NTGS Core Facility Sampling Report

Bulk Rock Analyses from Select Wells of the McArthur Basin, Northern Territory

Date of sampling:
23-27 June 2014 (Sever 1, Walton 2, Shenandoah 1A, Lady Penryhn 2 McManus 1)

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Map Sheets:
1:100,000: Elsey, Mais, Maryfield, Warramban
1:250,000: Tanumbirini, Hodgson Downs, Larrimah

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1. Introduction

Sampling and analyses were undertaken on legacy core retrieved from 5 wells in the Beetaloo Basin, NT: Walton2, McManus 1, Shenandoah 1A, Lady Penrhyn 2, and Sever 1, The sample preparation and analyses were undertaken at Adelaide University and formed part of an ARC Linkage research project (LP120200086) directed by Prof Martin Kennedy (now of Macquarie University).

This report presents the bulk rock analyses of selected intervals collected to date.

2. Rationale

This study's overall aim is to identify geological processes critical to carbon burial, diagenesis and hydrocarbon generation in shale. The geological controls of shale are currently poorly understood to direct effective exploration. The McArthur Basin was identified as a study area for this research along with other Australian and North American basins. The McArthur Basin is undergoing extensive exploration for unconventional shale gas.

3. Sampling methods and sample preparation

Quarter-rounds of core were taken at set intervals and labelled. Approximately 10g of core was crushed, milled to a fine powder (< 200 μm) and selectively analysed for bulk rock properties including total organic carbon (TOC), thermal maturity (Calc. Ro) and quantitative XRD.

4. Analytical methods

All sample preparation and analyses were undertaken at the University of Adelaide. Measurements were performed on the < 200 μm milled powders for TOC and thermal maturity analyses, while a 2-3 g subset of those powders underwent micronisation for quantitative XRD analyses.

Total carbon (TC) content for each sample was measured in a PerkinElmer EA 2400 series II CHNS analyzer. Inorganic carbon (IC, as carbonate) content was determined using the pressure-calcimeter method of Sherrod et al. (2002). TOC content was estimated by difference (TOC=TC-IC).

Thermal maturity was determined by pyrolysis and total petroleum hydrocarbon analysis using a Weatherford Instruments Source Rock Analyser (SRA-TPH Workstation). The absence of the maceral vitrinite in Precambrian rocks does not permit the use of the vitrinite reflectance index (Ro) for estimations of thermal maturation. Instead, thermal maturity was determined using the method of Jarvie et al. (2001), which relates measured Tmax to a normalized reflectance value using the conversion formula: Calc. Ro = 0.0180 x Tmax - 7.16 (Jarvie et al., 2001). The Tmax-based estimation of thermal maturity has been found to be unreliable in samples of low pyrolysis yields (S2 <0.2 kg/tonne) (Crick, 1989; Jarvie et al., 2001) and its use is recommended only for kerogens of Type II and III. Samples used for Tmax-based estimation of thermal maturity were carefully selected in consideration of these limitations.

Quantitative bulk mineralogy was determined on randomly oriented micronized powders, with a 10% zinc oxide internal standard, by X-ray diffractometry (XRD) using a Bruker D8 Advance A25 XRD

unit with Cu radiation source at 40 kV and 40 mA. Mineral phases were identified using the Bruker DIFFRAC.EVA software and Crystallography Open Database reference patterns. Quantification of the crystalline material was performed using the RockJock software (Eberl, 2003).

5. Results

Results are given in the following tables with Tables 1 to 5 giving the bulk rock data and Table 6 giving the quantitative XRD data.

Formation	*Depth (m)*	*Carbonate (wt%)*	*TOC (wt %)*	*S1 (mg/g)*	*S2 (mg/g)*	*S3 (mg/g)*	*PI*	*HI*	*OI*	*T Max (°C)*	*Calc.% Ro*
Upper Velkerri	253.40	0.09	1.01	0.08	0.40		0.17	40		435	0.67
Middle Velkerri	274.60	1.96	0.43	0.06	0.16		0.27	37		431	0.59
Middle Velkerri	292.90	0.34	2.05	0.46	2.18		0.17	106		436	0.68
Middle Velkerri	314.00	0.17	1.62	0.36	0.89		0.29	55		435	0.67
Middle Velkerri	337.60	8.95	0.32	0.06	0.23		0.21	73		427	0.53
Middle Velkerri	360.50	0.34	4.69	0.86	10.82		0.07	231		440	0.75
Middle Velkerri	367.90	0.43	5.86	0.71	6.81		0.09	116		435	0.67
Middle Velkerri	372.70	0.77	4.80	0.44	6.23		0.07	130		433	0.64
Middle Velkerri	374.00	2.55	3.62	0.43	5.95		0.07	164		441	0.77
Middle Velkerri	377.00	0.77	4.09	0.55	5.11		0.10	125		436	0.68
Middle Velkerri	378.60	0.43	4.82	0.51	5.83		0.08	121		436	0.70
Middle Velkerri	382.80	0.51	6.47	0.82	10.93		0.07	169		439	0.75
Middle Velkerri	385.50	0.51	3.50	0.39	3.95		0.09	113		432	0.61
Middle Velkerri	386.78	0.60	3.19	0.59	4.57		0.11	143		440	0.75
Middle Velkerri	388.68	0.60	3.56	0.53	3.79		0.12	107		440	0.76
Middle Velkerri	390.00	0.43	4.64	0.74	6.30		0.11	136		441	0.78
Middle Velkerri	393.00	0.00	2.51	0.55	3.42		0.14	136		436	0.69
Middle Velkerri	395.85	0.00	2.97	0.67	5.55		0.11	187		443	0.81
Middle Velkerri	395.95	0.51	5.59	0.99	9.02		0.10	161		441	0.78
Middle Velkerri	398.80	0.60	4.03	0.65	6.73		0.09	167		441	0.79
Middle Velkerri	401.85	0.34	4.77	0.56	6.73		0.08	141		438	0.72
Middle Velkerri	403.31	4.18	4.22	0.46	7.18		0.06	170		445	0.85
Middle Velkerri	405.70	0.94	4.88	0.83	9.16		0.08	188		446	0.87
Middle Velkerri	408.85	1.03	4.02	0.72	4.91		0.13	122		437	0.71
Middle Velkerri	411.42	0.51	3.45	1.17	4.60		0.20	133		441	0.78
Middle Velkerri	413.55	0.43	3.89	1.13	4.17		0.21	107		441	0.78
Middle Velkerri	414.55	0.34	2.55	0.60	2.62		0.19	103		442	0.79
Middle Velkerri	418.38	0.17	1.13	0.48	1.51		0.24	134		446	0.87
Middle Velkerri	423.25	0.34	3.40	0.82	3.29		0.20	97		437	0.71
Middle Velkerri	427.68	0.43	2.82	0.96	2.77		0.26	98		440	0.77
Middle Velkerri	434.74	0.60	2.15	0.80	3.12		0.20	145		444	0.83
Middle Velkerri	436.50	1.11	2.23	0.64	2.72		0.19	122		442	0.79
Lower Velkerri	444.00	0.26	0.26	0.03	0.10		0.23	39		459	1.10
Lower Velkerri	499.90	0.51	4.39	0.62	6.36		0.09	145		438	0.73

Table 1: Bulk rock analyses for Lady Penrhyn 2

Formation	*Depth (m)*	*Carbonate (wt%)*	*TOC (wt %)*	*S1 (mg/g)*	*S2 (mg/g)*	*S3 (mg/g)*	*PI*	*HI*	*OI*	*T Max (°C)*	*Calc.% Ro*
Bukalara SST	487.10	0.00	0.05								
Bukalara SST	537.50	5.49	0.06								
Kyalla Fm	565.00	1.67	0.65	0.10	0.57		0.15	88		436	0.69
Kyalla Fm	585.00	20.25	0.55	0.04	0.10		0.29	18		558	2.89
Kyalla Fm	603.80	65.42	0.80	0.04	0.17		0.19	21		454	1.01
Kyalla Fm	628.60	0.00	0.30	0.03	0.23		0.12	77		431	0.60
Kyalla Fm	637.00	0.13	0.44	0.03	0.35		0.08	79		435	0.67
Kyalla Fm	651.10	0.75	0.46	0.04	0.36		0.10	78		435	0.66
Kyalla Fm	666.60	0.05	0.50	0.03	0.34		0.08	68		429	0.56
Moroak SST	694.40	3.67	0.69	0.03	0.74		0.04	107		437	0.70
Moroak SST	729.90	0.82	0.11	0.03	0.11		0.21	99		438	0.73
Moroak SST	734.50	0.00	0.54	0.06	0.49		0.11	91		431	0.59
Moroak SST	737.80	2.75	0.62	0.80	2.70		0.23	436		419	0.38
Upper Velkerri	739.20	0.00	0.56	0.05	0.59		0.08	105		437	0.71
Upper Velkerri	1032.00	19.17	0.62	0.22	0.64		0.26	103		437	0.71
Upper Velkerri	1075.50	0.21	0.53	0.12	0.29		0.29	54		437	0.70
Upper Velkerri	1094.10	2.44	0.82	0.16	0.28		0.36	34		441	0.78
Upper Velkerri	1154.10	0.00	2.19	0.96	1.71		0.36	78		432	0.62
Upper Velkerri	1184.90	0.13	0.98	1.25	1.54		0.45	156		316	
Middle Velkerri	1203.20	0.13	3.04	2.03	3.76		0.35	124		434	0.65
Middle Velkerri	1210.50	0.21	1.37	1.66	3.15		0.35	229		364	
Middle Velkerri	1242.60	0.21	5.02	1.68	5.55		0.23	110		424	0.47
Middle Velkerri	1271.00	0.00	7.15	2.31	8.20		0.22	115		431	0.60
Middle Velkerri	1293.40	0.06	6.40	1.55	5.39		0.22	84		432	0.62
Middle Velkerri	1306.50	0.21	4.80	1.10	2.25		0.33	47		411	0.23
Middle Velkerri	1318.40	0.67	0.83	0.25	0.34		0.42	41			
Middle Velkerri	1337.60	0.13	0.37	0.21	0.21		0.50	56		439	0.74
Middle Velkerri	1367.70	0.21	2.17	1.01	1.53		0.40	70		436	0.70
Middle Velkerri	1400.50	7.76	1.12	0.12	0.14		0.46	13		422	0.44
Middle Velkerri	1424.43	0.21	6.99	2.83	7.03		0.29	101		437	0.71
Middle Velkerri	1424.43	0.06	6.00	2.28	7.86		0.22	131		443	0.81
Middle Velkerri	1444.55	6.75	1.90	1.01	1.55		0.39	82		459	1.10
Middle Velkerri	1477.20	1.44	0.93	0.99	1.17		0.46	126		309	
Middle Velkerri	1512.50	0.36	2.85	0.90	0.90		0.50	32		437	0.70
Middle Velkerri	1527.30	0.05	4.44	1.75	2.90		0.38	65		447	0.88
Middle Velkerri	1548.10	78.53	0.34	0.04	0.05		0.44	15		444	0.84
Lower Velkerri	1567.95	0.06	0.13	0.01	0.03		0.25	22		515	2.11

Table 2: Bulk rock analyses for McManus 1

Formation	*Depth (m)*	*Carbonate (wt%)*	*TOC (wt %)*	*S1 (mg/g)*	*S2 (mg/g)*	*S3 (mg/g)*	*PI*	*HI*	*OI*	*T Max (°C)*	*Calc.% Ro*
Upper Velkerri	667.80	0.07	0.08	0.01	0.02		0.33	25		328	
Middle Velkerri	674.55	1.61	4.07	0.09	0.07		0.56	2		451	0.96
Middle Velkerri	675.55	0.07	1.65	0.04	0.04		0.50	2		386	
Middle Velkerri	688.00	0.83	0.99	0.03	0.04		0.43	4		471	1.32
Middle Velkerri	691.00	0.15	0.56	0.02	0.03		0.40	5		531	2.41
Middle Velkerri	698.18	0.67	0.71	0.02	0.03		0.40	4		305	
Middle Velkerri	703.95	0.22	0.39	0.02	0.02		0.50	5		349	
Middle Velkerri	708.95	0.83	0.32	0.02	0.02		0.50	6		304	
Middle Velkerri	712.90	0.98	0.13	0.01	0.01		0.50	8		351	
Middle Velkerri	718.25	0.83	0.17	0.07	0.04		0.64	23		393	
Middle Velkerri	724.85	0.07	4.32	0.20	0.08		0.71	2		410	0.21
Middle Velkerri	729.35	0.75	4.83	0.24	0.10		0.71	2		389	
Middle Velkerri	735.90	0.83	12.64	0.21	0.18		0.54	1		439	0.75
Middle Velkerri	740.02	0.67	20.13	0.54	0.47		0.53	2		496	1.77
Middle Velkerri	743.92	0.91	2.24	0.02	0.00		1.00	0		N/A	
Middle Velkerri	746.50	2.39	1.95	0.00	0.00			0		515	2.11
Middle Velkerri	752.10	0.98	8.51	0.03	0.00		1.00	0		452	0.97
Middle Velkerri	755.60	0.15	4.45	0.00	0.00			0		485	1.57
Middle Velkerri	757.40	1.69	1.15	0.00	0.00			0		513	2.08
Middle Velkerri	840.68	0.83	5.08	0.00	0.00			0		300	
Middle Velkerri	844.35	0.15	7.04	0.01	0.00		1.00	0		511	2.04
Middle Velkerri	849.48	0.30	1.04	0.00	0.00			0		343	
Middle Velkerri	855.60	0.15	1.48	0.00	0.00			0		344	
Middle Velkerri	863.30	0.92	1.25	0.00	0.00			0		328	
Middle Velkerri	870.07	0.30	1.05	0.07	0.00		1.00	0		312	
Middle Velkerri	888.20	0.38	3.82	0.00	0.00			0		360	
Middle Velkerri	897.00	0.61	3.78	0.00	0.00			0		483	1.53
Middle Velkerri	905.00	0.77	1.77	0.00	0.00			0		322	
Middle Velkerri	917.15	0.22	0.10	0.00	0.00			0		512	2.05
Lower Velkerri	918.00	0.38	0.08	0.00	0.00			0		N/A	
Lower Velkerri	932.95	1.30	1.75	0.00	0.00			0		537	2.51
Lower Velkerri	946.00	0.59	0.09	0.00	0.00			0		515	2.10

Table 3: Bulk rock analyses for Sever 1

Formation	*Depth (m)*	*Carbonate (wt%)*	*TOC (wt %)*	*S1 (mg/g)*	*S2 (mg/g)*	*S3 (mg/g)*	*PI*	*HI*	*OI*	*T Max (°C)*	*Calc.% Ro*
Kyalla Fm	950.00	1.80	0.49								
Kyalla Fm	960.00	2.20	0.42								
Kyalla Fm	970.00	2.37	0.43	0.08	0.78		0.09	183		442	0.79
Kyalla Fm	980.00	2.12	0.65	0.11	1.26		0.08	195		442	0.80
Kyalla Fm	990.00	2.12	0.83	0.14	1.79		0.07	217		440	0.77
Kyalla Fm	1000.00	2.12	0.72	0.13	1.52		0.08	212		441	0.77
Kyalla Fm	1010.00	2.21	0.42	0.07	0.77		0.08	181		443	0.81
Kyalla Fm	1020.00	2.13	0.43	0.07	0.63		0.10	145		441	0.78
Kyalla Fm	1040.00	2.29	0.36	0.05	0.49		0.09	138		444	0.83
Kyalla Fm	1050.00	2.21	0.25	0.04	0.27		0.13	106		441	0.79
Kyalla Fm	1530.00	2.38	0.30	0.05	0.18		0.22	59		466	1.23
Kyalla Fm	1555.00	2.45	0.21	0.03	0.12		0.20	58		466	1.24
Kyalla Fm	1558.50	13.68	1.34	1.04	3.90		0.21	291		383	
Kyalla Fm	1575.50	5.70	1.46	0.33	3.10		0.10	213		389	
Kyalla Fm	1596.50	11.58	2.68	1.63	6.81		0.19	254		411	0.23
Kyalla Fm	1617.50	2.04	1.66	0.63	1.22		0.34	74		447	0.89
Kyalla Fm	1635.50	1.63	2.14	0.61	1.27		0.32	59		447	0.89
Kyalla Fm	1656.50	2.88	1.47	0.33	0.78		0.30	53		453	1.00
Kyalla Fm	1677.50	1.79	1.04	0.21	0.56		0.27	54		452	0.97
Kyalla Fm	1698.50	1.54	0.98	0.28	0.58		0.33	59		435	0.66
Moroak SST	2163.50	1.46	0.34	0.04	0.13		0.24	38		411	0.23
Upper Velkerri	2301.50	2.45	0.42	0.03	0.12		0.20	29		430	0.58
Upper Velkerri	2310.50	2.13	0.38	0.03	0.04		0.43	10		420	0.41
Upper Velkerri	2328.50	1.96	0.42	0.03	0.04		0.43	10		317	
Upper Velkerri	2340.50	1.13	0.48	0.03	0.08		0.27	17		394	
Upper Velkerri	2352.50	1.38	0.45	0.03	0.05		0.38	11		337	
Upper Velkerri	2358.50	1.38	0.54	0.03	0.11		0.21	20		410	0.22
Upper Velkerri	2367.50	0.96	0.49	0.03	0.04		0.43	8		N/A	
Upper Velkerri	2376.50	1.29	0.44	0.04	0.10		0.29	22		408	0.18

Table 4a: Bulk rock analyses for Shenandoah 1A part 1

Formation	*Depth (m)*	*Carbonate (wt%)*	*TOC (wt %)*	*S1 (mg/g)*	*S2 (mg/g)*	*S3 (mg/g)*	*PI*	*HI*	*OI*	*T Max (°C)*	*Calc.% Ro*
Middle Velkerri "B"	2475.50	1.79	0.49	0.04	0.09		0.31	18		408	0.19
Middle Velkerri "B"	2481.50	2.54	0.37	0.04	0.07		0.36	19		422	0.43
Middle Velkerri "B"	2490.50	2.62	0.31	0.03	0.09		0.25	29		431	0.59
Middle Velkerri "B"	2499.50	2.88	0.35	0.04	0.12		0.25	34		426	0.50
Middle Velkerri "B"	2508.50	1.63	0.83	0.04	0.07		0.36	8		311	
Middle Velkerri "B"	2517.50	1.88	1.05	0.06	0.30		0.17	28		400	0.04
Middle Velkerri "B"	2526.50	2.37	1.39	0.06	0.10		0.38	7		337	
Middle Velkerri "B"	2535.50	2.54	1.47	0.06	0.09		0.40	6		325	
Middle Velkerri "B"	2538.50	2.37	1.80	0.06	0.10		0.38	6		319	
Middle Velkerri "B"	2541.50	2.62	1.85	0.05	0.10		0.33	5		392	
Middle Velkerri "B"	2541.50	2.71	1.87	0.05	0.09		0.36	5		353	
Middle Velkerri "B"	2544.50	2.62	2.15	0.06	0.10		0.38	5		436	0.69
Middle Velkerri "B"	2547.50	2.38	2.27	0.06	0.11		0.35	5		448	0.91
Middle Velkerri "B"	2550.50	2.95	2.39	0.07	0.14		0.33	6		328	
Middle Velkerri "B"	2553.50	3.11	2.71	0.06	0.15		0.29	6		305	
Middle Velkerri "B"	2556.50	2.21	1.56	0.05	0.07		0.42	4		N/A	
Lower Velkerri	2559.50	1.97	1.39	0.05	0.08		0.38	6		N/A	
Lower Velkerri	2562.50	2.12	1.53	0.05	0.11		0.31	7		394	
Lower Velkerri	2580.50	1.54	0.73	0.05	0.09		0.36	12		318	
Lower Velkerri	2598.50	1.80	0.37	0.03	0.07		0.30	19		331	
Lower Velkerri	2625.50	1.71	0.30	0.03	0.07		0.30	23		328	
Lower Velkerri	2640.50	2.71	0.35	0.03	0.07		0.30	20		363	
Lower Velkerri	2661.50	1.38	0.28	0.03	0.07		0.30	25		421	0.42
Lower Velkerri	2682.50	2.30	0.55	0.03	0.07		0.30	13		N/A	
Lower Velkerri	2700.50	0.88	0.53	0.04	0.06		0.40	11		323	
Lower Velkerri	2712.50	1.21	0.62	0.04	0.11		0.27	18		401	0.05

Table 4b: Bulk rock analyses for Shenandoah 1A part 2

Formation	*Depth (m)*	*Carbonate (wt%)*	*TOC (wt %)*	*S1 (mg/g)*	*S2 (mg/g)*	*S3 (mg/g)*	*PI*	*HI*	*OI*	*T Max (°C)*	*Calc.% Ro*
Middle Velkerri	266.30	0.00	7.73	1.95	19.22		0.09	249		416	0.33
Middle Velkerri	281.90	0.00	10.30	5.96	19.28		0.24	187		417	0.35
Middle Velkerri	284.05	4.43	0.71	0.13	0.35		0.27	49		409	0.21
Middle Velkerri	289.40	0.26	2.47	1.53	5.12		0.23	207		405	0.13
Middle Velkerri	293.20	0.26	1.52	1.44	5.47		0.21	360		397	-1.00
Middle Velkerri	300.10	0.08	13.77	4.19	70.87		0.06	515		431	0.60
Middle Velkerri	302.75	0.00	12.41	3.82	62.65		0.06	505		431	0.59
Middle Velkerri	310.70	6.71	0.83	0.24	1.55		0.13	188		433	0.64
Middle Velkerri	319.30	0.00	16.03	7.44	86.51		0.08	540		436	0.68
Middle Velkerri	326.65	0.00	9.80	2.25	46.23		0.05	472		430	0.58
Middle Velkerri	327.80	0.17	12.90	3.90	67.01		0.05	519		433	0.64
Middle Velkerri	334.60	0.17	9.71	2.42	38.44		0.06	396		425	0.48
Middle Velkerri	339.75	0.00	7.23	1.48	31.05		0.05	429		429	0.56
Middle Velkerri	343.00	0.08	6.85	1.33	27.92		0.05	408		428	0.54
Middle Velkerri	347.60	0.00	7.15	1.10	27.29		0.04	382		428	0.55
Middle Velkerri	354.30	0.00	5.72	1.12	19.44		0.05	340		425	0.49
Middle Velkerri	357.25	0.00	5.64	1.01	22.27		0.04	395		426	0.51
Middle Velkerri	359.78	0.00	14.17	4.01	71.48		0.05	504		429	0.56
Middle Velkerri	361.55	0.00	4.18	0.78	13.56		0.05	324		427	0.53
Middle Velkerri	366.15	0.00	5.06	0.78	14.48		0.05	286		426	0.51
Middle Velkerri	367.27	0.60	4.46	0.96	20.24		0.05	454		432	0.62
Middle Velkerri	379.50	0.00	10.34	2.01	44.38		0.04	429		428	0.55
Middle Velkerri	389.40	0.00	8.93	2.47	41.32		0.06	463		430	0.58
Middle Velkerri	397.00	0.51	6.67	1.71	33.97		0.05	509		434	0.65
Middle Velkerri	402.80	0.00	8.41	2.62	40.66		0.06	483		434	0.65
Middle Velkerri	408.36	0.00	8.91	3.06	45.91		0.06	515		435	0.67
Middle Velkerri	414.03	0.60	9.39	3.05	48.88		0.06	521		437	0.71
Middle Velkerri	429.70	2.13	6.25	2.97	31.83		0.09	509		440	0.76
Middle Velkerri	436.95	0.00	6.22	2.20	27.37		0.07	440		436	0.69
Middle Velkerri	441.05	0.43	2.81	1.31	11.14		0.11	397		437	0.71
Middle Velkerri	447.86	0.00	1.08	0.60	3.29		0.15	305		436	0.68
Middle Velkerri	452.45	1.11	2.48	1.80	10.40		0.15	420		433	0.64
Middle Velkerri	457.40	0.43	4.08	2.18	15.29		0.12	375		439	0.74
Middle Velkerri	460.55	0.09	3.96	1.67	13.14		0.11	332		436	0.69
Middle Velkerri	470.35	0.00	3.99	1.61	9.39		0.15	235		430	0.58
Middle Velkerri	479.40	0.60	3.44	1.54	10.61		0.13	309		436	0.69
Middle Velkerri	489.40	0.43	2.72	1.20	8.48		0.12	312		435	0.67
Middle Velkerri	498.56	0.00	2.75	1.40	7.49		0.16	272		433	0.64
Middle Velkerri	507.95	0.00	2.62	1.80	6.77		0.21	258		434	0.65
Middle Velkerri	513.50	0.00	3.51	1.59	8.34		0.16	238		433	0.64
Middle Velkerri	520.15	0.17	2.30	1.61	6.10		0.21	265		428	0.54
Middle Velkerri	524.50	0.17	2.97	2.12	5.65		0.27	190		432	0.61
Middle Velkerri	529.15	0.43	3.27	2.05	8.53		0.19	261		429	0.56
Middle Velkerri	549.60	0.34	3.65	1.84	8.03		0.19	220		434	0.66

Table 5: Bulk rock analyses for Walton 2

Lady Penrhyn 2																			
Depth (m)	Degree of fit*	Quartz	K-Feldspar	Albite	Pyrite	Marcasite	Apatite	Biotite	Smectite	Kaolinite	Illite	Chlorite	Muscovite	Calcite	High Mg Calcite	Dolomite	Siderite	Total Clays	Total Feldspars
253.4	0.0668	23.8	5.5	0	1	0	1	0	0	14.1	22.5	10.4	21.7	0	0	0	0	68.8	5.5
292.9	0.0728	36.2	3.7	0	0.8	1.2	0	0	0	4	41.4	0	12.7	0	0	0	0	58.1	3.7
337.6	0.0721	37.9	0	3.8	1.8	0	0	0	0	1	36.9	9.4	2.2	0	0	7	0	49.5	3.8
360.5	0.0607	40.1	0	7.2	6.4	2.1	2.7	0	0	0	41.6	0	0	0	0	0	0	41.6	7.2
382.8	0.059	29.1	0	10.6	4.3	2.1	3.2	0	0	0	40.8	9.9	0	0	0	0	0	50.7	10.6
403.3	0.0737	46.9	0	5.8	1	0.7	0	0	0	0	33	7.1	1	0	0	3.8	0.7	41.2	5.8
418.4	0.0833	60.7	0	4	0.6	0	1.6	0	0	0	27.1	6.1	0	0	0	0	0	33.2	4
427.7	0.0685	46.7	0	7.2	1.6	1.7	0	0	0	0	30.3	9.4	3	0	0	0	0	42.7	7.2
444	0.061	28.4	0	4.3	0	0	0	0	0	7.3	46.6	13.4	0	0	0	0	0	67.3	4.3
Sever 1																			
Depth (m)	Degree of fit*	Quartz	K-Feldspar	Albite	Pyrite	Marcasite	Apatite	Biotite	Smectite	Kaolinite	Illite	Chlorite	Muscovite	Calcite	High Mg Calcite	Dolomite	Siderite	Total Clays	Total Feldspars
740	0.0792	44.6	6.3	10.1	0	0	2.6	0	0	3.3	33.2	0	0	0	0	0	0	36.5	16.4
757.4	0.0662	32.9	0	35.9	0	0	0	0	0	0	0	31.2	0	0	0	0	0	31.2	35.9
844.4	0.0746	40.8	4.9	16.1	0	0	2.1	0	0	0	26.8	9.3	0	0	0	0	0	36.1	21
917.2	0.0457	2.9	0	20.7	0	0	0	0	0	0	35.4	40.9	0	0	0	0	0	76.3	20.7
Shenandoah 1A																			
Depth (m)	Degree of fit*	Quartz	K-Feldspar	Albite	Pyrite	Marcasite	Apatite	Biotite	Smectite	Kaolinite	Illite	Chlorite	Muscovite	Calcite	High Mg Calcite	Dolomite	Siderite	Total Clays	Total Feldspars
1596.5	0.099	8.4	0	0	0	0	0	0	0	0	39.3	7.5	0	25.6	19.3	0	0	46.7	0
1635.5	0.07	29.4	4.2	0	0	0	0	0	0	0	55.5	10.9	0	0	0	0	0	66.4	4.2
1698.5	0.0862	42.4	0	0	0	0	0	0	0	0	40.2	10.4	7	0	0	0	0	57.6	0
2376.5	0.0785	43.2	0	5.7	1.1	0	0	0	0	0	31.3	9.1	9.5	0	0	0	0	50	5.7
2526.5	0.0714	42.7	8.9	0	1.5	0.8	0	0	0	0	31.9	9	5.1	0	0	0	0	46.1	8.9
2553.5	0.0716	42.1	8.9	0	1.4	0.9	0	0	0	0	32.4	8.8	5.6	0	0	0	0	46.8	8.9
2640.5	0.0667	32.1	0	11.6	0.7	0	0	0	0	0	41.6	10.9	3.1	0	0	0	0	55.6	11.6
McManus 1																			
Depth (m)	Degree of fit*	Quartz	K-Feldspar	Albite	Pyrite	Marcasite	Apatite	Biotite	Smectite	Kaolinite	Illite	Chlorite	Muscovite	Calcite	High Mg Calcite	Dolomite	Siderite	Total Clays	Total Feldspars
565	0.064	23.8	10.8	0	0	0	0	0	0	15.9	38.6	0	8	0	0	1.6	1.3	62.6	10.8
737.8	0.1053	63.6	11.4	0	0	0	0	3.1	0	6	7.6	0	7.7	0	0	1.1	2.7	21.2	11.4
1032	0.0722	27.1	6.6	0	1.3	0	0	0	0	18.1	12.3	0	12.1	0	0	21.1	1.4	42.5	6.6
1154.1	0.0648	31	0	5.2	2.2	1.1	1.8	0	0	7.9	41.7	0	9.1	0	0	0	0	58.7	5.2
1203.2	0.0732	42.9	0	8.3	0.9	1.1	2.1	0	0	1.3	38.6	0	4.8	0	0	0	0	44.7	8.3
1271	0.0606	35.2	0	11.8	3.8	2.6	2.5	0	0	2.3	40.4	0	1.4	0	0	0	0	44.1	11.8
1337.6	0.0644	27.8	0	8.1	0.9	0	0	0	0	3.8	41.5	14.2	3.7	0	0	0	0	63.2	8.1
1367.7	0.0662	32.7	0	8	0.3	0.7	1.4	0	0	5.8	44.7	0	6.5	0	0	0	0	57	8
1400.5	0.0367	4.5	0	0	32.5	0	3.8	0	39.7	8.6	0	0	0	0	0	9.5	1.4	48.4	0
1424.4	0.0743	50.5	0	9.3	1.4	0.8	2.9	0	0	0	27.7	7.4	0	0	0	0	0	35.1	9.3
1477.2	0.0729	42.2	0	9.2	0.5	0.7	3.4	0	0	0	30.6	11.9	0	0	0	1.5	0	42.5	9.2
1527.3	0.0682	36.1	0	11.8	1.3	1	3	0	0	0	34.3	12.6	0	0	0	0	0	46.8	11.8
Walton 2																			
Depth (m)	Degree of fit*	Quartz	K-Feldspar	Albite	Pyrite	Marcasite	Apatite	Biotite	Smectite	Kaolinite	Illite	Chlorite	Muscovite	Calcite	High Mg Calcite	Dolomite	Siderite	Total Clays	Total Feldspars
266.3	0.0686	44.8	0	0	5.3	0	0	0	0	0	47.4	0	1.8	0	0	0	0.7	49.2	0
284.1	0.0692	40.6	6.2	0	0	0	0	0	0	0	46.3	0	0	0	0	3.5	3.4	46.3	6.2
319.3	0.0612	25.6	0	0	4	2.2	3.9	0	0	8.2	52.5	3.6	0	0	0	0	0	64.3	4
361.6	0.0713	39.2	4.4	3.5	0.3	0.6	2.1	0	0	8	41.9	0	0	0	0	0	0	49.9	7.9
414	0.075	44.9	0	7.1	0.8	0.7	2.8	0	0	3	40.7	0	0	0	0	0	0	43.7	7.1
447.9	0.0758	52.5	0	4.9	0	0.5	2.3	0	0	0	34.1	5.7	0	0	0	0	0	39.9	4.9
513.5	0.069	41.8	0	9.9	1.1	1.1	2.9	0	0	0	42.7	0.4	0	0	0	0	0	43.2	9.9
549.6	0.0699	49.3	0	6.9	0.9	0.7	0	0	0	0	32.3	9.8	0	0	0	0	0	42.2	6.9

***Degree of fit considered acceptable is < 0.1, the smaller the better (Eberl, 2003); Values are weight % of the total crystalline phases quantified with RockJock software**

Table 6: Quantitative XRD results