallel shear fracture
- ◇ = Slickenline trend on bed-parallel shear

SYMBOLS: ROSE DIAGRAM

Rose petals = strike of:

- = Steeply dipping Set 1 extension fracture
- = Steeply dipping Set 2A extension fracture
- = Shallow dipping Set 2B extension fracture
- = Cleavage in Duvernay
- = Cleavage in Majeau Lake
- = Bed-parallel shear fracture
- = Slickenline trend on bed-parallel shear

Figure 2. Paleomagnetically oriented natural fractures in Ireton, Duvernay, & Majeau Lake cores from Two Creek 14-11-63-17. The average strikes of natural fractures are Set 1 = 16°, Set 2A = 96°, Set 2B = 91°, Duvernay cleavage = 130°, Majeau Lake cleavage = 101°, bed-parallel shears = 129°, slickenline trend = 42°.

APPLIED PALEOMAGNETICS, INC.

Paleomagnetic Core Orientation Service

Client: ConocoPhillips Canada Resources Corp.	Formation Age: Late Devonian	Date: 6 April 2014
Well Name: COPRC 100 Hz Two Creek 14-11-63-17 W5M	Magnetization Age: Late Cenozoic	
Location: Two Creek field, Alberta	Ref. Paleomag. Pole: 90°N/0°E	Sampled: JEB, DVA
Lat.: 54.43°N, Long.: 116.44°W	Ref. Pmag. Direction (D/I): 0°/+70.3°	Measured: JEB
Formations: Ireton & Duvernay		Calc. with: ORIENT.IBM
Lithologies: Gray siltst (Ireton) Dark gray organic-rich siltst (Duvernay)		Orientation checked by: DVA

Continuous Interval (m)	Plug Depths (Min/Max)	#Sel./ #Meas.	Well Dev./ Corr. Ref. Dir.	MOL Orientation[γ] [Relative to North]	Remarks
2957.22-2966.57 C1-1	2958.55- 2965.96	12/12	11.3° @ 329.1° 29.2°/+78.5°	198° [S 18° W]	Ireton & Duvernay. Intvl contains Set 2A & Set 2B fracs. Intvl top = desorp #1.
2970.09-2976.02 C2-1	2970.78- 2974.77	8/8	10.8° @ 332.0° 25.7/+78.7°	10° [N 10° E]	Duvernay. Intvl contains Set 2A & Set 2B fracs. Intvl top = desorp. #2.
2976.02-2983.13 C2-2	2976.46- 2982.89	8/8	10.5° @ 333.0° 24.1°/+78.7°	9° [N 9° E]	Duvernay. Intvl contains Set 2A & Set 2B fracs.
2983.13-2987.82 C2-3	2983.28- 2987.77	12/12	10.3° @ 333.4° 22.9°/+78.6°	25° [N 25° E]	Duvernay. Intvl contains Set 2A & Set 2B fracs. Intvl bottom = desorp. #3.

Notes:

[γ]The Master Orientation Line (MOL) is a blue line constructed by Applied Paleomagnetics, Inc. Whole (unslabbed) core. Core diameter = 3.0 inch (7.6 cm) drilled conventionally using oil-based mud.

APPLIED PALEOMAGNETICS, INC.

Paleomagnetic Core Orientation Service

Client: ConocoPhillips Canada Resources Corp.	Formation Age: Late Devonian	Date: 6 April 2014
Well Name: COPRC 100 Hz Two Creek 14-11-63-17 W5M	Magnetization Age: Late Cenozoic	
Location: Two Creek field, Alberta	Ref. Paleomag. Pole: 90°N/0°E	Sampled: JEB, DVA
Lat.: 54.43°N, Long.: 116.44°W	Ref. Pmag. Direction (D/I): 0°/+70.3°	Measured: JEB
Formations: Duvernay & Majeau Lake		Calc. with: ORIENT.IBM
Lithologies: Dark gray organic-rich siltst (Duvernay) Calcareous med. gray siltst (Majeau Lake)		Orientation checked by: DVA

Continuous Interval (m)	Plug Depths (Min/Max)	#Sel./ #Meas.	Well Dev./ Corr. Ref. Dir.	MOL Orientation[γ] [Relative to North]	Remarks
3004.94-3011.58 C2-4	3007.55- 3011.48	12/12	9.7° @ 337.2° 18.8°/+78.7°	37° [N 37° E]	Duvernay. Interval contains cleavage, Set 1 natural frac, & bed-parallel shear.
3014.12-3019.84 C2-5	3015.05- 3019.00	12/12	9.1° @ 336.2° 17.2°/+78.1°	45° [N 45° E]	Duvernay & Majeau Lake. Intvl contains cleavage, Set 2A frac, & bed-parallel shears. Intvl top = desorp. #5. Intvl bottom = desorp. #6.

Notes:

[γ]The Master Orientation Line (MOL) is a blue line constructed by Applied Paleomagnetics, Inc. Whole (unslabbed) core.
Core diameter = 3.0 inch (7.6 cm) drilled conventionally using oil-based mud.

EXPLANATION OF COLUMN HEADINGS

Continuous Interval:

Paleomagnetic directions from plugs from the same “continuous interval” should exhibit a common azimuth relative to the Master Orientation Line (MOL).

Plug Depths (Min/Max):

Minimum and maximum depths of plugs yielding reliable paleomagnetic directions included in the statistical calculation of the core orientation.

#Sel./#Meas.:

The difference between the number measured and the number selected is equal to the number of specimens rejected on the basis of either an anomalous magnetization direction or intensity relative to the average paleomagnetic signal for the interval.

Well Dev./Corr. Ref. Dir.:

The well deviation angle (from vertical) and well deviation azimuth (from north) provided by the well deviation survey. Rotating the “reference paleomagnetic direction” (given in the header) by the well deviation yields the “corrected reference direction” to which the core is paleomagnetically oriented.

MOL Orientation:

The azimuth and bearing of the MOL in degrees (clockwise positive) from present-day geographic north.

Table 2
Paleomagnetically Oriented Natural Fractures & Bedding in Ireton, Duvernay, & Majeau Lake Core from COPRC 100 HZ Twock 14-11-63-17

API Plane ID	Core Depth(m)	Downdip Azimuth and Dip of Fractures/Bedding in Well Coords. DnDipAz (°)	Well Coords. Dip (°)	Geog. Coords. DnDipAz (°)	Geog. Coords. Dip (°)	Remarks
Continuous Interval: C1-1		Well Deviation: Inc. 11.3° @ Az. 329.1°				
1.101 B	2957.33	287.8	12.0	223.7	8.2	Siltstone
1.102 B	2957.57	289.8	11.0	217.9	7.4	Siltstone
1.103 B	2958.06	301.8	11.0	222.9	5.2	Siltstone
1.104 B	2958.16	281.8	12.0	220.1	9.3	Siltstone
1.105 B	2958.23	318.8	13.0	272.9	2.8	Siltstone
1.106 B	2958.37	292.8	14.0	239.8	8.2	Siltstone
1.107 B	2958.43	290.8	10.0	210.5	7.0	Siltstone
1.108 B	2958.99	291.8	11.0	218.8	7.1	Siltstone
1.109 B	2959.42	294.8	10.0	211.3	6.3	Siltstone
1.110 B	2959.99	295.3	10.0	211.4	6.3	Siltstone
1.111 B	2960.44	310.8	10.0	209.8	3.6	Siltstone
1.112 B	2961.05	289.8	10.0	210.3	7.2	Siltstone
1.113 2A	2961.49	189.8	78.0	188.8	86.6	Set 2A, plnr, hackle plume, en echln step, brkn, H=10
1.114 2A	2962.52	192.8	76.0	191.4	84.2	Set 2A, plnr, p.open, H=22, W=0.1
1.115 B	2962.39	282.8	10.0	208.4	8.4	Nodular siltstone
1.116 B	2962.98	275.8	11.0	211.5	9.9	vfgSS, thinly lam
1.117 B	2963.07	296.8	14.0	244.0	7.5	vfgSS, thinly lam
1.118 B	2963.16	339.8	15.0	7.4	4.5	vfgSS, thinly lam
1.119 B	2963.26	318.8	13.0	272.9	2.8	vfgSS, thinly lam
1.120 B	2963.47	297.8	12.0	230.3	6.3	vfgSS, thinly lam
1.121 B	2963.81	290.8	11.0	218.4	7.3	vfgSS, thinly lam
1.122 B	2964.31	312.8	10.0	208.5	3.2	vfgSS, thinly lam
1.123 B	2964.66	286.8	9.0	202.1	7.6	vfgSS, thinly lam
1.124 B	2964.94	302.8	10.0	211.9	5.0	vfgSS, thinly lam
1.125 B	2965.31	284.8	11.0	215.7	8.3	vfgSS, thinly lam
1.126 B	2965.52	283.8	12.0	221.3	8.9	vfgSS, thinly lam
1.127 B	2965.95	279.8	11.0	213.4	9.2	vfgSS, thinly lam
1.128 2B	2966.08	337.8	37.0	341.1	25.9	Set 2B, unmin, plnr, hackles, H=5, W=0.1
Continuous Interval: C2-1		Well Deviation: Inc. 10.8° @ Az. 332.0°				
2.101 B	2970.23	285.8	11.0	220.7	8.5	Siltstone
2.102 2A	2970.31	191.8	74.0	190.4	82.4	Set 2A, unmin, plnr, en echln step, p.open, H=23, W=0.1
2.103 2B	2970.54	350.8	33.0	358.7	23.0	Set 2B, unmin, plnr, hackles, H=5, W=0.1
2.104 B	2970.90	268.8	11.0	211.8	11.4	Siltstone
2.105 B	2970.95	298.8	13.0	243.3	7.1	Siltstone
2.106 2A	2971.00	190.8	75.0	189.6	83.5	Set 2A, unmin, plnr, hackles, brkn, H=9
2.107 B	2971.23	287.8	11.0	221.7	8.1	Siltstone
2.108 B	2971.52	287.8	12.0	227.9	8.6	Siltstone
2.109 B	2971.71	288.8	11.0	222.3	8.0	Siltstone
2.110 B	2972.27	278.8	11.0	217.0	9.7	Siltstone
2.111 B	2973.04	286.8	10.0	214.6	8.0	Siltstone
2.112 B	2973.75	282.8	10.0	213.1	8.6	Siltstone
2.113 B	2974.42	285.8	11.0	220.7	8.5	Siltstone
2.114 B	2975.36	279.8	12.0	222.7	10.0	Siltstone
2.115 B	2975.87	284.8	11.0	220.2	8.7	Siltstone
Continuous Interval: C2-2		Well Deviation: Inc. 10.5° @ Az. 333.0°				
2.201 B	2976.11	287.5	10.0	217.3	7.9	Siltstone
2.202 B	2976.56	281.5	10.0	214.7	8.9	Siltstone
2.203 B	2976.87	278.5	10.0	213.4	9.4	Siltstone
2.204 K	2976.68	11.5	89.9	11.9	81.7	Cleat in coaly seam, 1.5cm sp
2.205 K	2976.68	99.5	89.9	279.0	83.9	Cleat in coaly seam, 1.5cm sp
2.206 B	2977.25	281.5	10.0	214.7	8.9	Siltstone
2.207 B	2978.36	289.5	11.0	225.0	7.9	Siltstone
2.208 2A	2978.55	186.5	74.0	185.3	82.8	Set 2A, unmin, plnr, hackles, H=19, W=0.1
2.209 B	2979.36	277.5	11.0	218.2	10.0	Siltstone
2.210 2A	2979.84	181.5	73.0	180.4	82.3	Set 2A, unmin, plnr,en echln step, p.open, splt, H=19, W=0.1
2.211 B	2980.07	279.5	10.0	213.9	9.2	Siltstone
2.212 2A	2980.08	189.5	75.0	188.3	83.5	Set 2A, unmin, brkn, prt of swrm w/ 2.213-2.216, 3.5cm sp, H=3
2.213 2A	2980.36	184.5	75.0	183.5	84.0	Set 2A, unmin, curvplnr, p.open, split, H=20, W=0.1
2.214 2A	2980.50	180.5	81.0	0.1	89.7	Set 2A, unmin, curvplnr, p.open, split, H=8, W=0.1
2.215 2A	2980.57	182.5	74.0	181.4	83.2	Set 2A, unmin, plnr, p.open, split, H=17, W=0.1
2.216 2A	2980.70	181.5	71.0	180.2	80.3	Set 2A, unmin, plnr, hackles, split, H=9, W=0.1
2.217 B	2980.92	277.5	11.0	218.2	10.0	Siltstone

Notes:
"Well coordinates" are with respect to the core axis (before correcting for well deviation); "Geographic coordinates" are with respect to present-day horizontal (after correcting for well deviation).
Plane ID: 1=Set 1 extension fracture; 2A=Steeply dipping Set 2 extension fracture; 2B=Shallow dipping Set 2 extension fracture; C=Cleavage in Duvernay; Z=Cleavage in Majeau Lake; S= Subhorizontal shear fracture (parallel to bedding); L=Perpendicular to slickenlines on bed-parallel shear; B=Bedding; K=Cleats in coal (solid bitumen); U=Fracture of uncertain origin.
Remarks: H=Fracture Height (cm) parallel to the core axis; W=Fracture Width (mm). Depths are core depths at midpoints of fractures. Fracture & bedding orientations are listed as downdip azimuth and dip angle.

Table 2
Paleomagnetically Oriented Natural Fractures & Bedding in Ireton, Duvernay, & Majeau Lake Core from COPRC 100 HZ Twock 14-11-63-17

API Plane ID	Core Depth(m)	Downdip Azimuth and Dip of Fractures/Bedding in Well Coords. DnDipAz (°)	Well Coords. Dip (°)	Geog. Coords. DnDipAz (°)	Geog. Coords. Dip (°)	Remarks
2.218 2A	2981.26	180.5	76.0	179.7	85.3	Set 2A, unmin, brkn, H=2
2.219 B	2981.90	278.5	10.0	213.4	9.4	Siltstone
2.220 2A	2982.52	176.5	82.0	356.2	88.4	Set 2A, unmin, curvplnr, p.open, split, term @ 2.221, H=17, W=0.1
2.221 2B	2982.42	329.5	26.0	327.2	15.5	Set 2B, unmin, plnr, hackles, H=2, W=0.1
2.222 2A	2982.67	177.5	83.0	357.3	87.4	Set 2A, unmin, plnr, split, H=9, W=0.1
2.223 2B	2982.76	347.5	55.0	349.9	44.9	Set 2B, unmin, hackles, H=9, W=0.1
2.224 2A	2982.75	175.5	83.0	355.3	87.3	Set 2A, unmin, plnr, split, H=14, W=0.1
2.225 B	2982.20	282.5	9.0	208.8	8.4	Siltstone
2.226 B	2982.89	277.5	11.0	218.2	10.0	Siltstone
Continuous Interval: C2-3		Well Deviation: Inc. 10.3° @ Az. 333.4°				
2.301 B	2983.25	290.2	10.0	220.3	7.4	Siltstone
2.302 B	2984.04	296.2	11.0	231.1	6.8	Siltstone
2.303 2A	2984.39	195.2	74.0	193.8	81.7	Set 2A, unmin, plnr, hackles, split, H=7, W=0.1
2.304 B	2984.48	297.2	12.0	239.2	7.1	Siltstone
2.305 2A	2984.88	196.2	74.0	194.7	81.6	Set 2A, unmin, plnr, splt, H=7, W=0.1
2.306 2B	2985.60	220.2	36.0	208.9	41.0	Set 2B, unmin, plnr, H=5, W=0.1
2.307 2B	2985.77	227.2	33.0	213.7	37.0	Set 2B, unmin, plnr, hackles, H=5, W=0.1
2.308 2B	2986.04	4.2	24.0	22.4	16.0	Set 2B, unmin, plnr, hackles, H=4, W=0.1
2.309 B	2986.31	297.2	11.0	231.7	6.6	Siltstone
2.310 2A	2986.68	193.2	74.0	191.8	82.0	Set 2A, unmin, plnr, mnr hackles, split, H=19, W=0.1
2.311 2A	2986.95	194.2	73.0	192.7	80.9	Set 2A, unmin, plnr, mnr hackles, split, H=24, W=0.1
2.312 B	2987.22	299.2	10.0	224.2	5.9	Siltstone
2.313 2A	2987.52	187.2	78.0	186.5	86.6	Set 2A, unmin, curvplnr, H=34, W=0.1
Continuous Interval: C2-4		Well Deviation: Inc. 9.7° @ Az. 337.2°				
2.401 C	3005.89	234.3	89.9	54.5	87.9	Cleavage in Duvernay LS, 2cm sp, H=0.5, W=0.1
2.402 C	3006.10	229.3	89.9	49.5	87.1	Cleavage in Duvernay LS, 2.5cm sp, H=1.5, W=0.1
2.403 C	3006.47	215.3	89.9	35.7	85.0	Cleavage in Duvernay LS, 1cm sp, H=0.3, W=0.1
2.404 C	3006.97	213.3	89.9	33.7	84.7	Cleavage in Duvernay LS, 1cm sp, dipolar, H=0.5, W=0.1
2.405 C	3007.04	211.3	89.9	31.7	84.4	Cleavage in Duvernay LS, 0.5cm sp, H=0.3, W=0.1
2.406 U	3008.29	0.3	65.0	2.6	56.1	Cleavage-assoc. induced frac in LS?, H=3, W=0.1
2.407 B	3008.65	308.3	11.0	246.6	5.3	Siltstone
2.408 B	3010.18	293.3	7.0	203.4	6.7	Siltstone
2.409 B	3010.33	285.3	9.0	217.0	8.2	Siltstone
2.410 1	3010.58	105.3	80.0	106.2	86.1	Set 1, unmin, curvplnr, splt, large hackles, H=45, W=0.1
2.411 B	3010.83	302.3	7.0	202.5	5.6	Siltstone
2.412 B	3011.12	307.3	8.0	212.4	4.8	Siltstone
2.413 S	3011.58	300.3	8.0	212.7	5.8	Shear w/ slicks, plnr, brkn, subparallel to bedding
2.414 L	3011.58	144.3	89.9	324.1	80.6	Perp to slicks on 2.413
Continuous Interval: C2-5		Well Deviation: Inc. 9.1° @ Az. 336.2°				
2.501 B	3014.28	309.4	8.0	218.4	4.1	Clayey siltstone
2.502 B	3015.44	306.4	8.0	218.4	4.5	Clayey siltstone
2.503 B	3015.87	309.4	8.0	218.4	4.1	Clayey siltstone
2.504 B	3016.43	309.4	8.0	218.4	4.1	Clayey siltstone
2.505 B	3017.02	310.7	8.0	218.3	3.9	Clayey siltstone
2.506 B	3017.53	315.7	8.0	217.1	3.2	Clayey siltstone
2.507 B	3017.86	306.7	8.0	218.4	4.4	Clayey siltstone
2.508 S	3018.03	308.7	8.0	218.4	4.2	Shear w/ slicks, subparallel to bedding
2.509 L	3018.03	119.7	89.9	299.4	82.8	Perp to slicks on 2.508
2.510 S	3018.06	307.7	8.0	218.4	4.3	Shear w/ slicks, subparallel to bedding
2.511 L	3018.06	120.7	89.9	300.4	82.7	Perp to slicks on 2.510
2.512 S	3018.11	307.7	8.0	218.4	4.3	Shear w/ slicks, subparallel to bedding
2.513 L	3018.11	132.7	89.9	312.5	81.8	Perp to slicks on 2.512
2.514 S	3018.36	297.7	9.0	226.7	5.9	Shear w/ slicks, subparallel to bedding
2.515 L	3018.36	142.7	89.9	322.6	81.3	Perp to slicks on 2.514
2.516 Z	3018.47	185.7	89.9	6.0	82.2	Cleavage in MJLK, H=2, W=0.1
2.517 Z	3018.54	198.7	89.9	19.1	83.4	Cleavage in MJLK, H=1, W=0.1
2.518 Z	3018.63	184.7	89.9	5.0	82.2	Cleavage in MJLK, H=1, W=0.1
2.519 U	3018.63	96.7	89.9	276.4	85.5	Cleavage-assoc. induced frac? H=1, W=0.1
2.520 2A	3019.63	197.7	77.0	196.7	83.8	Set 2A, unmin, curvplnr, p.open, steps, hackle plume, H=22, W=0.1
2.521 Z	3019.59	195.7	89.9	16.1	83.1	Cleavage in MJLK, H=0.5, W=0.1

Notes:

"Well coordinates" are with respect to the core axis (before correcting for well deviation); "Geographic coordinates" are with respect to present-day horizontal (after correcting for well deviation).

Plane ID: 1=Set 1 extension fracture; 2A=Steeply dipping Set 2 extension fracture; 2B=Shallow dipping Set 2 extension fracture; C=Cleavage in Duvernay; Z=Cleavage in Majeau Lake; S= Subhorizontal shear fracture (parallel to bedding); L=Perpendicular to slickenlines on bed-parallel shear; B=Bedding; K=Cleats in coal (solid bitumen); U=Fracture of uncertain origin.

Remarks: H=Fracture Height (cm) parallel to the core axis; W=Fracture Width (mm). Depths are core depths at midpoints of fractures.

Fracture & bedding orientations are listed as downdip azimuth and dip angle.