APPENDIX C – PPG INDUSTRIES CORE ANALYSES, MARSHALL COUNTY, WEST VIRGINIA

PPG INDUSTRIES SALT CORE DATA, MARSHALL COUNTY, WEST VIRGINIA

Thirty-four core samples from the PPG36 well were analyzed for 51 different major and trace elements. Major element concentrations were reported in weight percentages (%), and trace element concentrations were reported in parts per million (ppm) or parts per billion (ppb). The samples were grouped into six different groups by the predominant lithology reported in the core description. For example, black shaley siltstone with euhedral halite crystals was grouped into the dark gray to black shaley siltstone category. Tables C-1 and C-2 show the major element and trace element concentrations by lithology, respectively. Elements were not included in these tables if concentrations were reported to be below laboratory detection limits. An additional four elements (barium, cobalt, hafnium and europium) were not included in the trace element table because these were only detected in a single siltstone sample. Detection limits for the various major and trace elements are included in Tables C-3 and C-4, respectively.

Major Element Lithology Table Summary

The halite samples had no iron, while the shaley siltstone and dolomicrite samples had a small amount. As expected, the halite samples had far more sodium than the siltstone or dolomicrite samples. In addition, the siltstone and dolomicrite reported more calcium and magnesium than the predominately halite samples. Titanium, aluminum and potassium concentrations increased in the darker halite samples, which likely get their dark color from dark anhydrite particles. Siltstone samples had the highest concentrations of these three elements. The siltstone and dolomicrite had almost twice as much sulfur as the halite samples.

Trace Element Lithology Table Summary

Halite samples had approximately twice as much bromine than either the siltstone or dolomicrite samples. Scandium concentrations increased in the darker halite samples, which likely get their dark color from dark anhydrite particles. Siltstone samples had the highest concentrations of this element. Lithium concentrations also increased in the darker halite samples, and dolomicrite and siltstone samples had the highest concentrations of lithium. The halite samples contained no molybdenum, thorium or uranium, and the siltstone samples reported higher concentrations of these three elements than the dolomicrite samples. The highest concentrations of the rare-earth elements – lanthanum, cerium, neodymium, samarium and ytterbium – were found in the siltstone samples. These elements were generally reported below detection limits in most of the halite samples, with the exception of detectable levels of lanthanum, neodymium and samarium in the black halite samples and some neodymium in one clear halite sample. Copper was detected in most of the lithologies (gray halite excepted), and dolomicrite samples had the highest concentrations of copper. Lead levels ranged from below detection limits to a few ppm for most lithologies, with the siltstone having the greatest concentration of lead and concentrations remaining below detection limits for the clear halite samples. Zinc and nickel were detected in all six lithologies, with siltstone and dolomicrite lithologies having the highest concentrations of these metals. Manganese and strontium were

also present in all six lithologies, but in much greater concentrations than zinc and nickel. Again, siltstone samples had the highest concentrations of these two elements. Yttrium and vanadium were mostly found to be below detection limits, with the exception of a couple ppm in the black halite and dolomicrite samples and 10 to 30 ppm in the siltstone samples.

In conclusion, the shaley siltstone samples have the highest concentrations of most of the elements analyzed for these core samples. Concentrations of several elements increase in the predominantly halite samples as the samples get darker. This probably results from increasing concentrations of non-salt particles such as anhydrite in these core samples. The gray to dark gray, coarsely crystalline halite lithology is shown in Figures 1A, 2 and 3. The dark gray to black, shaley siltstone lithology is illustrated in Figures 1C and 3.



Figure 1. a: Coarse halite crystals with evenly disseminated black anhydrite pieces that give the section a dark gray color; b: post-lithification fracture includes some salt crystals along the fracture zone; c: brown-gray calcareous shale, thinly laminated, sometimes wavy, partially replaced by salt and pepper carbonate(?)-anhydrite mixture. The shale is interbedded with the carbonate-anhydrite beds.



Figure 2. Uniformly coarse (0.25-0.5 inch) halite crystals with evenly disseminated black anhydrite pieces, which give the section a dark gray color.



Figure 3. Mix of gray coarse crystalline halite as above and disoriented large (up to 0.8 ft) clasts of thin bedded anhydrite-carbonate plus calcareous shale. Core base is 6,648 ft.

Major Element Concentrations by Lithology

		RANGE	Low	High	Low	High	Low	High	Low	High	Low	High
		Element	FE		NA		SN		CA2		P	
		Units	%		%		%		%		%	
Lithology	Number of samples	Element Detection Limit	0.01		0.01		0.01		0.01		0.001	
Clear coarsely crystalline halite	4		ND	ND	16.90	21.10	ND	ND	0.08	0.31	ND	ND
Gray, coarsely crystalline halite	4		ND	ND	16.70	21.40	ND	0.08	0.40	5.94	ND	0.001
Dark gray, coarsely crystalline halite	8		ND	ND	13.30	22.70	ND	ND	0.11	4.43	ND	0.003
Black coarsely crystalline halite	6		ND	ND	17.60	22.90	ND	0.10	0.55	6.29	ND	0.005
Dark gray to black, shaley siltstone	4		ND	1.45	0.55	9.45	ND	ND	9.68	15.90	0.002	0.025
Light and dark gray dolomricite	8		ND	0.38	0.82	10.40	ND	ND	9.08	14.80	0.001	0.010

*ND = Not Detected/Below detection limits

Table C-1

Major Element Concentrations by Lithology

		Low	High	Low	High	Low	High	Low	High	Low	High
		MG		TI		AL		K		S	
		%		%		%		%		%	
Lithology	**Number of samples**	0.01		0.01		0.01		0.01		0.010	
Clear coarsely crystalline halite	4	ND	0.03	ND	ND	ND	0.02	0.03	0.04	0.030	0.230
Gray, coarsely crystalline halite	4	0.02	0.57	ND	ND	ND	0.08	0.03	0.05	0.300	4.490
Dark gray, coarsely crystalline halite	8	ND	0.44	ND	ND	0.01	0.27	0.02	0.11	0.080	3.670
Black coarsely crystalline halite	6	0.03	1.60	ND	0.02	0.01	0.39	0.03	0.29	0.350	3.520
Dark gray to black, shaley siltstone	4	1.41	9.61	ND	0.14	0.06	2.38	0.11	1.95	0.640	8.000
Light and dark gray dolomricite	8	2.20	6.35	ND	0.03	0.08	0.60	0.09	0.51	2.920	6.070

*ND = Not Detected/Below detection limits

Table C-1

Trace Element Concentrations by Lithology

		RANGE	Low	High	Low	High	Low	High	Low	High	Low	High
		Element	AS		BR		CR		CS		RB	
		Units	PPM		PPM		PPM		PPM		PPM	
Lithology	**Number of samples**	**Element Detection Limit**	0.5		0.5		5.0		1.0		15.0	
Clear coarsely crystalline halite	4		ND	ND	54.8	138.0	ND	19.0	ND	ND	ND	ND
Gray, coarsely crystalline halite	4		ND	2.4	58.7	97.7	ND	15.0	ND	ND	ND	33.0
Dark gray, coarsely crystalline halite	8		ND	ND	62.4	135.0	ND	10.0	ND	ND	ND	ND
Black coarsely crystalline halite	6		ND	1.0	83.7	116.0	ND	ND	ND	3.0	ND	ND
Dark gray to black, shaley siltstone	4		ND	15.8	20.7	61.5	ND	36.0	ND	3.0	ND	115.0
Light and dark gray dolomricite	8		ND	6.4	22.6	56.5	ND	18.0	ND	ND	ND	ND

*ND = Not Detected/Below detection limits

** The following elements have been removed from the table because sample PPG36-1-17 was the only sample registering any detection: BA, CO, HF, and EU.

Trace Element Concentrations by Lithology

		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		SB		SC		TH		U		LA		CE	
		PPM		PPM		PPM		PPM		PPM		PPM	
Lithology	**Number of samples**	0.1		0.1		0.2		0.5		0.5		3.0	
Clear coarsely crystalline halite	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Gray, coarsely crystalline halite	4	ND	ND	ND	1.0	ND	ND	ND	ND	ND	ND	ND	ND
Dark gray, coarsely crystalline halite	8	ND	0.2	ND	0.6	ND	ND	ND	ND	ND	ND	ND	ND
Black coarsely crystalline halite	6	ND	ND	ND	1.2	ND	ND	ND	ND	ND	0.6	ND	ND
Dark gray to black, shaley siltstone	4	ND	0.9	0.9	4.3	ND	4.5	ND	4.9	ND	18.3	ND	39.0
Light and dark gray dolomricite	8	ND	0.3	0.3	3.5	ND	1.4	ND	2.5	ND	3.8	ND	6.0

*ND = Not Detected/Below detection limits

** The following elements have been removed from the table because sample PPG36-1-17 was the only sample registering any detection: BA, CO, HF, and EU.

Trace Element Concentrations by Lithology

		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		ND		SM		YB		MO2		CU		PB	
		PPM		PPM		PPM		PPM		PPM		PPM	
Lithology	**Number of samples**	5.0		0.1		0.2		2.00		1.00		4.00	
Clear coarsely crystalline halite	4	ND	10.0	ND	ND	ND	ND	ND	ND	ND	3.00	ND	ND
Gray, coarsely crystalline halite	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4.00
Dark gray, coarsely crystalline halite	8	ND	ND	ND	ND	ND	ND	ND	ND	ND	2.00	ND	6.00
Black coarsely crystalline halite	6	ND	11.0	ND	0.2	ND	ND	ND	ND	ND	4.00	ND	6.00
Dark gray to black, shaley siltstone	4	ND	17.0	ND	3.0	ND	1.1	ND	7.00	ND	11.00	ND	16.00
Light and dark gray dolomricite	8	ND	8.0	ND	0.5	ND	0.2	ND	3.00	2.00	21.00	ND	4.00

*ND = Not Detected/Below detection limits

** The following elements have been removed from the table because sample PPG36-1-17 was the only sample registering any detection: BA, CO, HF, and EU.

Table C-2

Trace Element Concentrations by Lithology

		Low	High	Low	High	Low	High	Low	High	Low	High	Low	High	Low	High
		ZN2		NI2		MN		SR2		V		Y		LI	
		PPM		PPM		PPM		PPM		PPM		PPM		PPM	
Lithology	**Number of samples**	1.00		1.00		1.00		1.00		2.00		2.00		1.00	
Clear coarsely crystalline halite	4	ND	2.00	ND	ND	9.00	16.00	4.00	23.00	ND	ND	ND	ND	ND	ND
Gray, coarsely crystalline halite	4	ND	17.00	ND	1.00	9.00	19.00	27.00	356.00	ND	ND	ND	ND	ND	20.00
Dark gray, coarsely crystalline halite	8	ND	3.00	ND	1.00	7.00	26.00	6.00	799.00	ND	ND	ND	ND	ND	52.00
Black coarsely crystalline halite	6	ND	5.00	ND	3.00	8.00	33.00	26.00	280.00	ND	4.00	ND	2.00	1.00	44.00
Dark gray to black, shaley siltstone	4	2.00	14.00	ND	19.00	19.00	214.00	618.00	5830.00	ND	27.00	ND	10.00	60.00	147.00
Light and dark gray dolomricite	8	3.00	12.00	1.00	6.00	16.00	58.00	502.00	2400.00	ND	9.00	ND	2.00	21.00	159.00

*ND = Not Detected/Below detection limits

** The following elements have been removed from the table because sample PPG36-1-17 was the only sample registering any detection: BA, CO, HF, and EU.

Major Element Detection Limits

Element	Units	Detection Limit
CA	%	0.01
FE	%	0.01
K	%	0.01
NA	%	0.01
P	%	0.001
S	%	0.010
SN	%	0.01
AL	%	0.01
MG	%	0.01
TI	%	0.01

Trace Element Detection Limits

Element	Units	Detection Limit
AG	PPM	0.40
AS	PPM	0.5
AU	PPB	2.0
BA	PPM	50.0
BR	PPM	0.5
CE	PPM	3.0
CO	PPM	1.0
CR	PPM	5.0
CS	PPM	1.0
EU	PPM	0.2
HF	PPM	1.0
HG	PPM	1.0
IR	PPB	5.0
LA	PPM	0.5
LU	PPM	0.05
ND	PPM	5.0
NI	PPM	20.0
RB	PPM	15.0
SB	PPM	0.1
SC	PPM	0.1
SE	PPM	3.0
SM	PPM	0.1
TA	PPM	0.5
TB	PPM	0.5
TH	PPM	0.2
U	PPM	0.5
V	PPM	2.00
W	PPM	1.0
Y	PPM	2.00
YB	PPM	0.2
BE	PPM	2.00
BI	PPM	5.00
CD	PPM	0.5
CU	PPM	1.00
MN	PPM	1.00
PB	PPM	4.00
LI	PPM	1.00
MO	PPM	2.00
NI2	PPM	1.00
SR2	PPM	1.00
ZN2	PPM	1.00