

Plug and 2D SEM Analysis

**Armstrong #1
Morgantown, West Virginia
Hamilton and Marcellus Fm.
(7547.30 ft. – 7778.15 ft.)**

January 2014

For

West Virginia University

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Individual Sample Results	

<i>Sample #</i>	<i>Depth (ft.)</i>	<i>Formation</i>	
1	7547.30	Hamilton	10
2	7591.40	Marcellus	14
3	7620.10	Marcellus	18
4	7677.65	Marcellus	22
5	7688.50	Marcellus	26
6	7702.65	Marcellus	30
7	7720.65	Marcellus	34
8	7729.50	Marcellus	38
9	7740.45	Marcellus	42
10	7753.30	Marcellus	46
11	7778.15	Marcellus	50

Attachments:

Data Table: WVU (Armstrong #1) Well Summary.xlsx – Attachment 1

CT Projection Image: 4 micron/pixel.tif – Attachment 2

2D SEM Images: Ten SE.png – Attachment 3

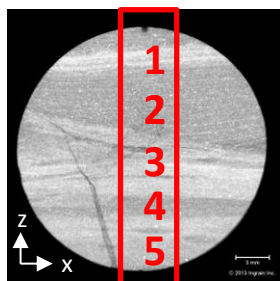
2D SEM Images: Ten ESB.png – Attachment 3

2D SEM Images: One Overview.png – Attachment 3

DATA AND RESULTS – Examples and Explanations

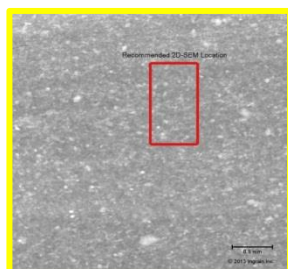


White Light Photo of Sample



2D grayscale X-ray projection/mosaic:

The X-ray projection image presented was obtained from a Micro-CT scanner. White shades typically represents high density, or higher PEF material (e.g. pyrite), Gray: minerals with densities of 2/3 g/cc, Black: fractures, organic material, or pore space. The scan resolution is indicated on individual sample pages. The red box represents a location where higher resolution CT projections were acquired at 4 microns/pixel. The numbers represent XRF location points that are reported in the table at the bottom of the page.

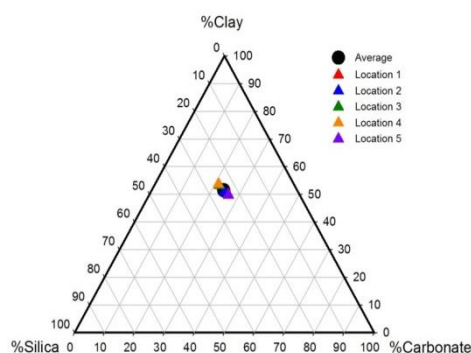


X-ray projection:

X-ray projection image at approximately 4 microns per pixel. Red box insert shows Ingrain selected locations for next stage of analysis, high resolution 2D scanning electron microscope (SEM) imaging.

X-ray Fluorescence (XRF) Ternary Diagram:

XRF weight percent of major elements plus trace elements thorium and uranium have been determined at approximately the numbered locations shown by red boxes in the above X-ray image. The data has been calibrated for shale samples. Weight percent of elements in other rock types may be less accurate. The elemental abundances have been converted to an approximate weight percent of silica, clay, and carbonate and are shown in the ternary diagram.

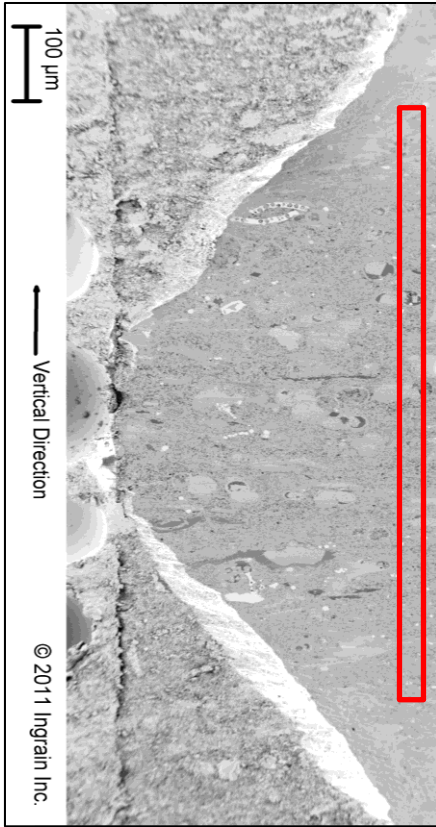


X-ray Fluorescence (XRF) Table:

The elemental abundances have been converted to an approximate weight percent of silica, clay, and carbonate and are shown listed in the table. Elemental percentages are reported in the attached well summary file.

Location	Mineralogy by weight percentage		
	Silica	Clay	Carbonate
Location 1			
Location 2			
Location 3			
Location 4			
Location 5			
Average			

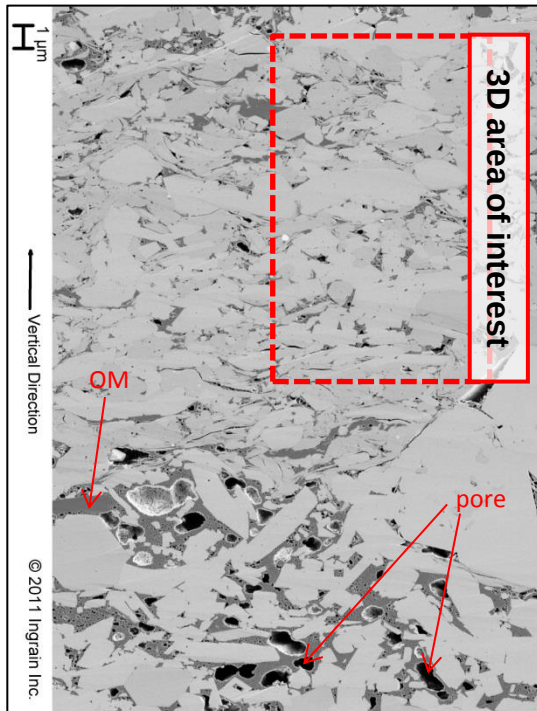
DATA AND RESULTS – Examples and Explanations



2D SEM Overview:

Once an AOI is selected from the Micro-CT analysis, an area that is approximately 1 millimeter by 500 microns is polished. A 2DSEM overview image is taken with a field of view of approximately 750 microns. The overview shows laminations and heterogeneities at a larger scale.

The red box within the overview indicates where the smaller field of view 2DSEM images are acquired.



2D SEM Individual Images:

20 to 25 images are initially acquired from the highlighted area in the overview. Fifteen are segmented for porosity, organic matter, porosity in the organic matter, and high dense materials. Images are taken at 15 nm/pixel. A cross plot and data table are included to show the quantitative results. The red dashed box indicated the AOI for 3D FIB-SEM analysis.

Interpretation of the 2D SEM Image:

White: High density material (e.g.: iron rich)
Light Grey: Minerals with densities 2-3 g/cc
Dark Grey: Organic Matter (OM)
Black: Pore space

DATA AND RESULTS – West Virginia University, Armstrong #1

Executive Summary

West Virginia University provided Ingrain with 11 Hamilton (1 plug) and Marcellus (10 plugs) depths from their Armstrong #1 well. Based on Macro40 XCT imaging and analysis, 11 plugs were selected for high resolution SEM imaging and digital rock physics computations to digitally determine volumetric percentages of organic matter, porosity, porosity in organic matter, and high density materials. This report contains the results for the 11 plugs with depths ranging 7547.30 ft. to 7778.15 ft.

The 11 plugs were photographed with white light and then analyzed with X-ray fluorescence to characterize mineralogy based on the elemental composition. For each, five readings were taken across the laminations and parallel to the vertical axis of the well. Following the X-ray fluorescence analysis, the 11 plugs were imaged with a X-ray CT system to characterize the specimen using projection techniques; one projection was done at a resolution of 15-21 microns/pixel, and another projection was done at a resolution of 4 microns/pixel.

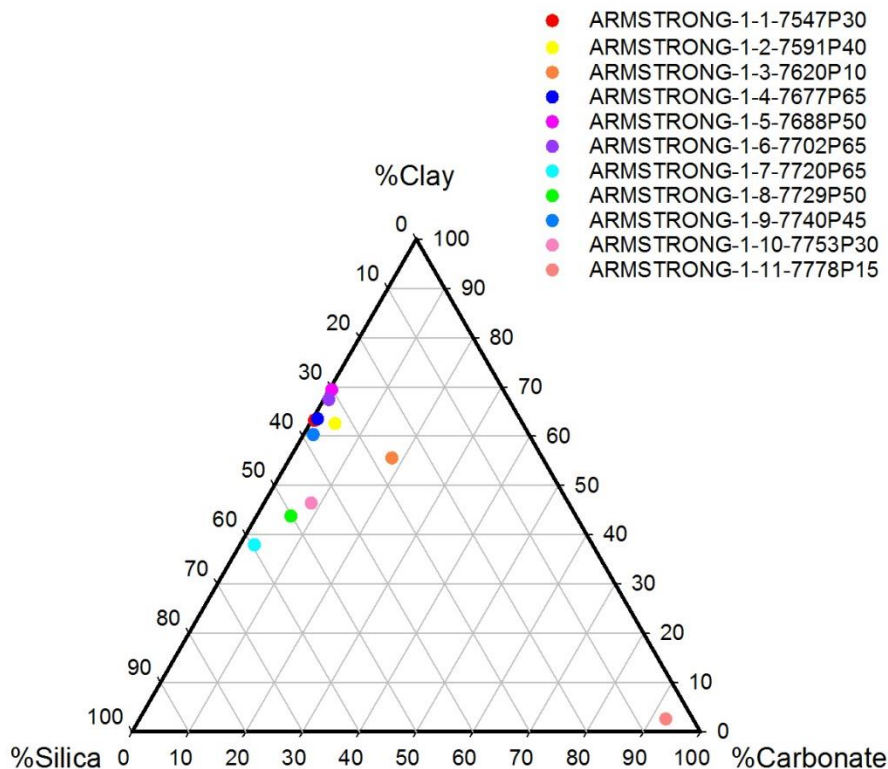
The samples are presented with laminae oriented approximately horizontally. The long axis of the plug was labeled as the Y-axis. Similarly, the X-axis was chosen for the other axis parallel to the laminations. The Z-axis is perpendicular to the X and Y axes and is thus parallel to the vertical axis of the well.

A small volume of material from a carefully chosen location was removed from each of the 11 samples. A surface of the sub-sample was ion polished and then imaged with Ingrain's SEM system to produce sets of 2D images along the YZ plane for each sample at a resolution of approximately 15 nanometers per pixel. These images were digitally analyzed to quantify organic matter, porosity, porosity in organic matter, and high density minerals. Results are reported for each image and a cross-plot of Porosity vs. Organic Matter is provided for each sub-sample.

Attachments to the report contain additional high resolution images to permit more detailed visual examination. These attachments are provided in a digital subdirectory called "Attachment 3 (2D SEM Images)".

Juliana Anderson, Lead Geologist
Vanessa Mendoza, Project Geologist

Summary of Average XRF Data – Armstrong #1

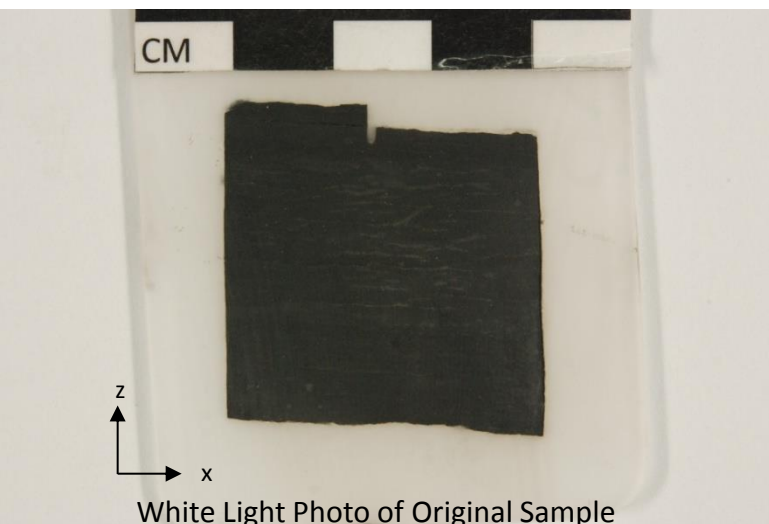


			Average mineralogy by weight percentage		
Sample	Depth (ft.)	Bulk Density (g/cm ³)	Silica	Clay	Carbonate
1	7547.30	2.63	36	63	0
2	7591.40	2.69	33	63	4
3	7620.10	2.77	27	56	18
4	7677.65	2.62	36	64	1
5	7688.50	2.58	30	69	0
6	7702.65	2.52	32	67	1
7	7720.65	2.46	60	38	3
8	7729.50	2.40	50	44	6
9	7740.45	2.45	38	60	2
10	7753.30	2.47	45	46	8
11	7778.15	2.66	5	3	93

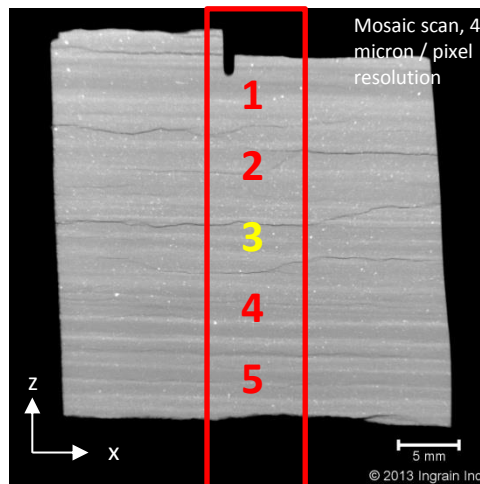
Summary of Results – 2D SEM

Sample #	Depth (ft.)	Average Porosity (%)	Average Organic Matter (%)	Average Porosity in Organic Matter (%)	Average High Density Material (%)
1	7547.30	1.2	3.5	0.7	1.2
2	7591.40	0.7	0.7	0.1	0.2
3	7620.10	1.8	0.4	0.0	0.0
4	7677.65	0.7	4.6	0.3	2.0
5	7688.50	0.9	7.9	0.6	5.0
6	7702.65	1.6	7.3	0.8	2.9
7	7720.65	1.6	13.7	1.3	3.4
8	7729.50	0.3	23.6	0.2	1.9
9	7740.45	0.8	13.2	0.5	2.7
10	7753.30	0.9	14.5	0.5	2.2
11	7778.15	0.9	6.4	0.4	0.6

Micro-XCT Imaging and SEM Sample Selection

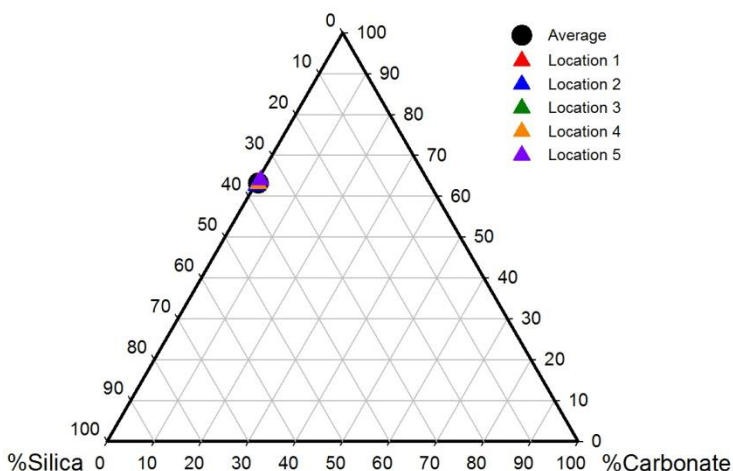


White Light Photo of Original Sample



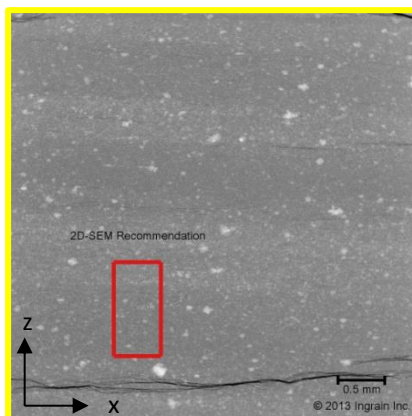
XCT Image Resolution - 21 µm per pixel

See attached image file : ARMSTRONG-1-1-7547P3_4X



XRF Elemental Analysis

	Mineralogy by weight percentage		
Location	Silica	Clay	Carbonate
Location 1	36	63	0
Location 2	37	63	0
Location 3	36	63	1
Location 4	36	63	1
Location 5	35	64	1
Average	36	63	0

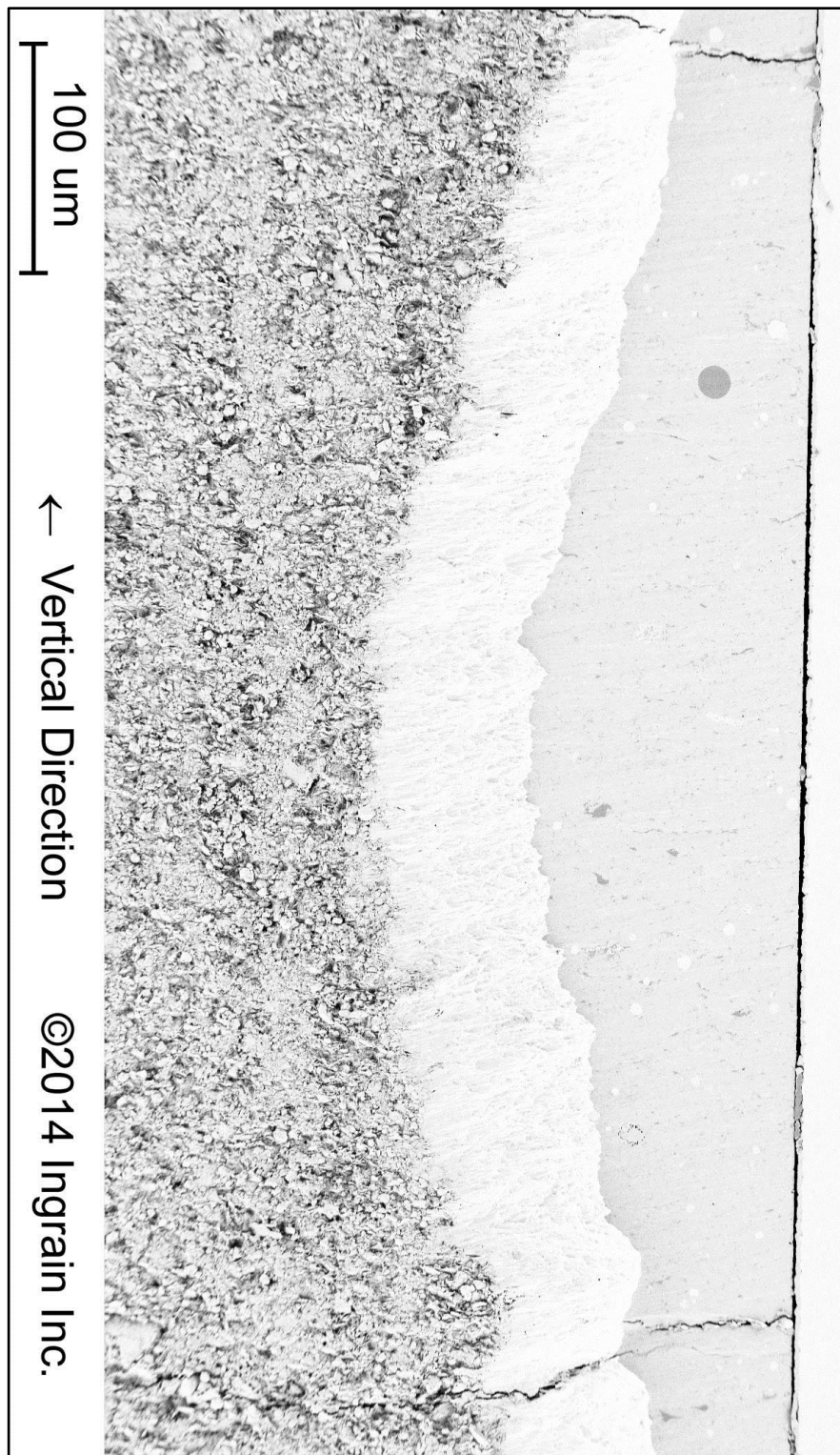


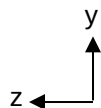
XCT Image Resolution - 4 µm per pixel

Location #3 is recommended for 2D-SEM

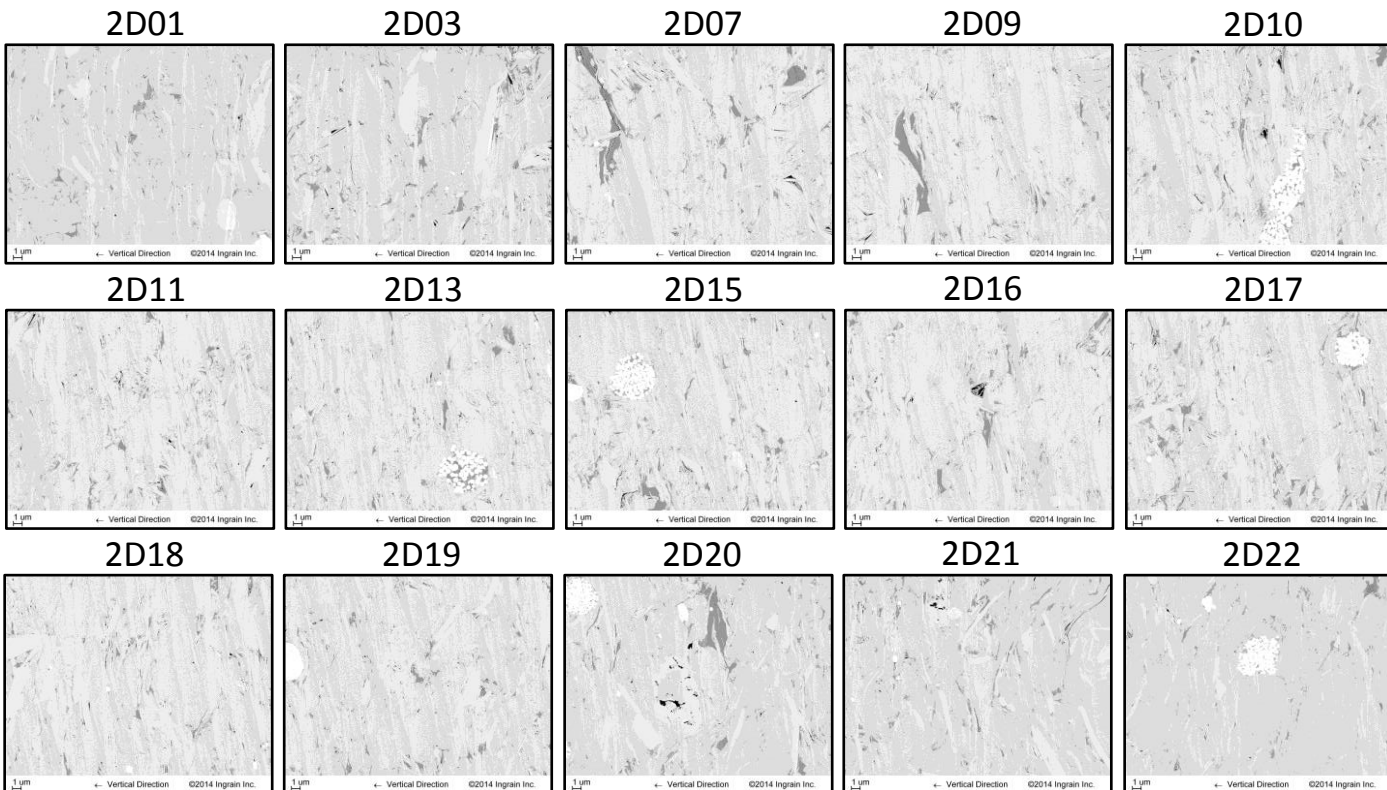
See attached image file : ARMSTRONG-1-1-7547P3_4X_TILE

2D SEM Overview



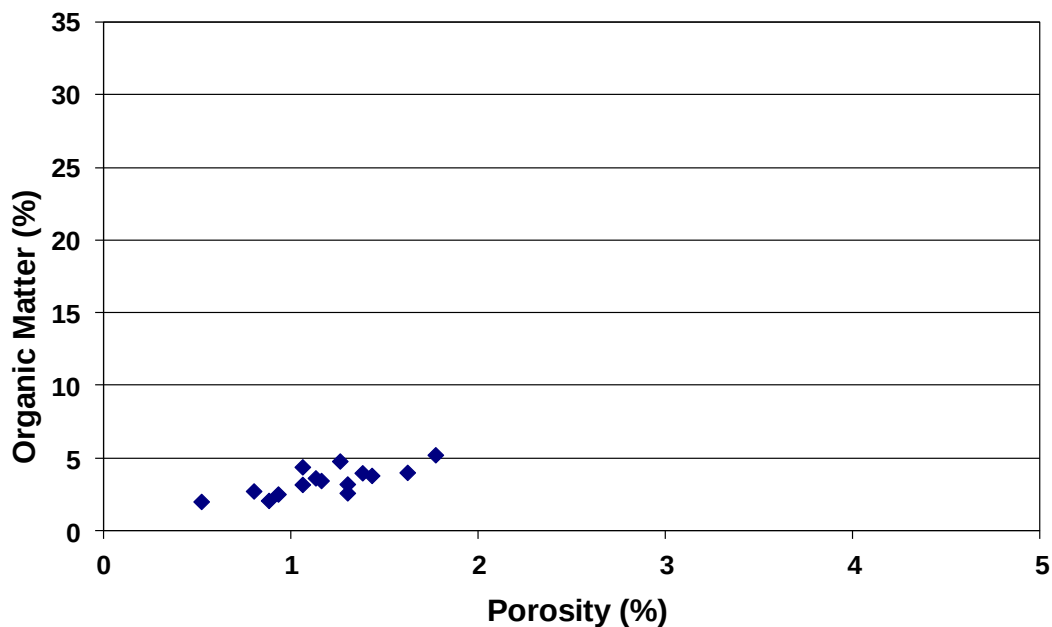


2D SEM Images @ 10 nm per pixel



2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D01	0.8	2.7	0.5	0.0
2D03	1.6	4.0	0.9	0.1
2D07	1.8	5.2	1.2	0.3
2D09	1.1	3.6	0.7	0.1
2D10	1.4	3.8	0.8	3.8
2D11	1.3	3.2	0.9	0.0
2D13	1.1	3.2	0.8	2.2
2D15	1.4	4.0	0.9	3.0
2D16	1.2	3.5	0.7	0.0
2D17	1.3	4.8	0.9	1.7
2D18	0.9	2.5	0.6	0.4
2D19	0.9	2.1	0.5	1.1
2D20	1.1	4.4	0.4	2.1
2D21	1.3	2.6	0.7	0.1
2D22	0.5	2.0	0.3	2.6

2D SEM Summary

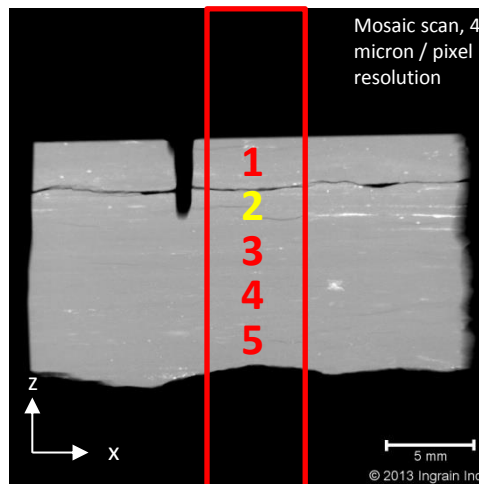


2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D01	0.8	2.7	0.5	0.0
2D03	1.6	4.0	0.9	0.1
2D07	1.8	5.2	1.2	0.3
2D09	1.1	3.6	0.7	0.1
2D10	1.4	3.8	0.8	3.8
2D11	1.3	3.2	0.9	0.0
2D13	1.1	3.2	0.8	2.2
2D15	1.4	4.0	0.9	3.0
2D16	1.2	3.5	0.7	0.0
2D17	1.3	4.8	0.9	1.7
2D18	0.9	2.5	0.6	0.4
2D19	0.9	2.1	0.5	1.1
2D20	1.1	4.4	0.4	2.1
2D21	1.3	2.6	0.7	0.1
2D22	0.5	2.0	0.3	2.6

Micro-XCT Imaging and SEM Sample Selection

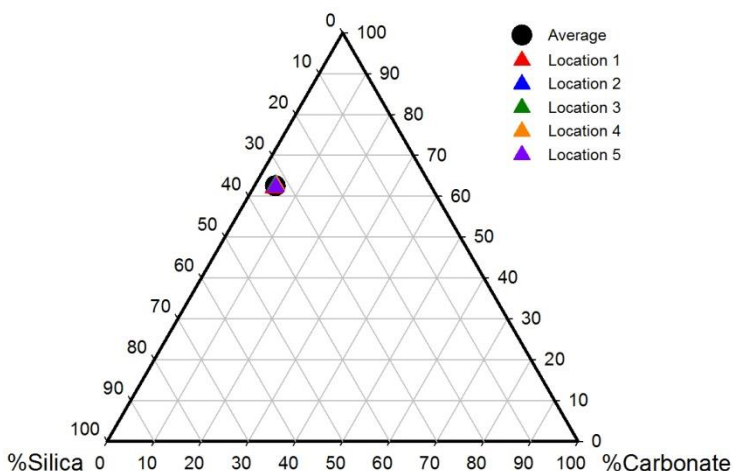


White Light Photo of Original Sample



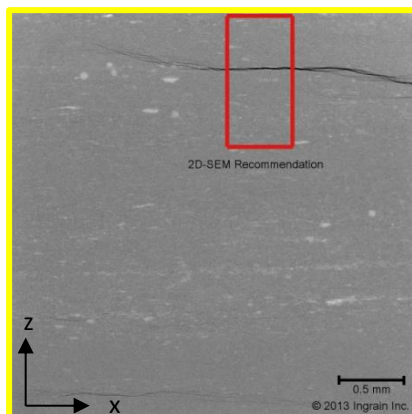
XCT Image Resolution - 15 µm per pixel

See attached image file : ARMSTRONG-1-2-7591P4_4X



XRF Elemental Analysis

	Mineralogy by weight percentage		
Location	Silica	Clay	Carbonate
Location 1	34	62	4
Location 2	33	63	4
Location 3	33	63	4
Location 4	33	63	5
Location 5	33	62	5
Average	33	63	4

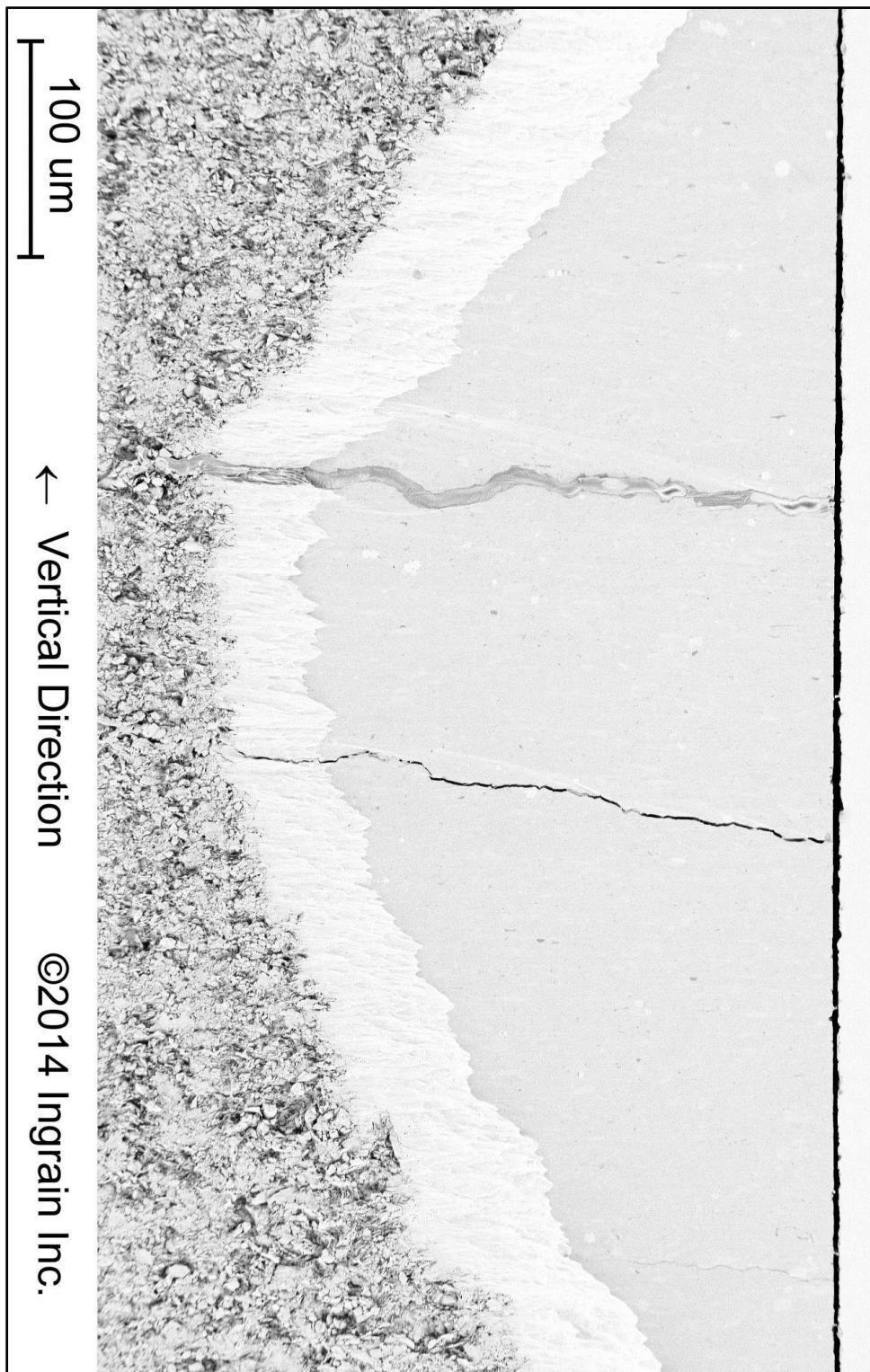


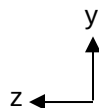
XCT Image Resolution - 4 µm per pixel

Location #2 is recommended for 2D-SEM

See attached image file : ARMSTRONG-1-2-7591P4_4X_TILE

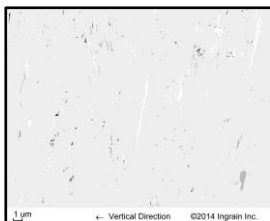
2D SEM Overview



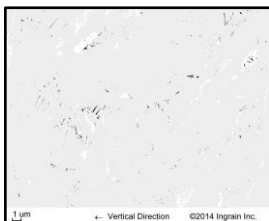


2D SEM Images @ 10 nm per pixel

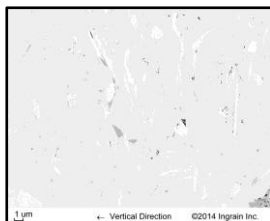
2D02



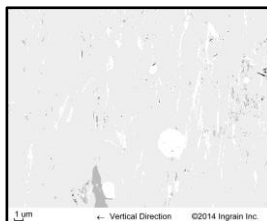
2D03



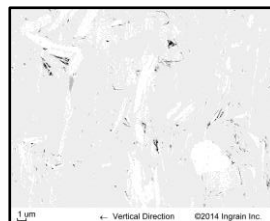
2D04



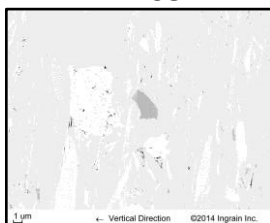
2D06



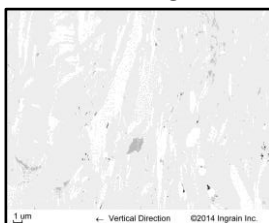
2D08



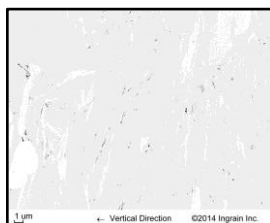
2D09



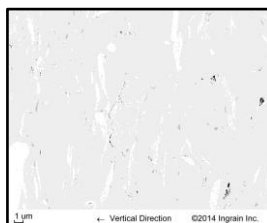
2D10



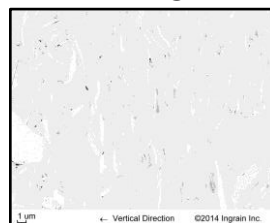
2D11



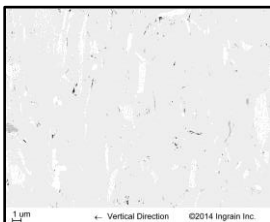
2D12



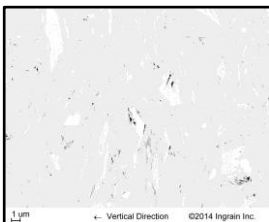
2D13



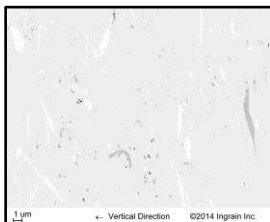
2D14



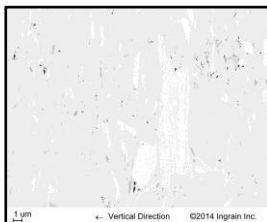
2D15



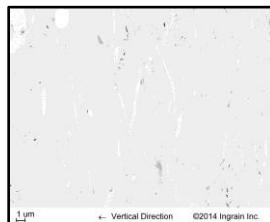
2D16



2D17

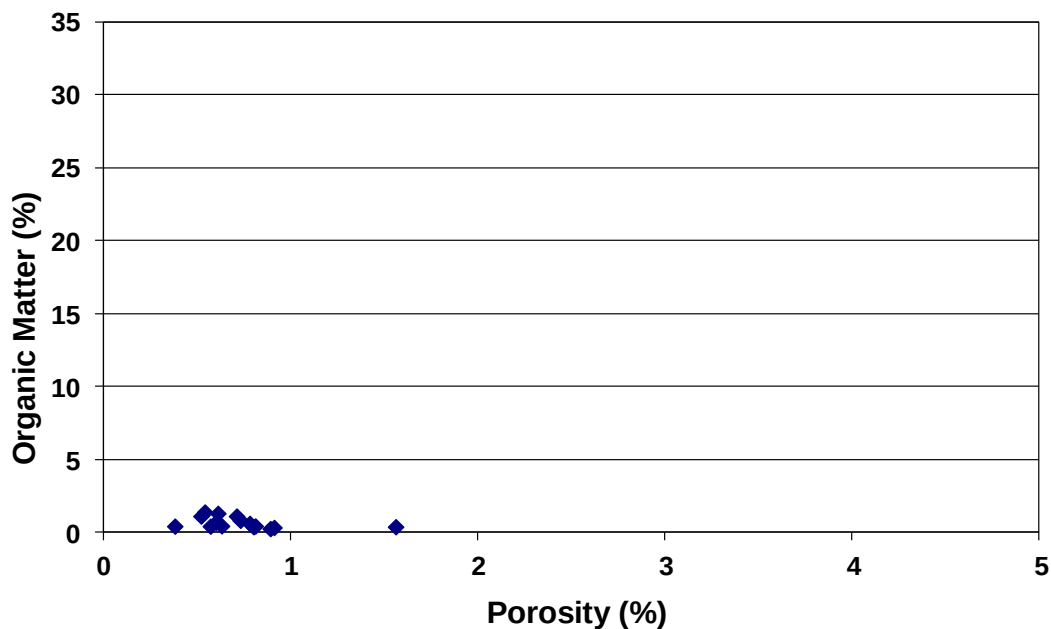


2D20



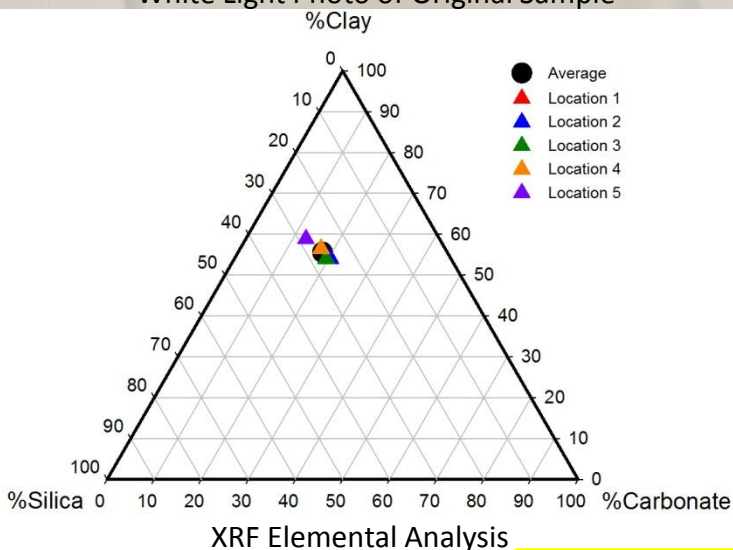
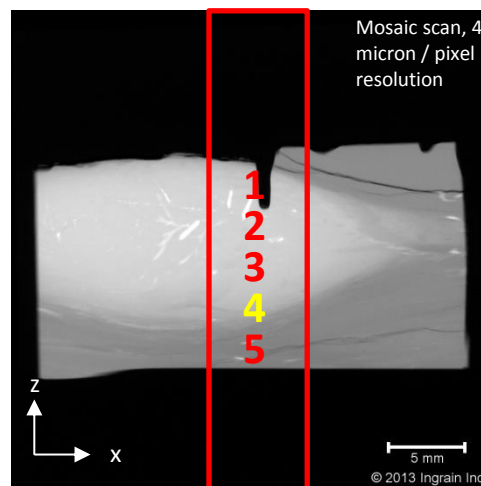
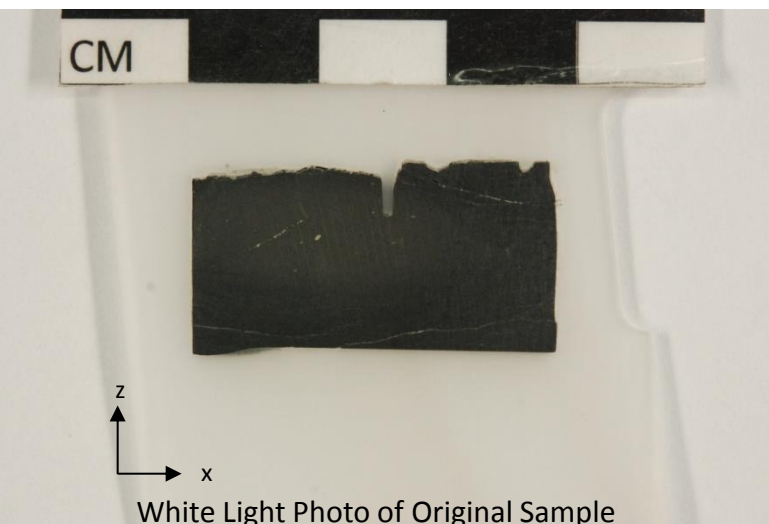
2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D02	0.8	0.4	0.0	0.0
2D03	0.9	0.3	0.1	0.6
2D04	0.6	1.3	0.3	0.1
2D06	0.5	1.4	0.2	1.2
2D08	1.6	0.4	0.3	0.0
2D09	0.7	1.1	0.1	0.0
2D10	0.5	1.1	0.1	0.3
2D11	0.6	0.4	0.2	0.0
2D12	0.6	0.4	0.1	0.0
2D13	0.6	0.7	0.1	0.0
2D14	0.8	0.4	0.1	0.4
2D15	0.9	0.3	0.1	0.6
2D16	0.7	0.8	0.1	0.0
2D17	0.8	0.6	0.2	0.0
2D20	0.4	0.4	0.1	0.4

2D SEM Summary

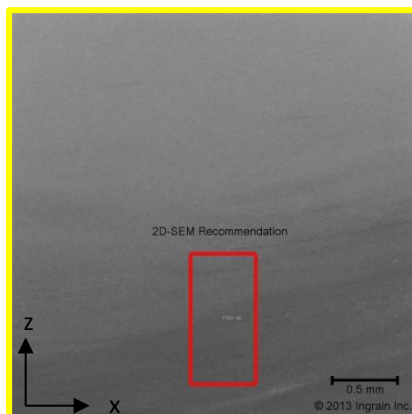


2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D02	0.8	0.4	0.0	0.0
2D03	0.9	0.3	0.1	0.6
2D04	0.6	1.3	0.3	0.1
2D06	0.5	1.4	0.2	1.2
2D08	1.6	0.4	0.3	0.0
2D09	0.7	1.1	0.1	0.0
2D10	0.5	1.1	0.1	0.3
2D11	0.6	0.4	0.2	0.0
2D12	0.6	0.4	0.1	0.0
2D13	0.6	0.7	0.1	0.0
2D14	0.8	0.4	0.1	0.4
2D15	0.9	0.3	0.1	0.6
2D16	0.7	0.8	0.1	0.0
2D17	0.8	0.6	0.2	0.0
2D20	0.4	0.4	0.1	0.4

Micro-XCT Imaging and SEM Sample Selection

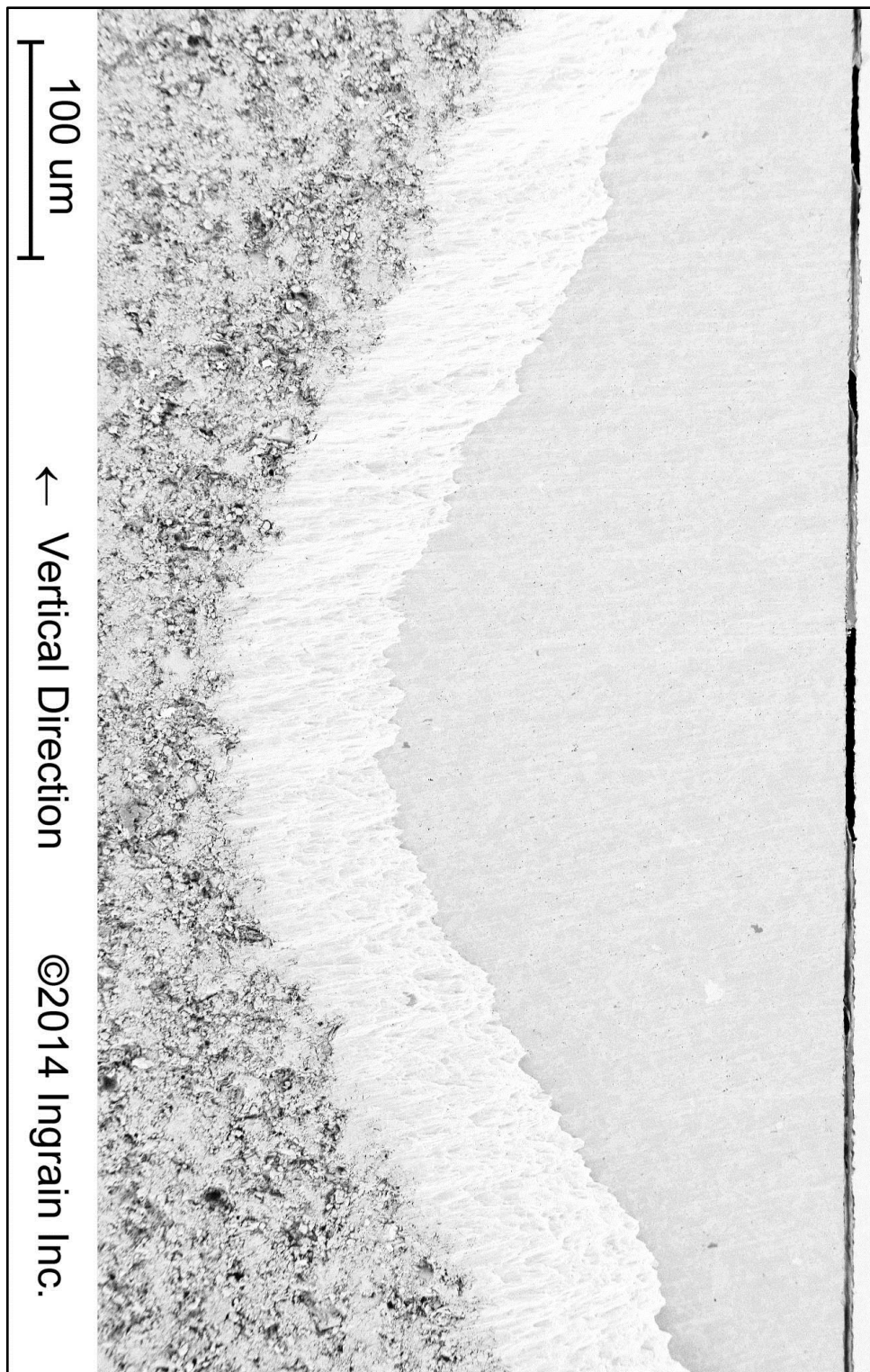


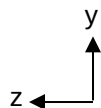
	Mineralogy by weight percentage		
Location	Silica	Clay	Carbonate
Location 1	26	54	20
Location 2	26	54	20
Location 3	27	54	19
Location 4	26	56	17
Location 5	28	59	13
Average	27	56	18



XCT Image Resolution - 4 µm per pixel
Location #4 is recommended for 2D-SEM
See attached image file : ARMSTRONG-1-3-7620P1_4X_TILE

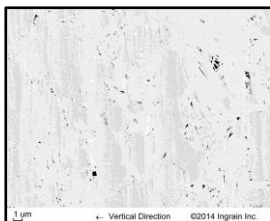
2D SEM Overview



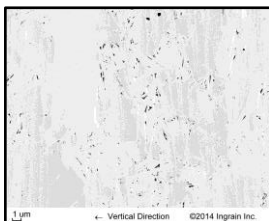


2D SEM Images @ 10 nm per pixel

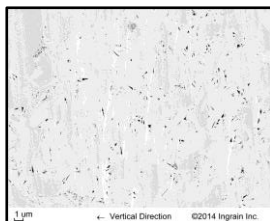
2D05



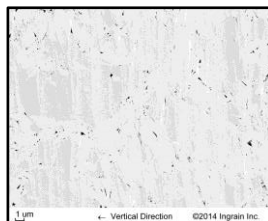
2D06



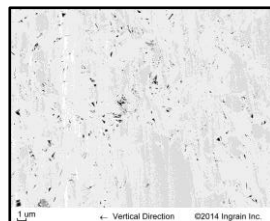
2D08



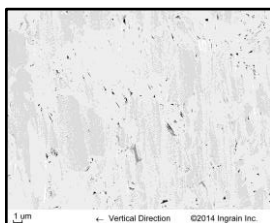
2D09



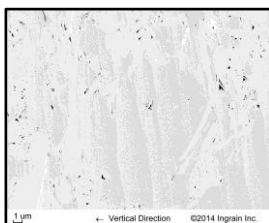
2D10



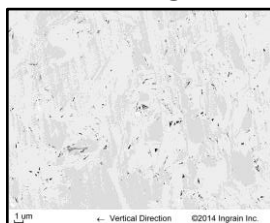
2D11



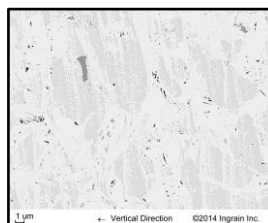
2D12



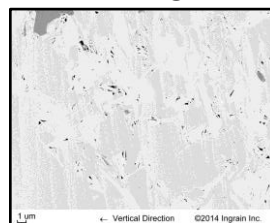
2D13



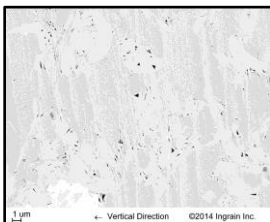
2D14



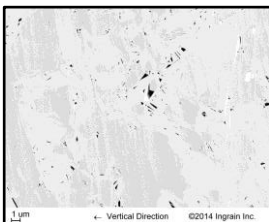
2D15



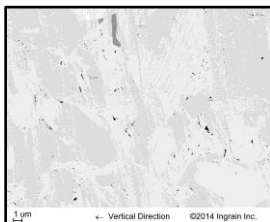
2D16



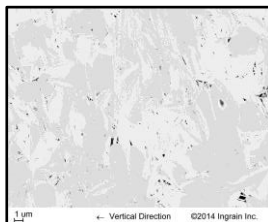
2D17



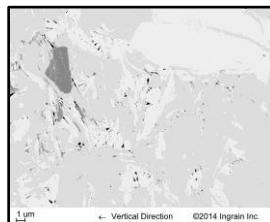
2D18



2D19

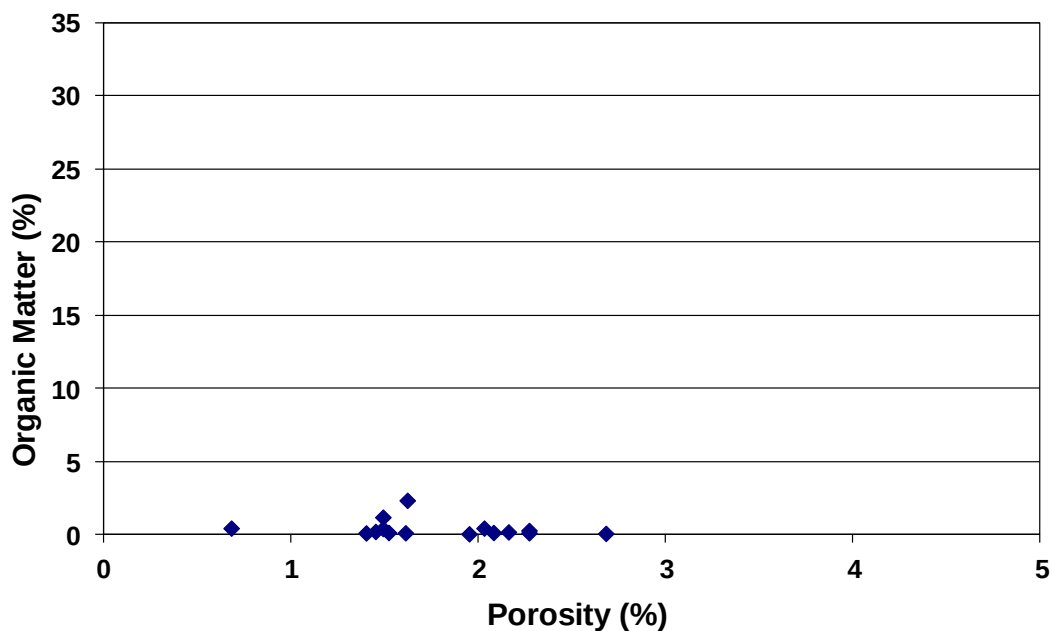


2D20



2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D05	2.3	0.1	0.0	0.0
2D06	2.7	0.1	0.0	0.0
2D08	2.1	0.1	0.0	0.0
2D09	1.5	0.1	0.0	0.0
2D10	2.3	0.3	0.1	0.0
2D11	2.0	0.4	0.1	0.0
2D12	1.6	0.1	0.0	0.2
2D13	2.2	0.2	0.0	0.0
2D14	1.5	0.4	0.0	0.0
2D15	1.5	1.2	0.1	0.0
2D16	1.5	0.2	0.0	0.0
2D17	2.0	0.1	0.0	0.2
2D18	0.7	0.4	0.0	0.0
2D19	1.4	0.1	0.0	0.0
2D20	1.6	2.3	0.2	0.0

2D SEM Summary

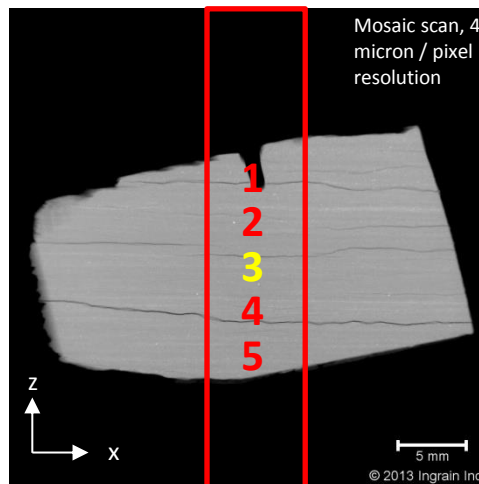


2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D05	2.3	0.1	0.0	0.0
2D06	2.7	0.1	0.0	0.0
2D08	2.1	0.1	0.0	0.0
2D09	1.5	0.1	0.0	0.0
2D10	2.3	0.3	0.1	0.0
2D11	2.0	0.4	0.1	0.0
2D12	1.6	0.1	0.0	0.2
2D13	2.2	0.2	0.0	0.0
2D14	1.5	0.4	0.0	0.0
2D15	1.5	1.2	0.1	0.0
2D16	1.5	0.2	0.0	0.0
2D17	2.0	0.1	0.0	0.2
2D18	0.7	0.4	0.0	0.0
2D19	1.4	0.1	0.0	0.0
2D20	1.6	2.3	0.2	0.0

Micro-XCT Imaging and SEM Sample Selection

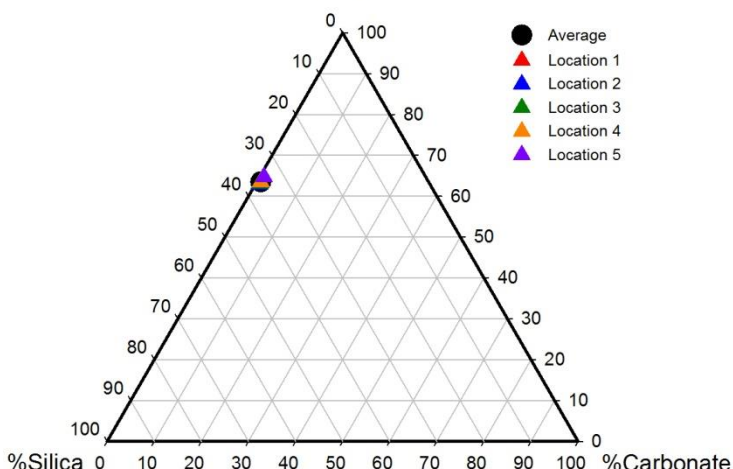


White Light Photo of Original Sample



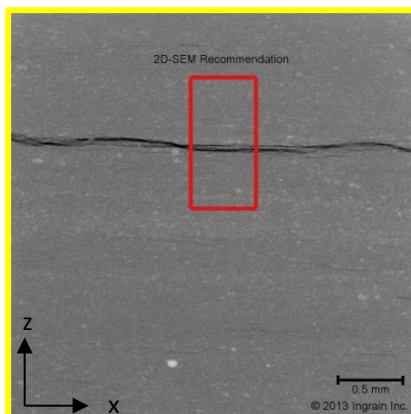
XCT Image Resolution - 19 μm per pixel

See attached image file : ARMSTRONG-1-4-7577P65_4X



XRF Elemental Analysis

Mineralogy by weight percentage			
Location	Silica	Clay	Carbonate
Location 1	36	63	1
Location 2	36	63	1
Location 3	36	63	1
Location 4	36	64	1
Location 5	34	65	1
Average	36	64	1

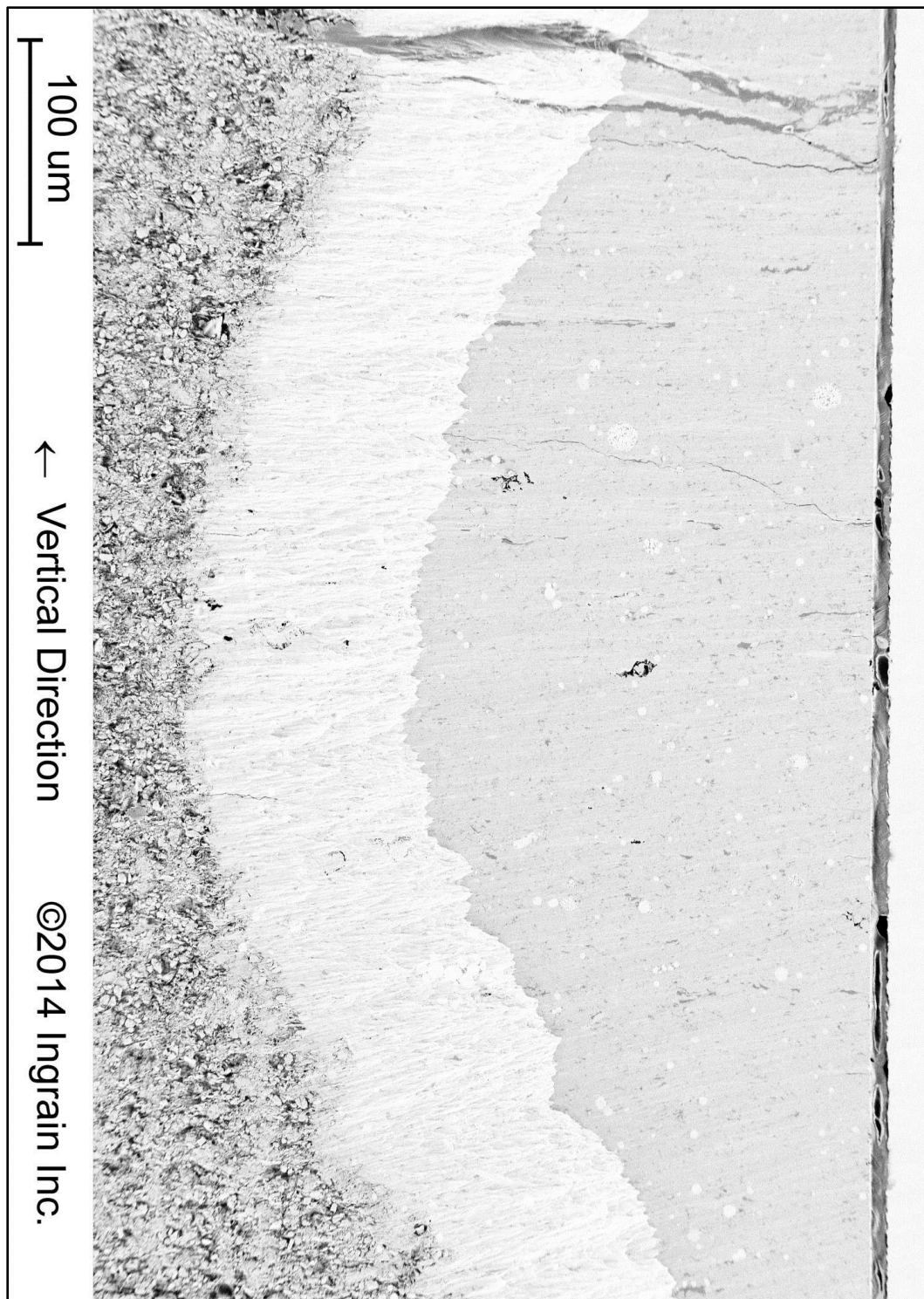


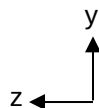
XCT Image Resolution - 4 μm per pixel

Location #3 is recommended for 2D-SEM

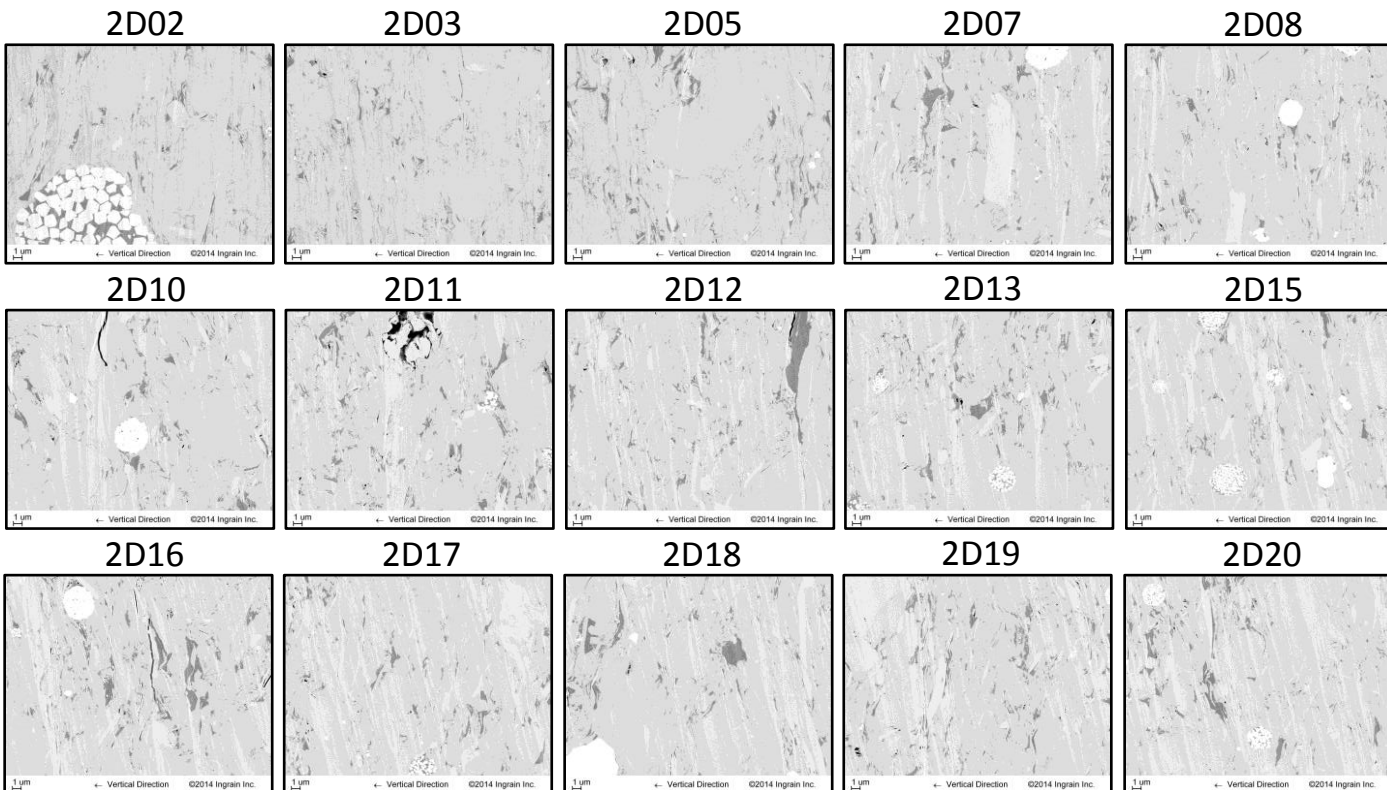
See attached image file : ARMSTRONG-1-4-7577P65_4X_TILE

2D SEM Overview



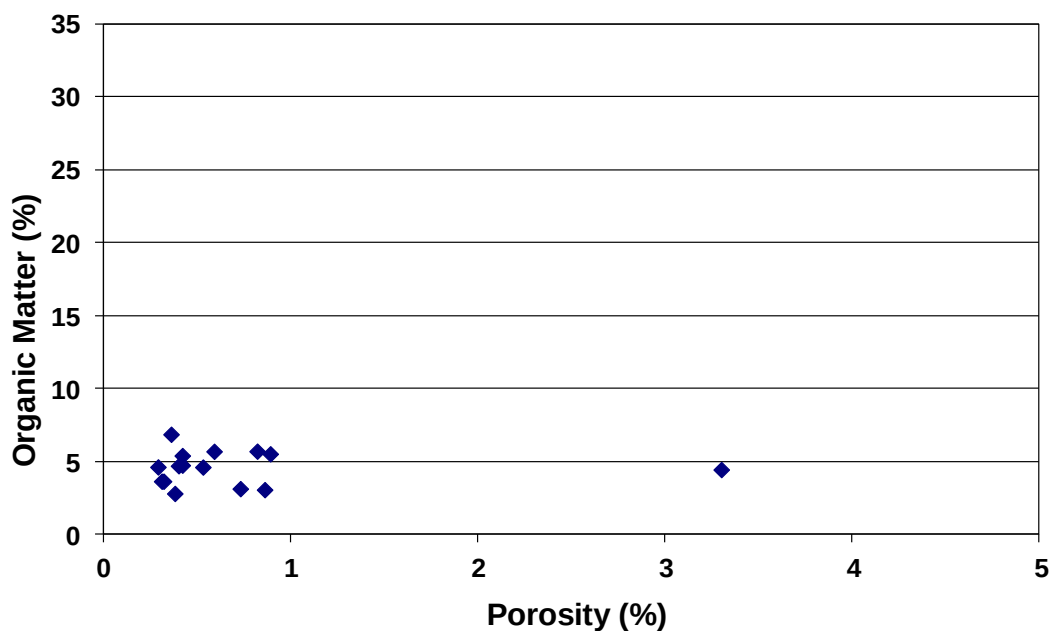


2D SEM Images @ 10 nm per pixel



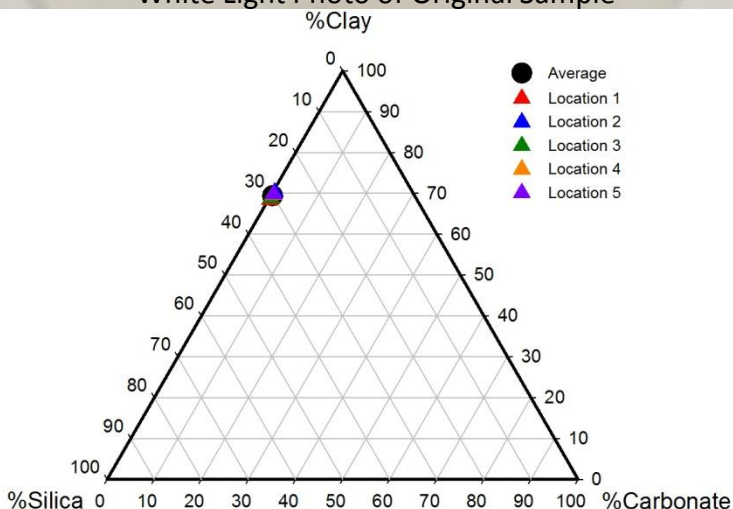
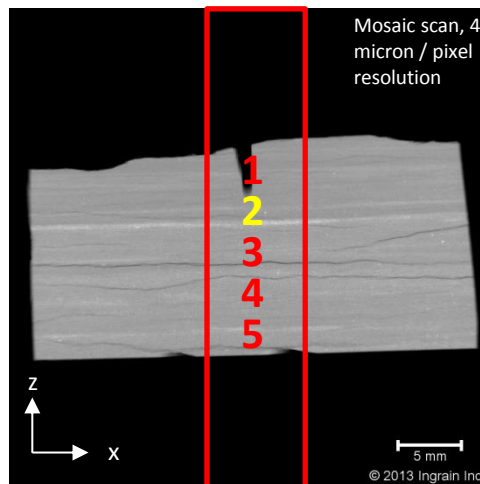
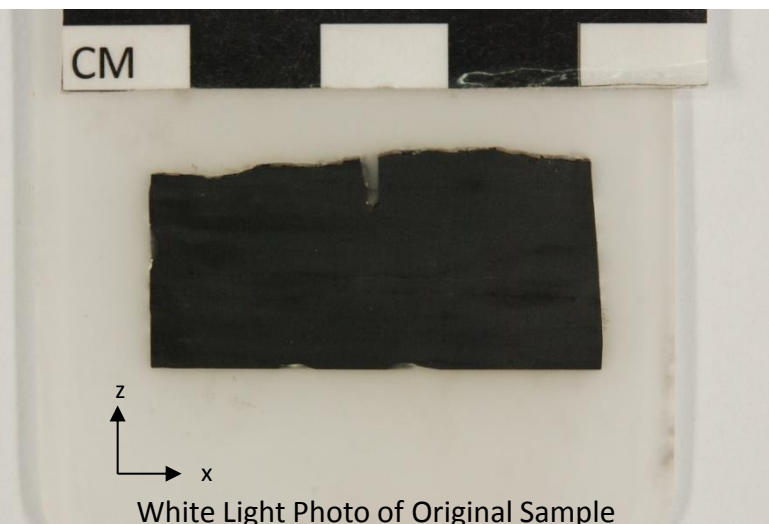
2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D02	0.4	6.9	0.2	11.4
2D03	0.4	2.8	0.2	0.2
2D05	0.4	4.7	0.2	0.2
2D07	0.5	4.6	0.3	1.6
2D08	0.7	3.1	0.4	1.6
2D10	0.9	3.1	0.4	1.9
2D11	3.3	4.4	0.5	0.6
2D12	0.8	5.7	0.4	0.1
2D13	0.6	5.7	0.4	1.3
2D15	0.3	3.6	0.2	3.7
2D16	0.9	5.5	0.4	1.8
2D17	0.3	3.6	0.2	0.5
2D18	0.3	4.6	0.2	3.2
2D19	0.4	5.4	0.3	0.2
2D20	0.4	4.7	0.2	1.4

2D SEM Summary

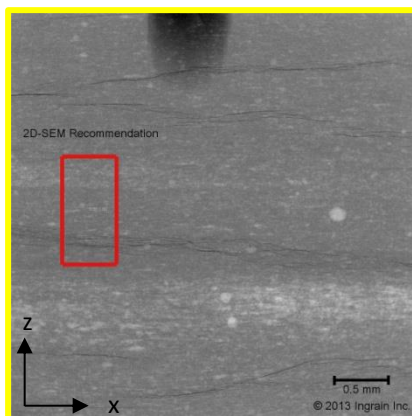


2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D02	0.4	6.9	0.2	11.4
2D03	0.4	2.8	0.2	0.2
2D05	0.4	4.7	0.2	0.2
2D07	0.5	4.6	0.3	1.6
2D08	0.7	3.1	0.4	1.6
2D10	0.9	3.1	0.4	1.9
2D11	3.3	4.4	0.5	0.6
2D12	0.8	5.7	0.4	0.1
2D13	0.6	5.7	0.4	1.3
2D15	0.3	3.6	0.2	3.7
2D16	0.9	5.5	0.4	1.8
2D17	0.3	3.6	0.2	0.5
2D18	0.3	4.6	0.2	3.2
2D19	0.4	5.4	0.3	0.2
2D20	0.4	4.7	0.2	1.4

Micro-XCT Imaging and SEM Sample Selection

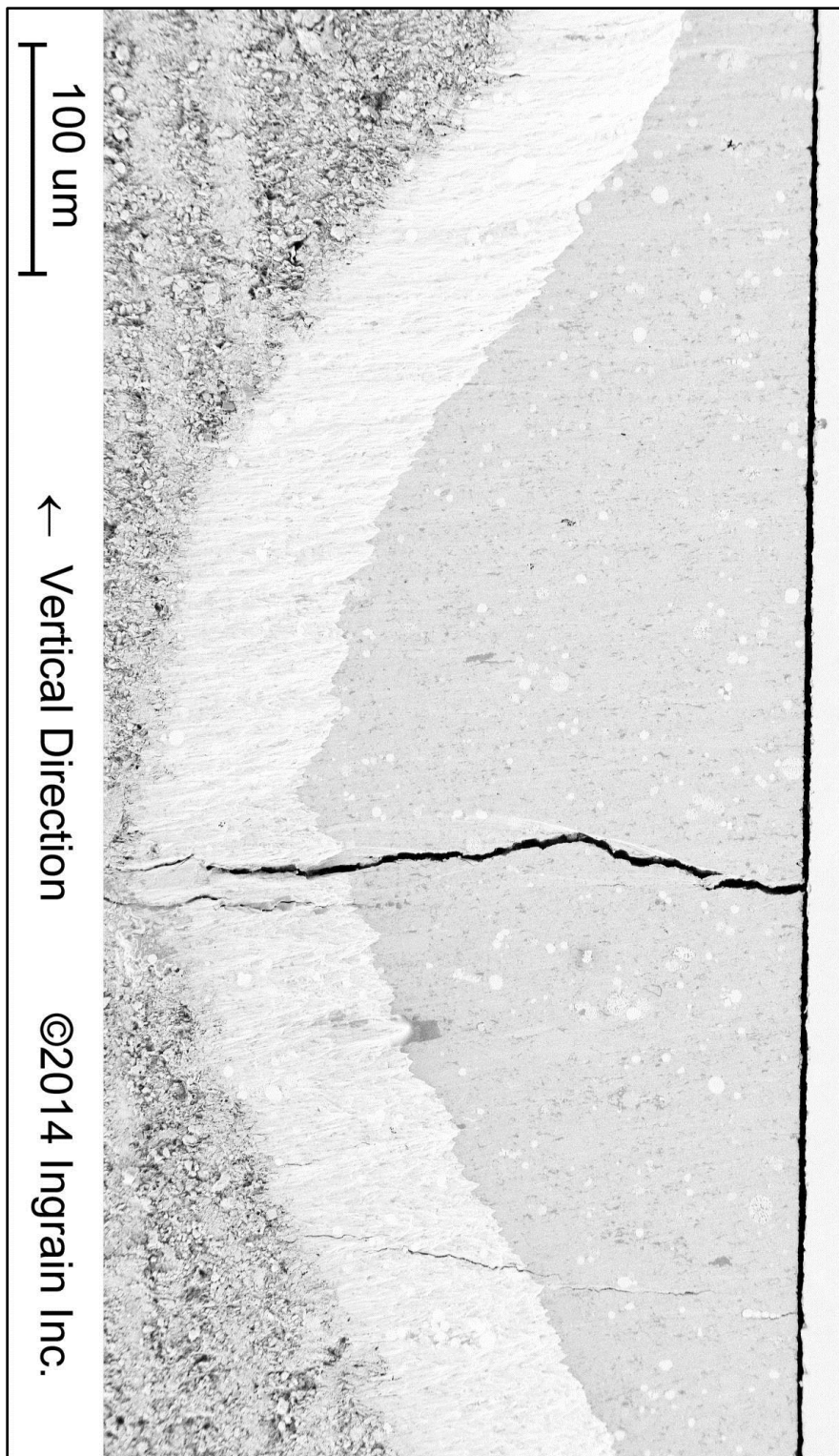


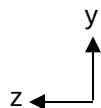
	Mineralogy by weight percentage		
Location	Silica	Clay	Carbonate
Location 1	31	69	0
Location 2	29	70	0
Location 3	31	69	0
Location 4	30	70	0
Location 5	30	70	0
Average	30	69	0



XCT Image Resolution - 4 µm per pixel
Location #2 is recommended for 2D-SEM
See attached image file : ARMSTRONG-1-5-7688P5_4X_TILE

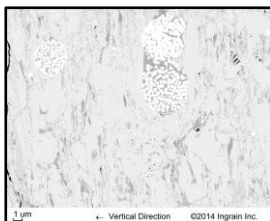
2D SEM Overview



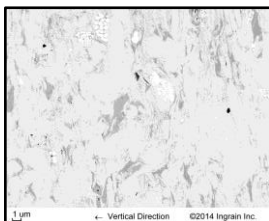


2D SEM Images @ 10 nm per pixel

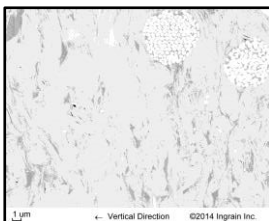
2D04



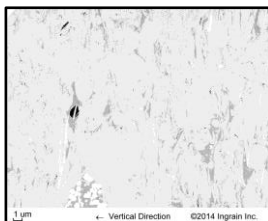
2D05



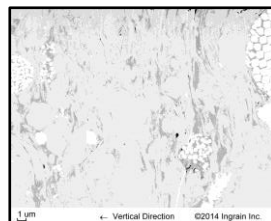
2D06



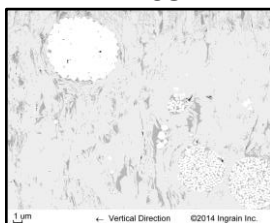
2D07



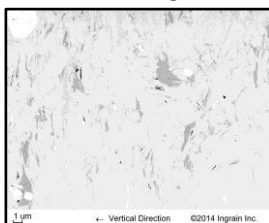
2D08



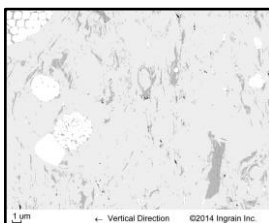
2D09



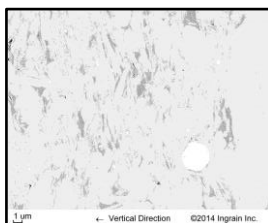
2D10



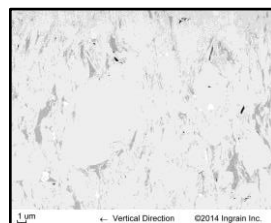
2D11



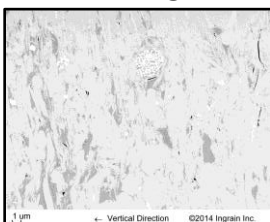
2D12



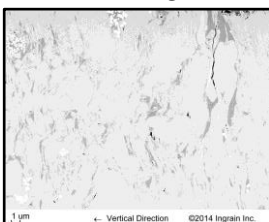
2D14



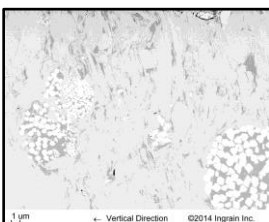
2D15



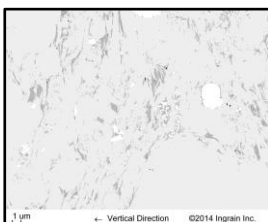
2D16



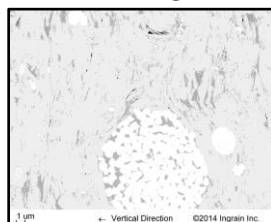
2D17



2D19

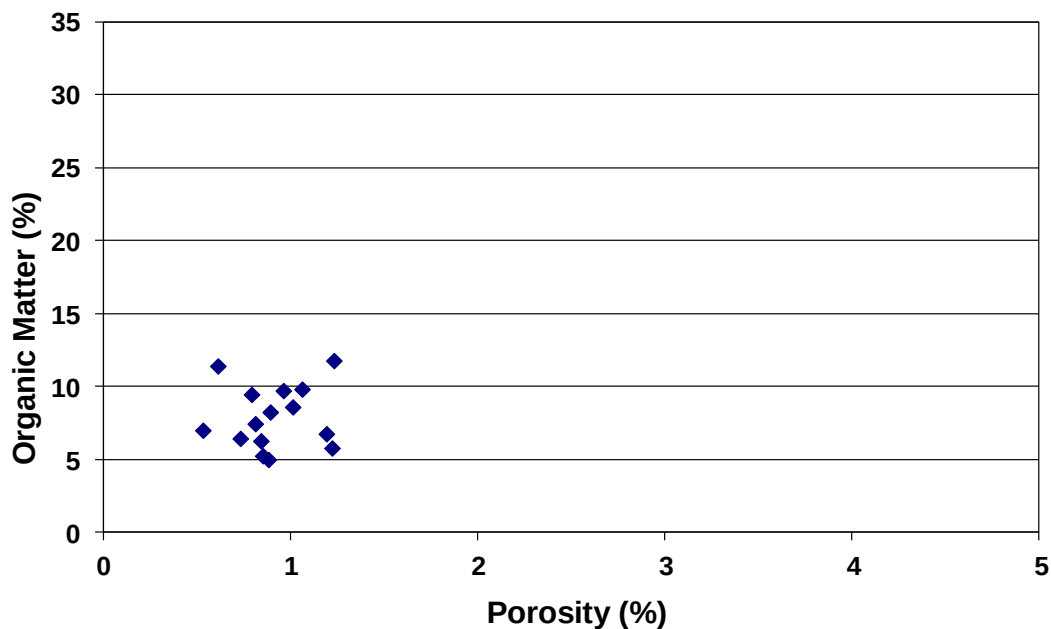


2D20



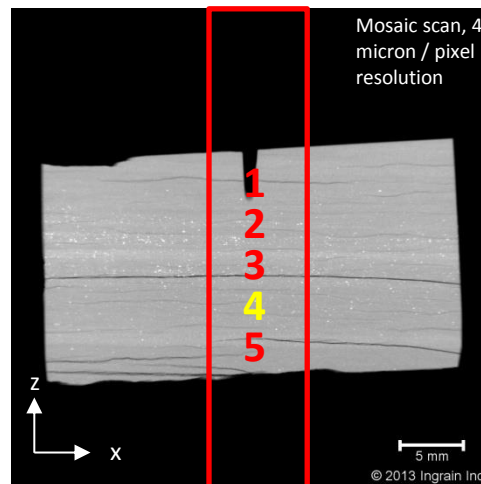
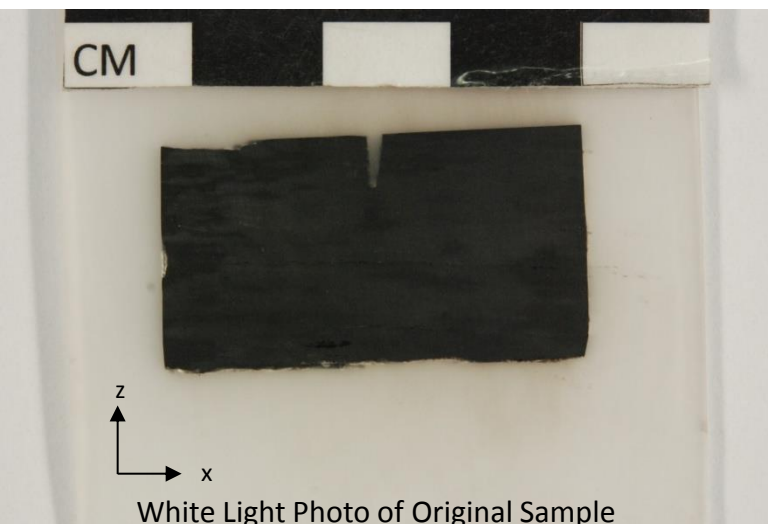
2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D04	0.8	9.5	0.4	6.4
2D05	0.6	11.4	0.4	1.0
2D06	1.0	8.6	0.7	6.3
2D07	1.2	5.8	0.8	1.1
2D08	1.1	9.8	0.8	7.7
2D09	0.9	8.3	0.6	12.4
2D10	0.9	5.0	0.4	1.8
2D11	0.8	7.5	0.6	6.2
2D12	0.7	6.4	0.5	1.2
2D14	0.8	6.3	0.5	0.2
2D15	1.2	11.8	0.9	1.2
2D16	1.2	6.8	0.6	0.9
2D17	1.0	9.7	0.6	10.7
2D19	0.9	5.3	0.6	2.1
2D20	0.5	7.0	0.3	15.9

2D SEM Summary



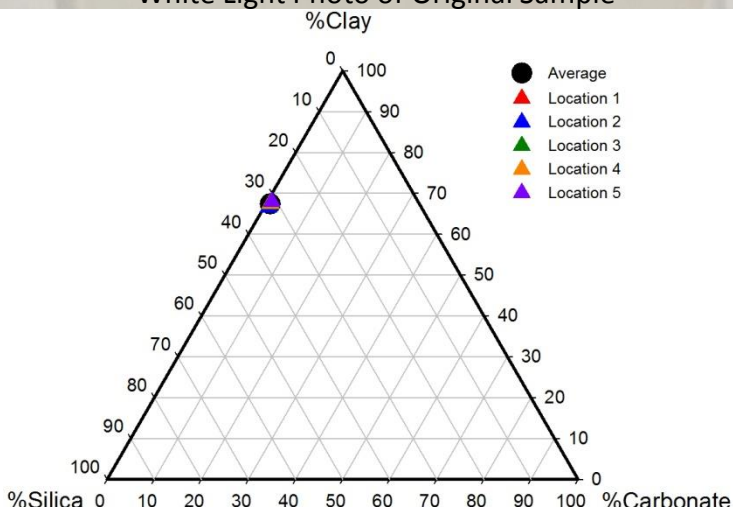
2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D04	0.8	9.5	0.4	6.4
2D05	0.6	11.4	0.4	1.0
2D06	1.0	8.6	0.7	6.3
2D07	1.2	5.8	0.8	1.1
2D08	1.1	9.8	0.8	7.7
2D09	0.9	8.3	0.6	12.4
2D10	0.9	5.0	0.4	1.8
2D11	0.8	7.5	0.6	6.2
2D12	0.7	6.4	0.5	1.2
2D14	0.8	6.3	0.5	0.2
2D15	1.2	11.8	0.9	1.2
2D16	1.2	6.8	0.6	0.9
2D17	1.0	9.7	0.6	10.7
2D19	0.9	5.3	0.6	2.1
2D20	0.5	7.0	0.3	15.9

Micro-XCT Imaging and SEM Sample Selection



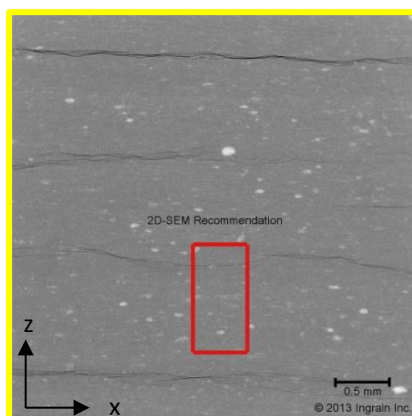
XCT Image Resolution - 19 μm per pixel

See attached image file : ARMSTRONG-1-6-7702P65_4X



XRF Elemental Analysis

	Mineralogy by weight percentage		
Location	Silica	Clay	Carbonate
Location 1	32	67	1
Location 2	32	67	1
Location 3	32	67	1
Location 4	32	68	1
Location 5	31	68	1
Average	32	67	1

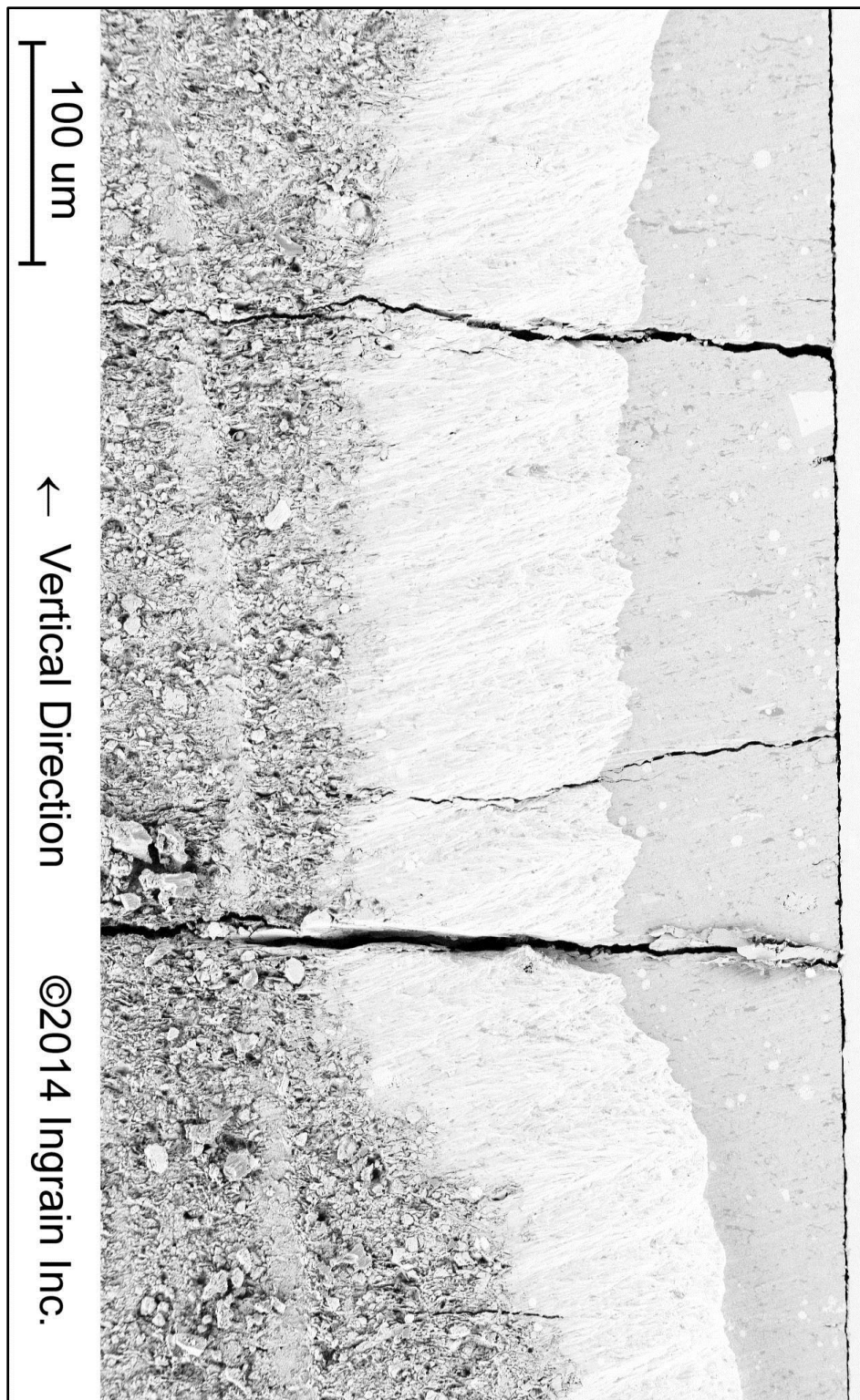


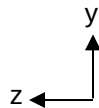
XCT Image Resolution - 4 μm per pixel

Location #4 is recommended for 2D-SEM

See attached image file : ARMSTRONG-1-6-7702P65_4X_TILE

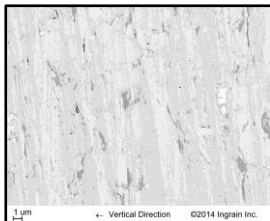
2D SEM Overview



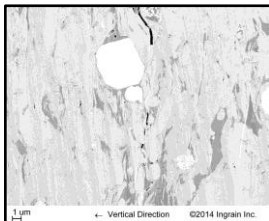


2D SEM Images @ 10 nm per pixel

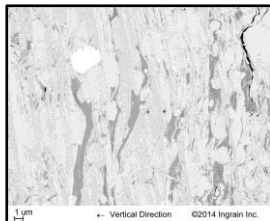
2D04



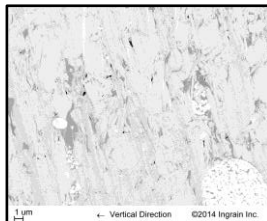
2D05



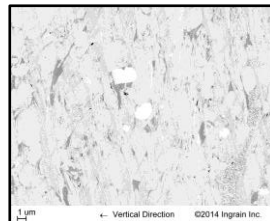
2D07



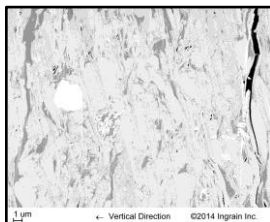
2D08



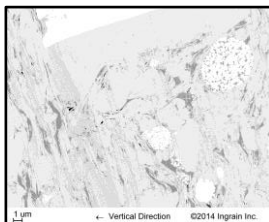
2D09



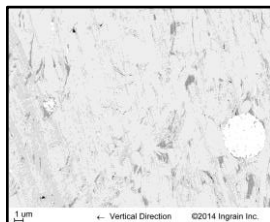
2D10



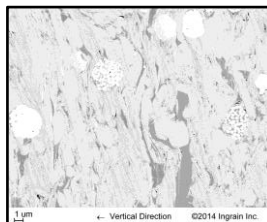
2D11



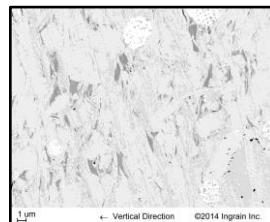
2D12



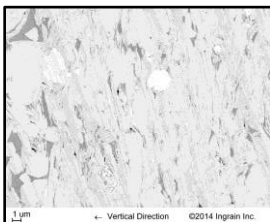
2D13



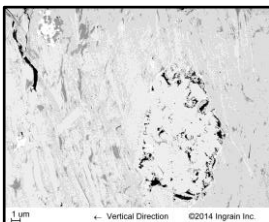
2D14



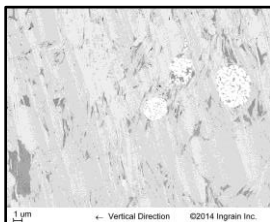
2D15



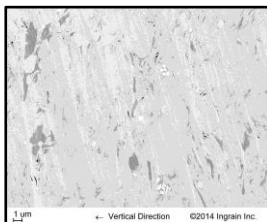
2D16



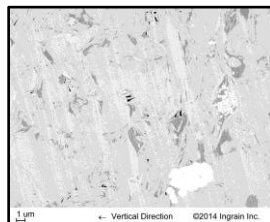
2D17



2D18

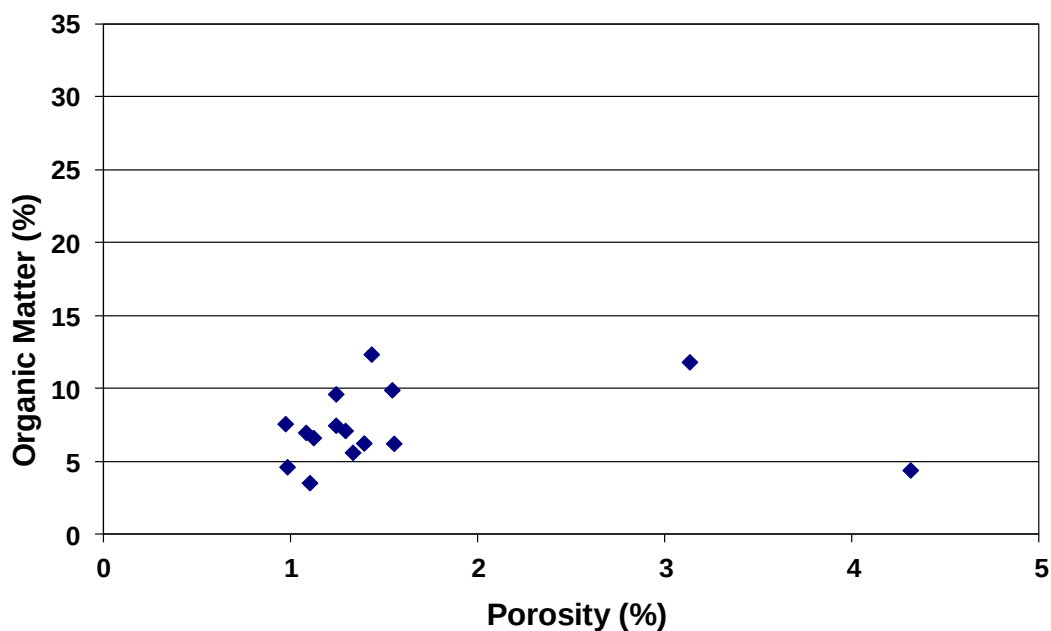


2D19



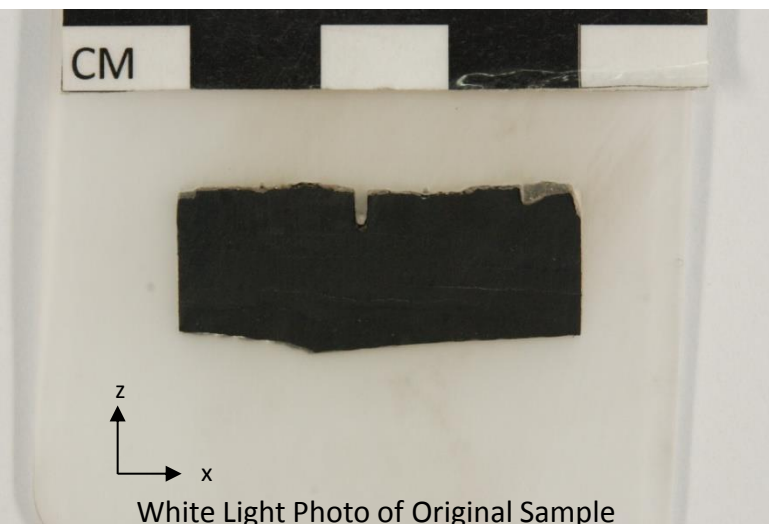
2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D04	1.0	4.6	0.6	0.4
2D05	1.2	9.6	0.7	4.8
2D07	1.4	12.4	0.7	1.1
2D08	1.1	7.0	0.6	5.1
2D09	1.4	6.3	0.8	1.5
2D10	3.1	11.8	1.5	2.1
2D11	1.2	7.5	0.9	9.2
2D12	1.1	3.5	0.6	3.0
2D13	1.5	9.9	1.1	5.1
2D14	1.3	5.6	0.6	3.1
2D15	1.6	6.2	1.0	1.1
2D16	4.3	4.4	0.8	0.6
2D17	1.0	7.6	0.7	3.3
2D18	1.1	6.6	0.7	0.4
2D19	1.3	7.1	0.8	2.8

2D SEM Summary

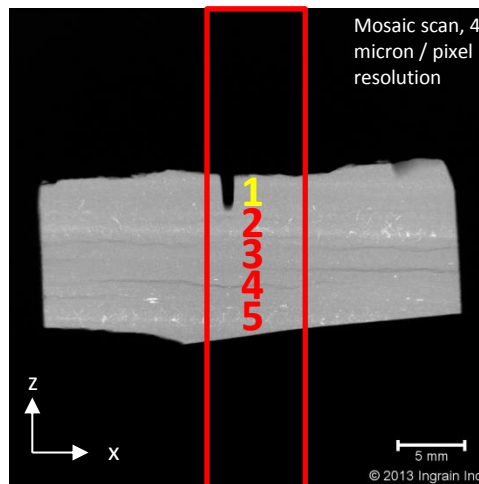


2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D04	1.0	4.6	0.6	0.4
2D05	1.2	9.6	0.7	4.8
2D07	1.4	12.4	0.7	1.1
2D08	1.1	7.0	0.6	5.1
2D09	1.4	6.3	0.8	1.5
2D10	3.1	11.8	1.5	2.1
2D11	1.2	7.5	0.9	9.2
2D12	1.1	3.5	0.6	3.0
2D13	1.5	9.9	1.1	5.1
2D14	1.3	5.6	0.6	3.1
2D15	1.6	6.2	1.0	1.1
2D16	4.3	4.4	0.8	0.6
2D17	1.0	7.6	0.7	3.3
2D18	1.1	6.6	0.7	0.4
2D19	1.3	7.1	0.8	2.8

Micro-XCT Imaging and SEM Sample Selection

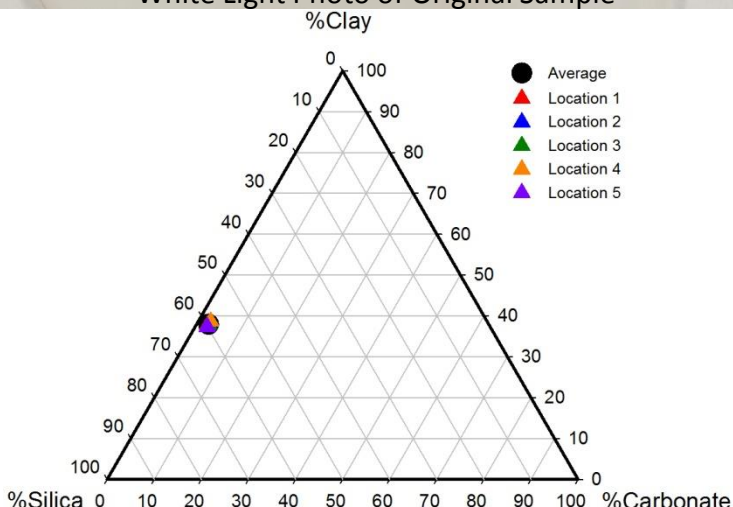


White Light Photo of Original Sample



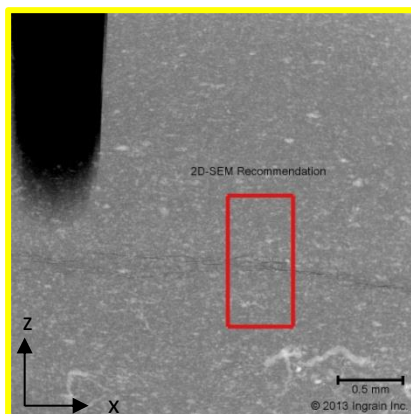
XCT Image Resolution - 19 μm per pixel

See attached image file : ARMSTRONG-1-7-7720P65_4X



XRF Elemental Analysis

	Mineralogy by weight percentage		
Location	Silica	Clay	Carbonate
Location 1	60	38	2
Location 2	59	38	3
Location 3	60	38	3
Location 4	59	39	3
Location 5	60	37	3
Average	60	38	3

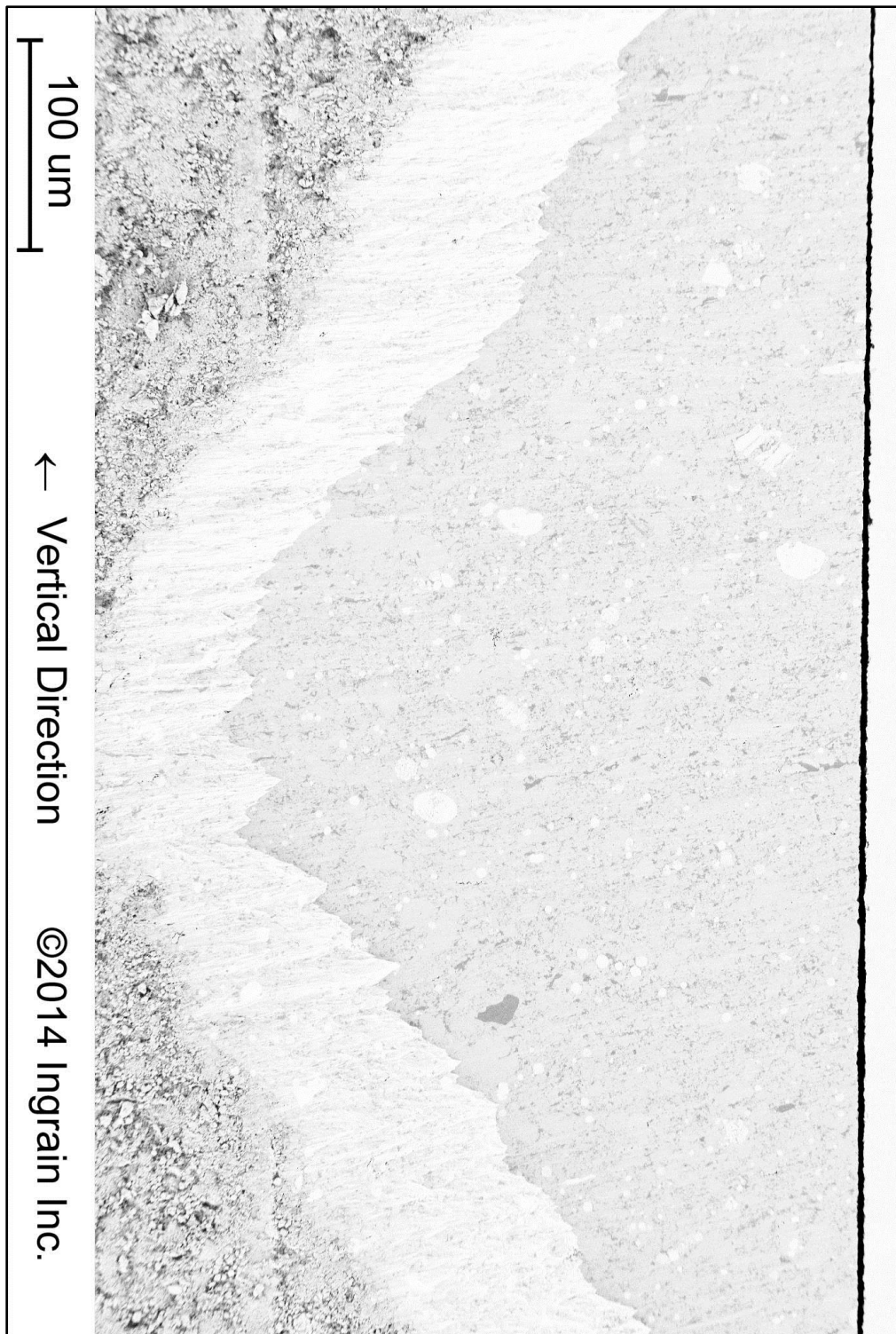


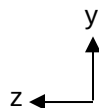
XCT Image Resolution - 4 μm per pixel

Location #1 is recommended for 2D-SEM

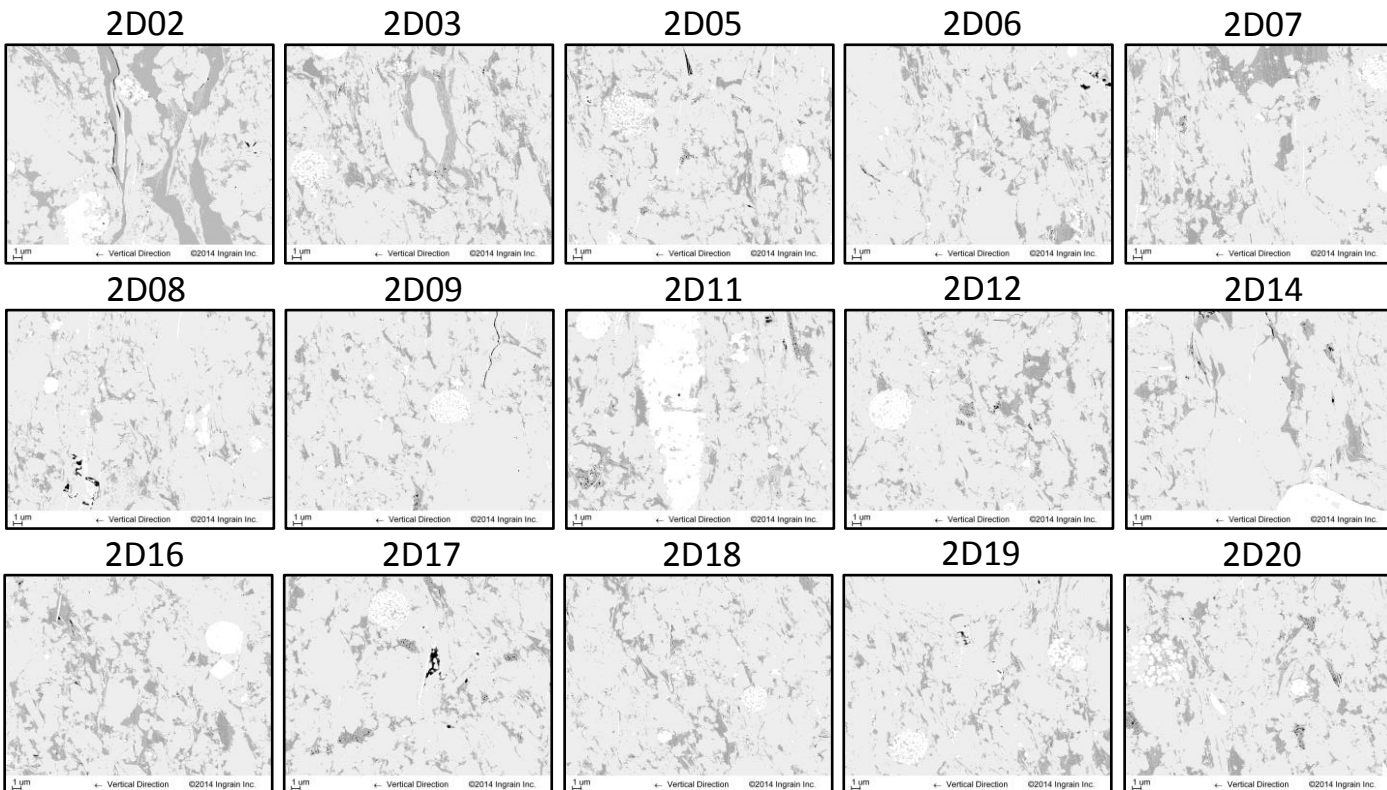
See attached image file : ARMSTRONG-1-7-7720P65_4X_TILE

2D SEM Overview



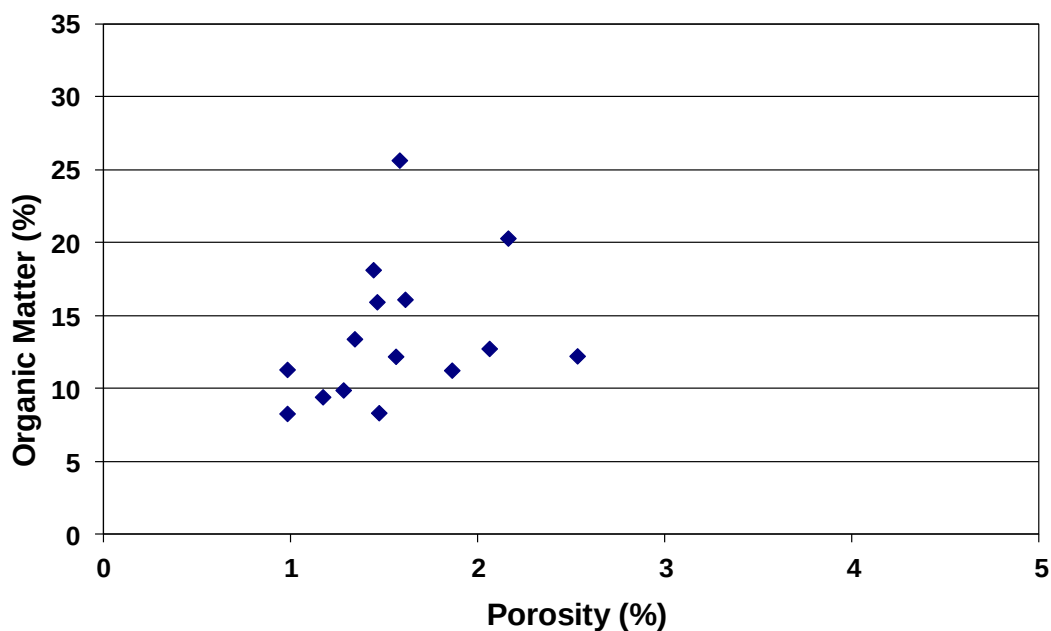


2D SEM Images @ 10 nm per pixel



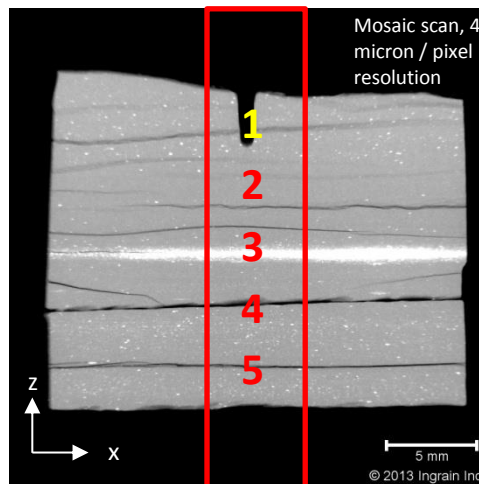
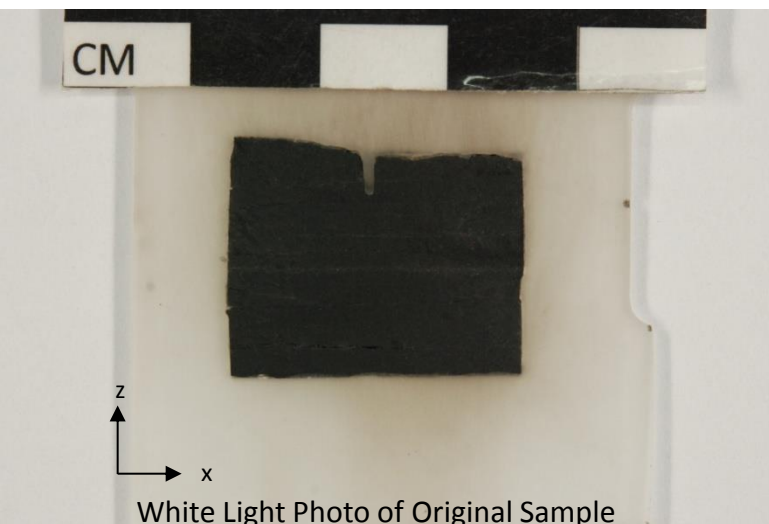
2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D02	1.6	25.7	1.2	4.0
2D03	2.2	20.3	2.1	2.5
2D05	2.1	12.8	1.8	3.2
2D06	1.9	11.3	1.4	0.7
2D07	1.6	16.1	1.5	2.3
2D08	1.5	8.3	1.0	1.1
2D09	1.0	8.3	0.8	2.1
2D11	1.3	13.4	1.3	18.3
2D12	1.6	12.2	1.4	2.6
2D14	1.3	9.9	1.0	4.0
2D16	1.4	18.2	1.4	2.6
2D17	2.5	12.2	1.9	1.7
2D18	1.2	9.4	1.0	1.3
2D19	1.0	11.3	0.7	2.5
2D20	1.5	16.0	1.4	2.5

2D SEM Summary

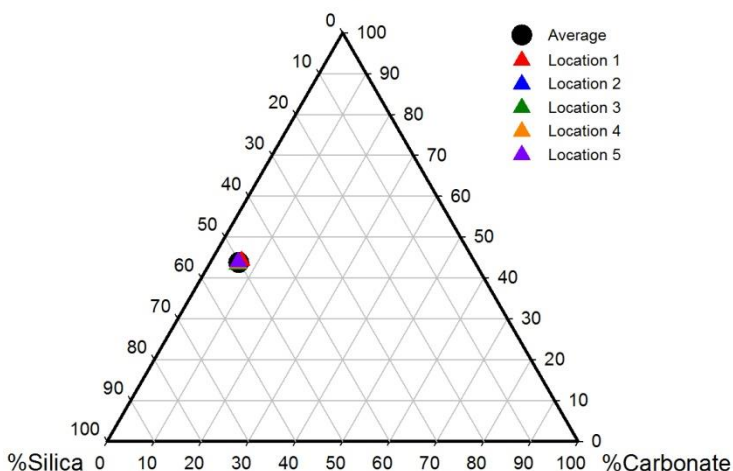


2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D02	1.6	25.7	1.2	4.0
2D03	2.2	20.3	2.1	2.5
2D05	2.1	12.8	1.8	3.2
2D06	1.9	11.3	1.4	0.7
2D07	1.6	16.1	1.5	2.3
2D08	1.5	8.3	1.0	1.1
2D09	1.0	8.3	0.8	2.1
2D11	1.3	13.4	1.3	18.3
2D12	1.6	12.2	1.4	2.6
2D14	1.3	9.9	1.0	4.0
2D16	1.4	18.2	1.4	2.6
2D17	2.5	12.2	1.9	1.7
2D18	1.2	9.4	1.0	1.3
2D19	1.0	11.3	0.7	2.5
2D20	1.5	16.0	1.4	2.5

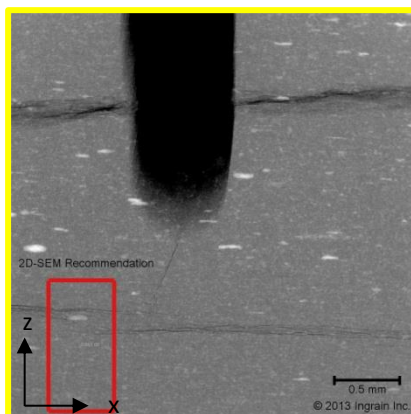
Micro-XCT Imaging and SEM Sample Selection



XCT Image Resolution - 15 μm per pixel
See attached image file : ARMSTRONG-1-8-7729P5_4X

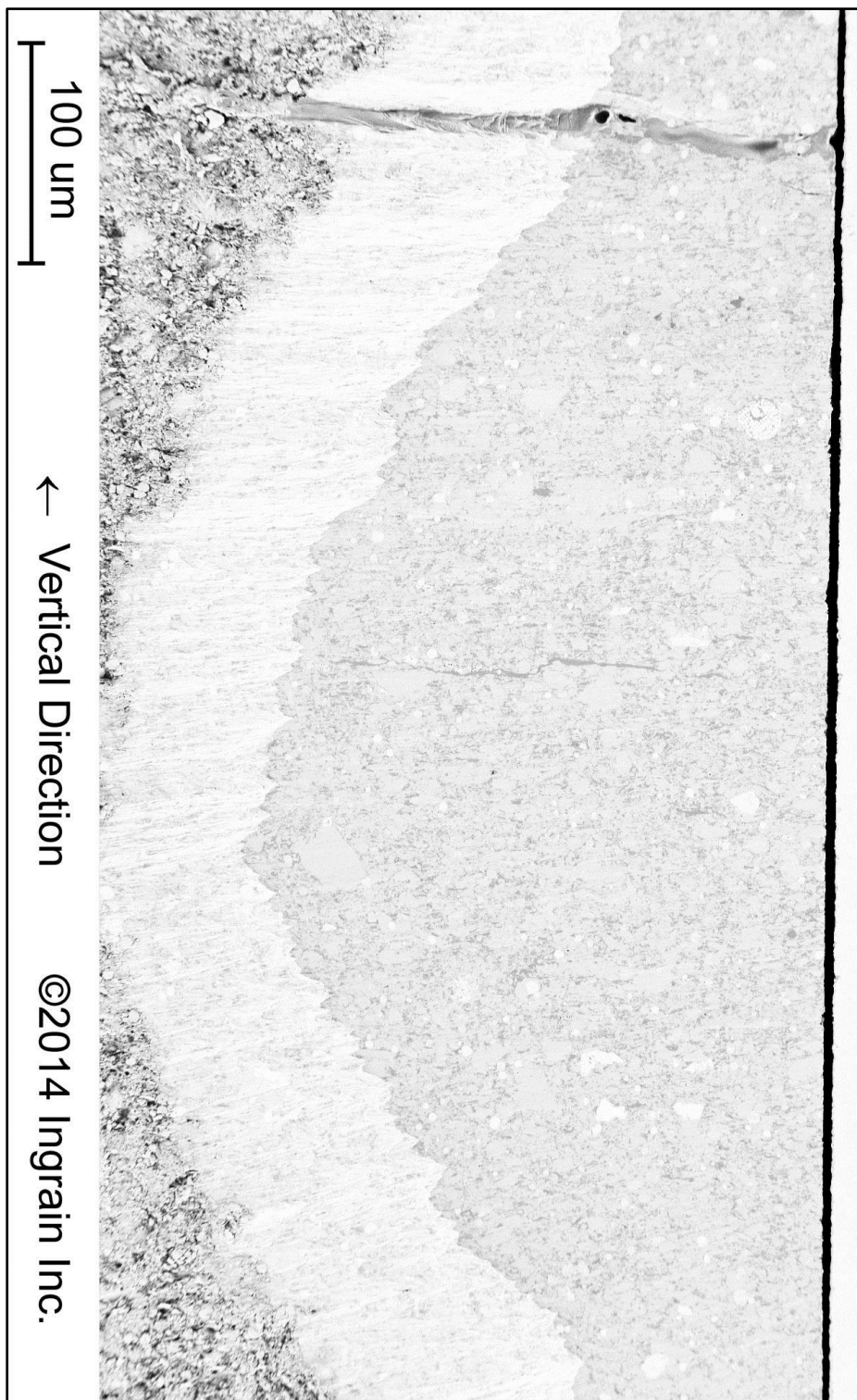


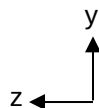
	Mineralogy by weight percentage		
Location	Silica	Clay	Carbonate
Location 1	49	44	6
Location 2	50	44	6
Location 3	51	43	6
Location 4	50	44	6
Location 5	50	44	6
Average	50	44	6



XCT Image Resolution - 4 μm per pixel
Location #1 is recommended for 2D-SEM
See attached image file : ARMSTRONG-1-8-7729P5_4X_TILE

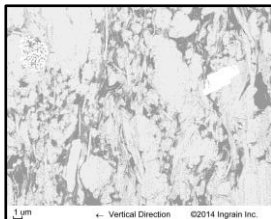
2D SEM Overview



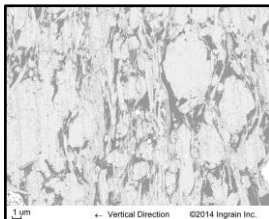


2D SEM Images @ 10 nm per pixel

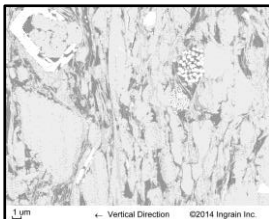
2D01



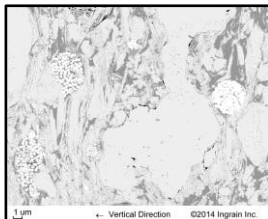
2D04



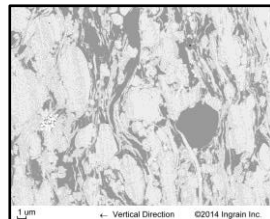
2D05



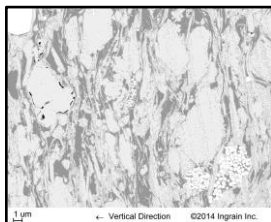
2D07



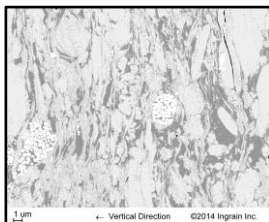
2D08



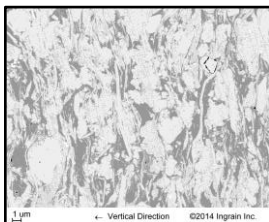
2D09



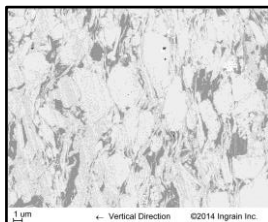
2D10



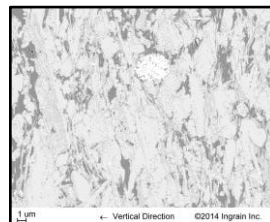
2D14



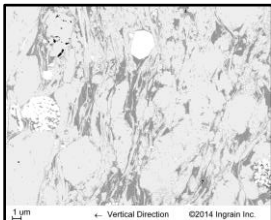
2D15



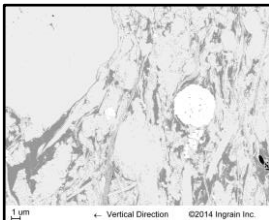
2D16



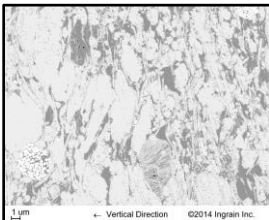
2D17



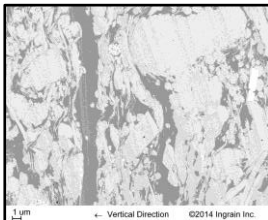
2D18



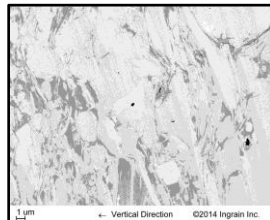
2D19



2D21

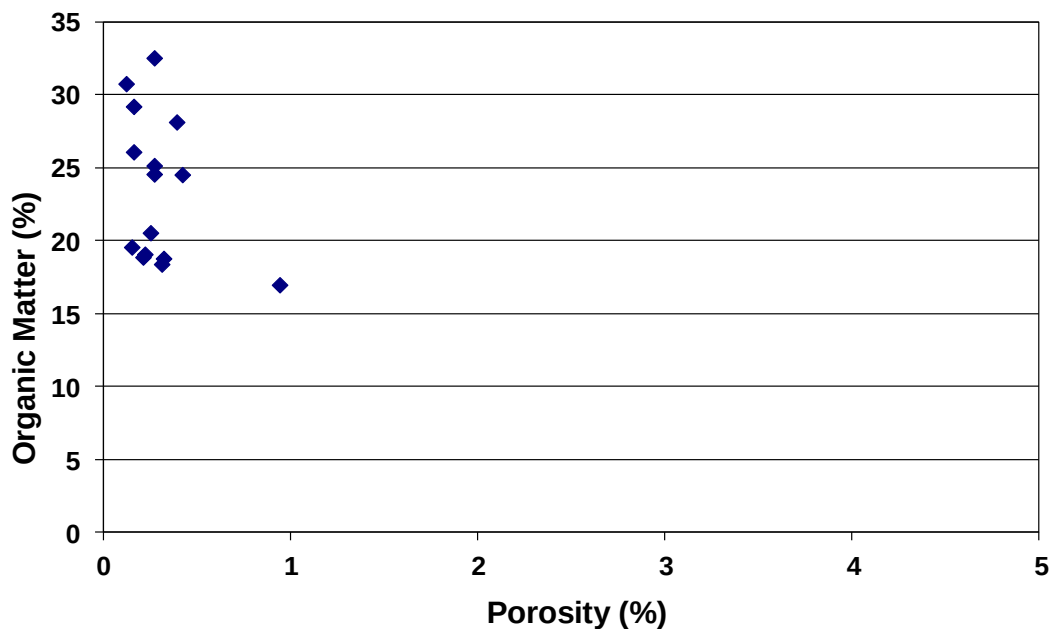


2D22



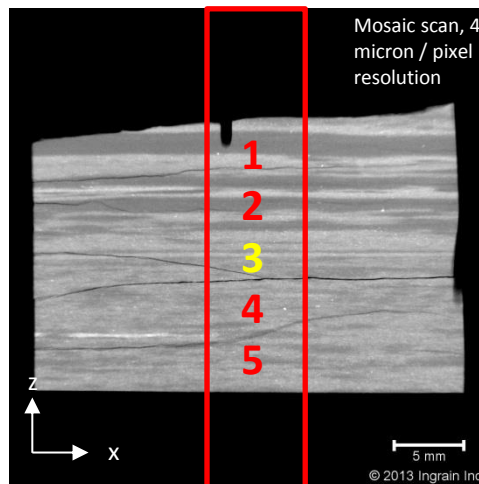
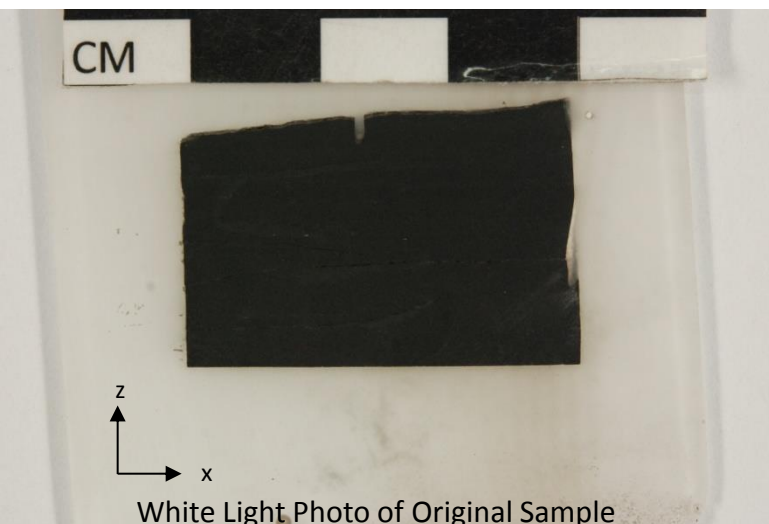
2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D01	0.3	24.6	0.2	1.9
2D04	0.2	26.1	0.1	0.7
2D05	0.2	18.9	0.1	4.4
2D07	0.9	17.0	0.4	4.1
2D08	0.1	30.8	0.1	0.3
2D09	0.4	28.2	0.1	3.6
2D10	0.4	24.5	0.2	3.0
2D14	0.3	32.6	0.2	0.1
2D15	0.3	20.6	0.2	0.2
2D16	0.2	19.6	0.1	1.3
2D17	0.2	19.1	0.1	3.5
2D18	0.3	18.8	0.2	3.0
2D19	0.3	25.2	0.3	1.4
2D21	0.2	29.2	0.1	0.7
2D22	0.3	18.4	0.2	0.0

2D SEM Summary

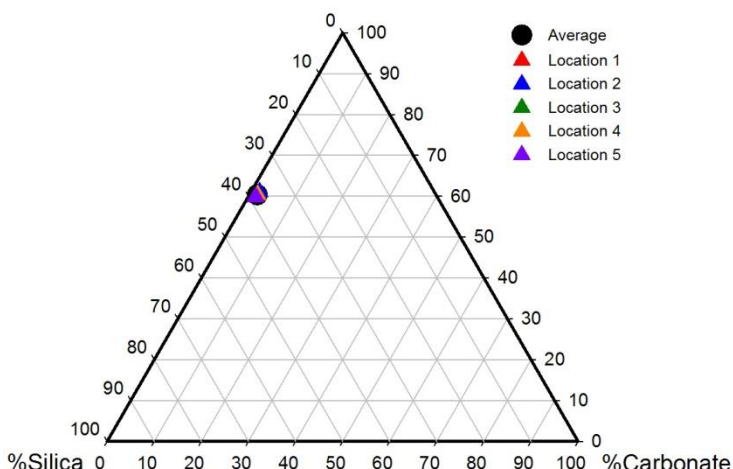


2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D01	0.3	24.6	0.2	1.9
2D04	0.2	26.1	0.1	0.7
2D05	0.2	18.9	0.1	4.4
2D07	0.9	17.0	0.4	4.1
2D08	0.1	30.8	0.1	0.3
2D09	0.4	28.2	0.1	3.6
2D10	0.4	24.5	0.2	3.0
2D14	0.3	32.6	0.2	0.1
2D15	0.3	20.6	0.2	0.2
2D16	0.2	19.6	0.1	1.3
2D17	0.2	19.1	0.1	3.5
2D18	0.3	18.8	0.2	3.0
2D19	0.3	25.2	0.3	1.4
2D21	0.2	29.2	0.1	0.7
2D22	0.3	18.4	0.2	0.0

Micro-XCT Imaging and SEM Sample Selection



XCT Image Resolution - 19 μm per pixel
See attached image file : ARMSTRONG-1-9-7740P45_4X



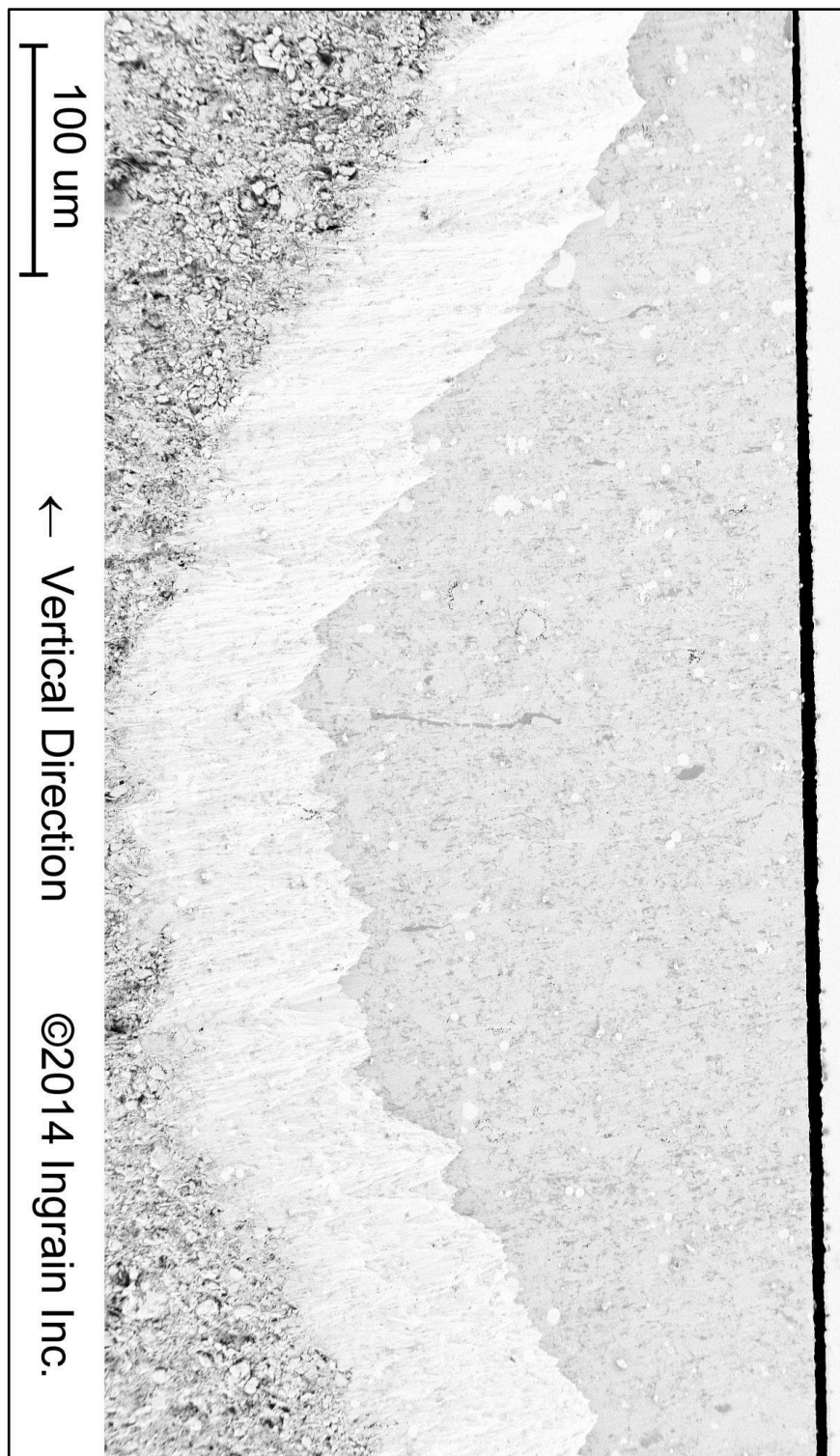
XRF Elemental Analysis

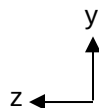
	Mineralogy by weight percentage		
Location	Silica	Clay	Carbonate
Location 1	38	60	2
Location 2	37	61	2
Location 3	38	60	2
Location 4	38	60	2
Location 5	39	60	2
Average	38	60	2



XCT Image Resolution - 4 μm per pixel
Location #3 is recommended for 2D-SEM
See attached image file : ARMSTRONG-1-9-7740P45_4X_TILE

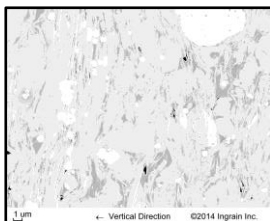
2D SEM Overview



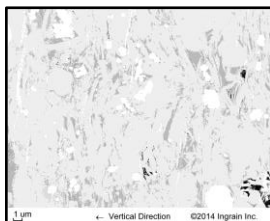


2D SEM Images @ 10 nm per pixel

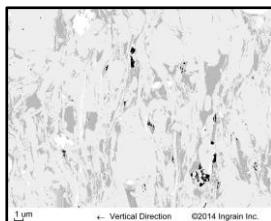
2D01



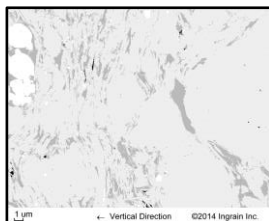
2D03



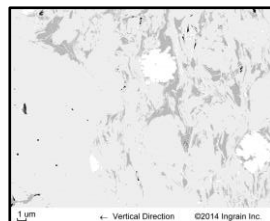
2D05



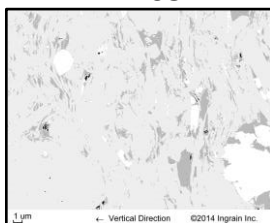
2D07



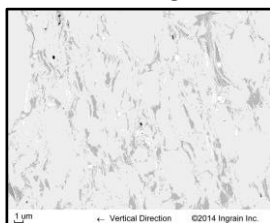
2D08



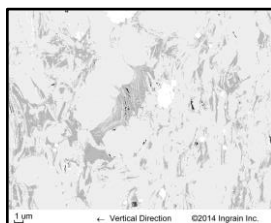
2D09



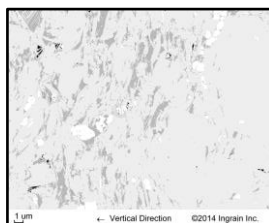
2D10



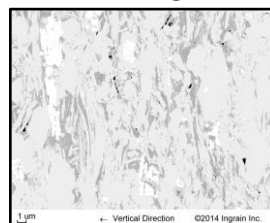
2D11



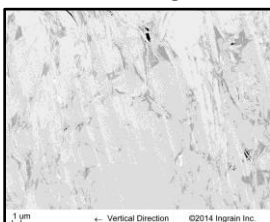
2D12



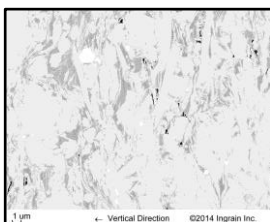
2D15



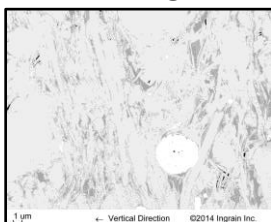
2D16



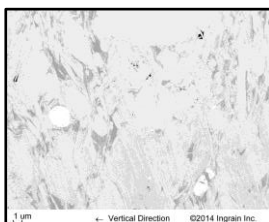
2D17



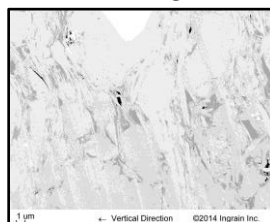
2D18



2D19

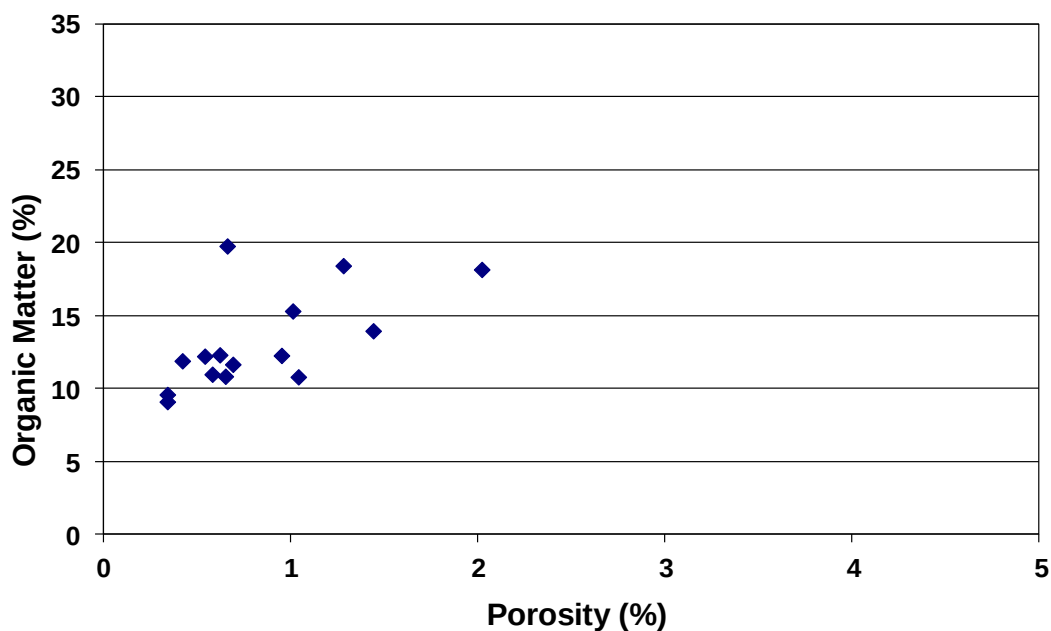


2D20



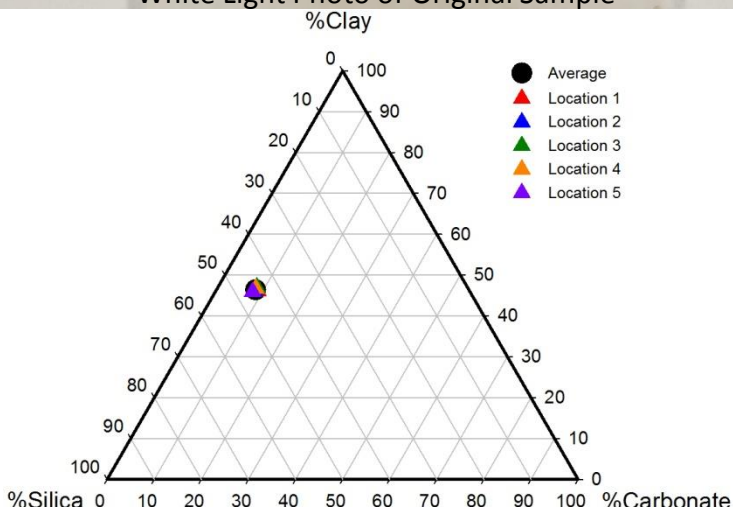
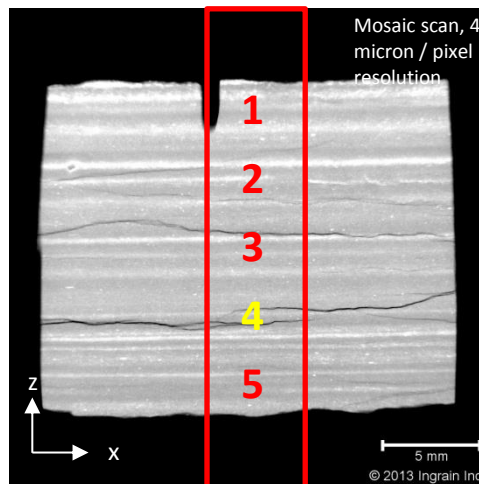
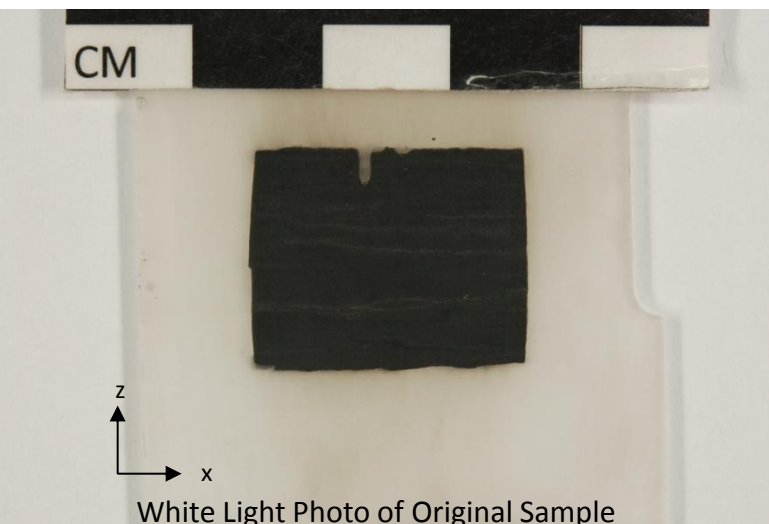
2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D01	1.0	12.3	0.6	6.7
2D03	1.4	14.0	0.4	5.0
2D05	2.0	18.2	1.0	1.3
2D07	0.6	12.3	0.4	3.1
2D08	1.0	10.8	0.7	3.7
2D09	0.7	11.7	0.5	6.0
2D10	0.5	12.2	0.4	0.2
2D11	1.3	18.4	1.0	1.5
2D12	0.7	10.8	0.5	2.2
2D15	0.7	19.8	0.5	4.0
2D16	0.3	9.6	0.1	0.1
2D17	1.0	15.3	0.6	0.5
2D18	0.4	11.9	0.2	2.7
2D19	0.3	9.1	0.2	1.2
2D20	0.6	11.0	0.2	1.9

2D SEM Summary

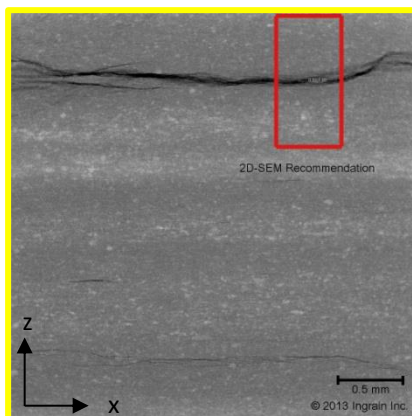


2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D01	1.0	12.3	0.6	6.7
2D03	1.4	14.0	0.4	5.0
2D05	2.0	18.2	1.0	1.3
2D07	0.6	12.3	0.4	3.1
2D08	1.0	10.8	0.7	3.7
2D09	0.7	11.7	0.5	6.0
2D10	0.5	12.2	0.4	0.2
2D11	1.3	18.4	1.0	1.5
2D12	0.7	10.8	0.5	2.2
2D15	0.7	19.8	0.5	4.0
2D16	0.3	9.6	0.1	0.1
2D17	1.0	15.3	0.6	0.5
2D18	0.4	11.9	0.2	2.7
2D19	0.3	9.1	0.2	1.2
2D20	0.6	11.0	0.2	1.9

Micro-XCT Imaging and SEM Sample Selection

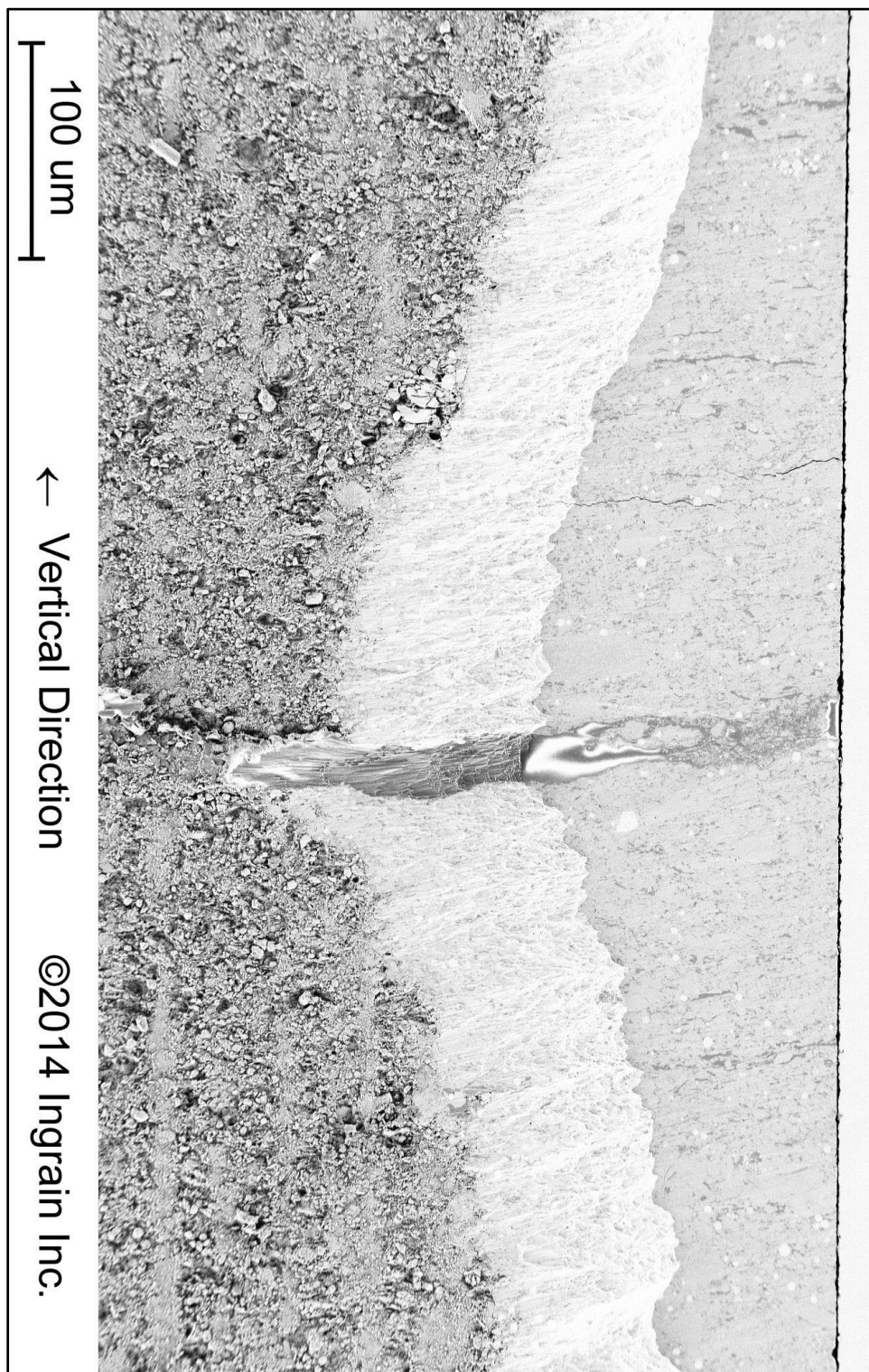


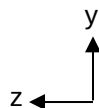
Mineralogy by weight percentage			
Location	Silica	Clay	Carbonate
Location 1	45	46	9
Location 2	45	46	8
Location 3	45	47	8
Location 4	45	47	8
Location 5	46	46	8
Average	45	46	8



XCT Image Resolution - 4 µm per pixel
Location #4 is recommended for 2D-SEM
See attached image file : ARMSTRONG-1-10-7753P3_4X_TILE

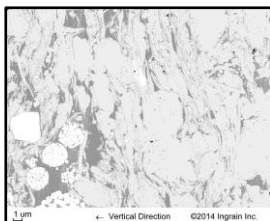
2D SEM Overview



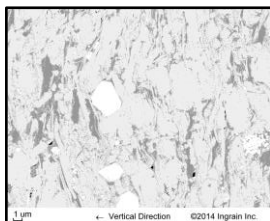


2D SEM Images @ 10 nm per pixel

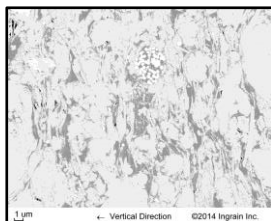
2D04



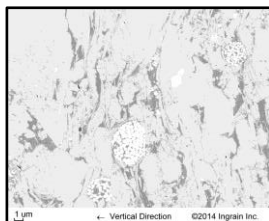
2D05



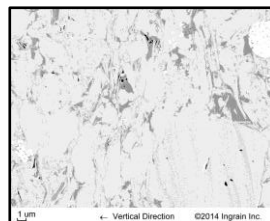
2D08



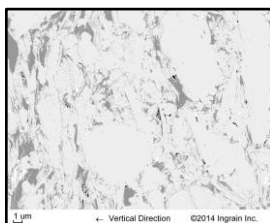
2D09



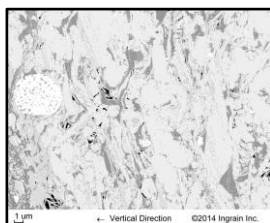
2D10



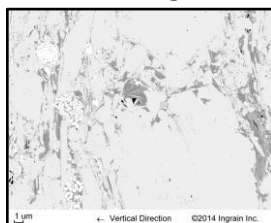
2D11



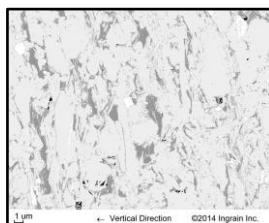
2D12



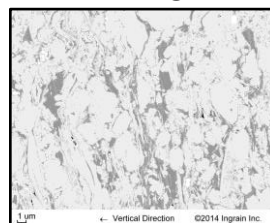
2D13



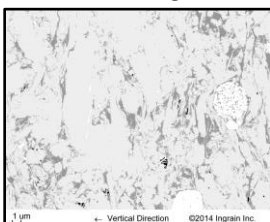
2D14



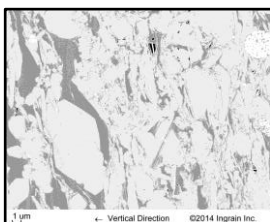
2D15



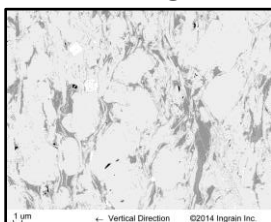
2D16



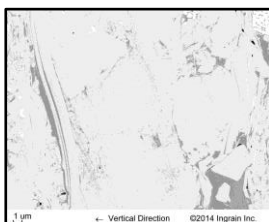
2D17



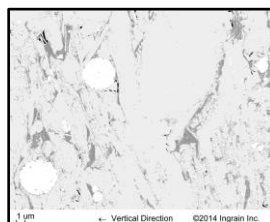
2D18



2D19

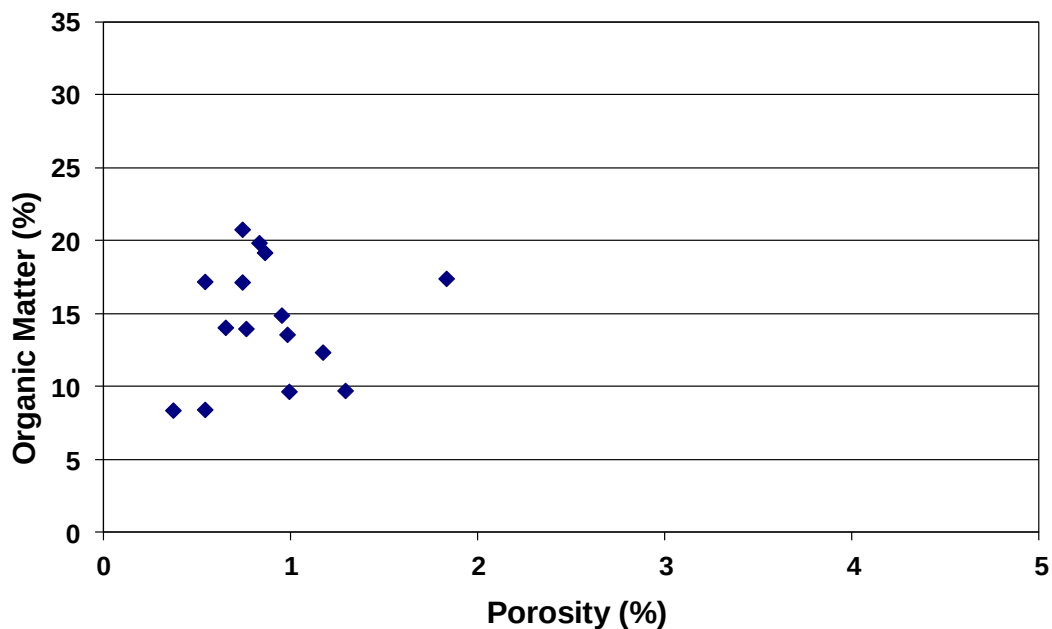


2D21



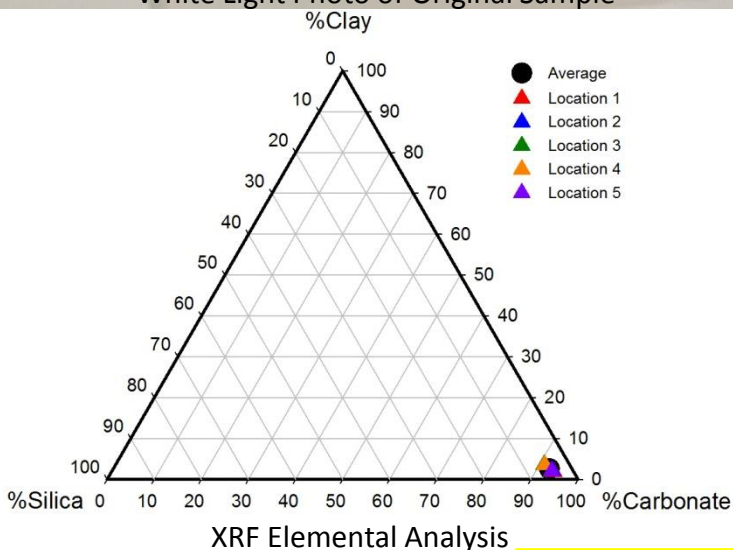
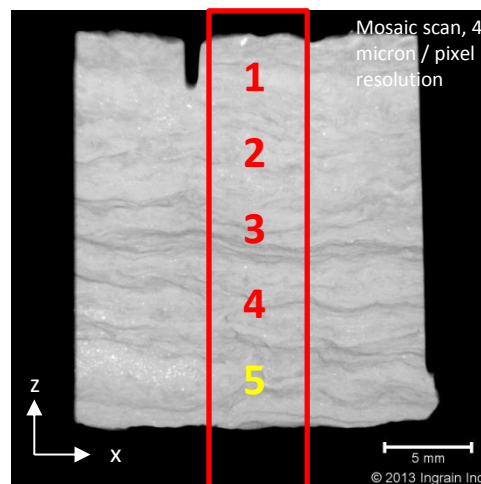
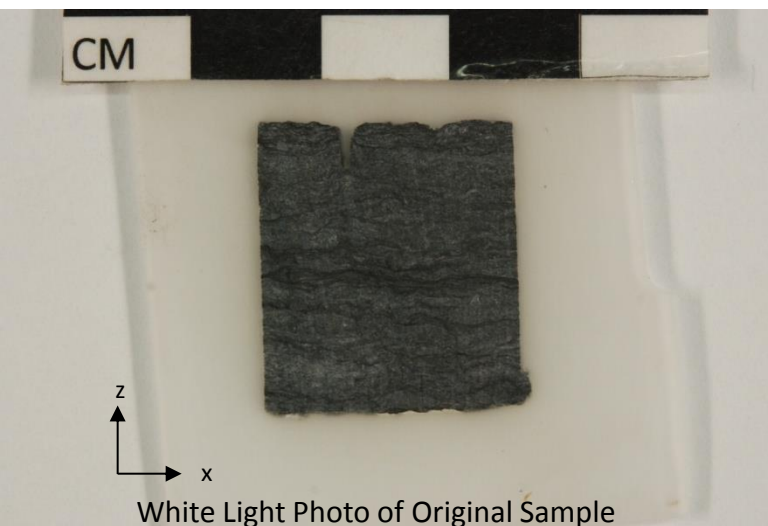
2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D04	0.5	17.2	0.3	5.3
2D05	0.7	17.2	0.6	3.6
2D08	0.8	19.9	0.5	1.3
2D09	0.7	14.1	0.5	3.5
2D10	1.0	9.7	0.5	2.1
2D11	1.0	13.6	0.6	0.2
2D12	1.8	17.4	1.0	3.0
2D13	1.3	9.7	0.8	2.1
2D14	1.2	12.4	0.6	0.6
2D15	0.9	19.2	0.7	0.4
2D16	0.8	14.0	0.4	2.9
2D17	0.7	20.8	0.5	1.4
2D18	1.0	14.9	0.7	0.6
2D19	0.4	8.4	0.2	1.4
2D21	0.5	8.4	0.2	4.2

2D SEM Summary

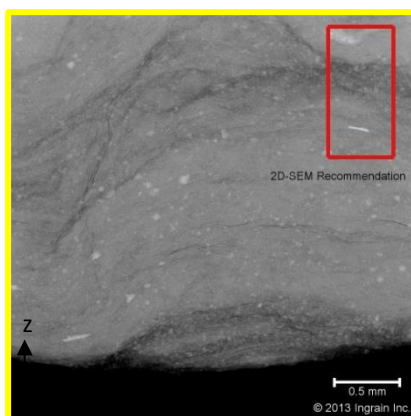


2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D04	0.5	17.2	0.3	5.3
2D05	0.7	17.2	0.6	3.6
2D08	0.8	19.9	0.5	1.3
2D09	0.7	14.1	0.5	3.5
2D10	1.0	9.7	0.5	2.1
2D11	1.0	13.6	0.6	0.2
2D12	1.8	17.4	1.0	3.0
2D13	1.3	9.7	0.8	2.1
2D14	1.2	12.4	0.6	0.6
2D15	0.9	19.2	0.7	0.4
2D16	0.8	14.0	0.4	2.9
2D17	0.7	20.8	0.5	1.4
2D18	1.0	14.9	0.7	0.6
2D19	0.4	8.4	0.2	1.4
2D21	0.5	8.4	0.2	4.2

Micro-XCT Imaging and SEM Sample Selection

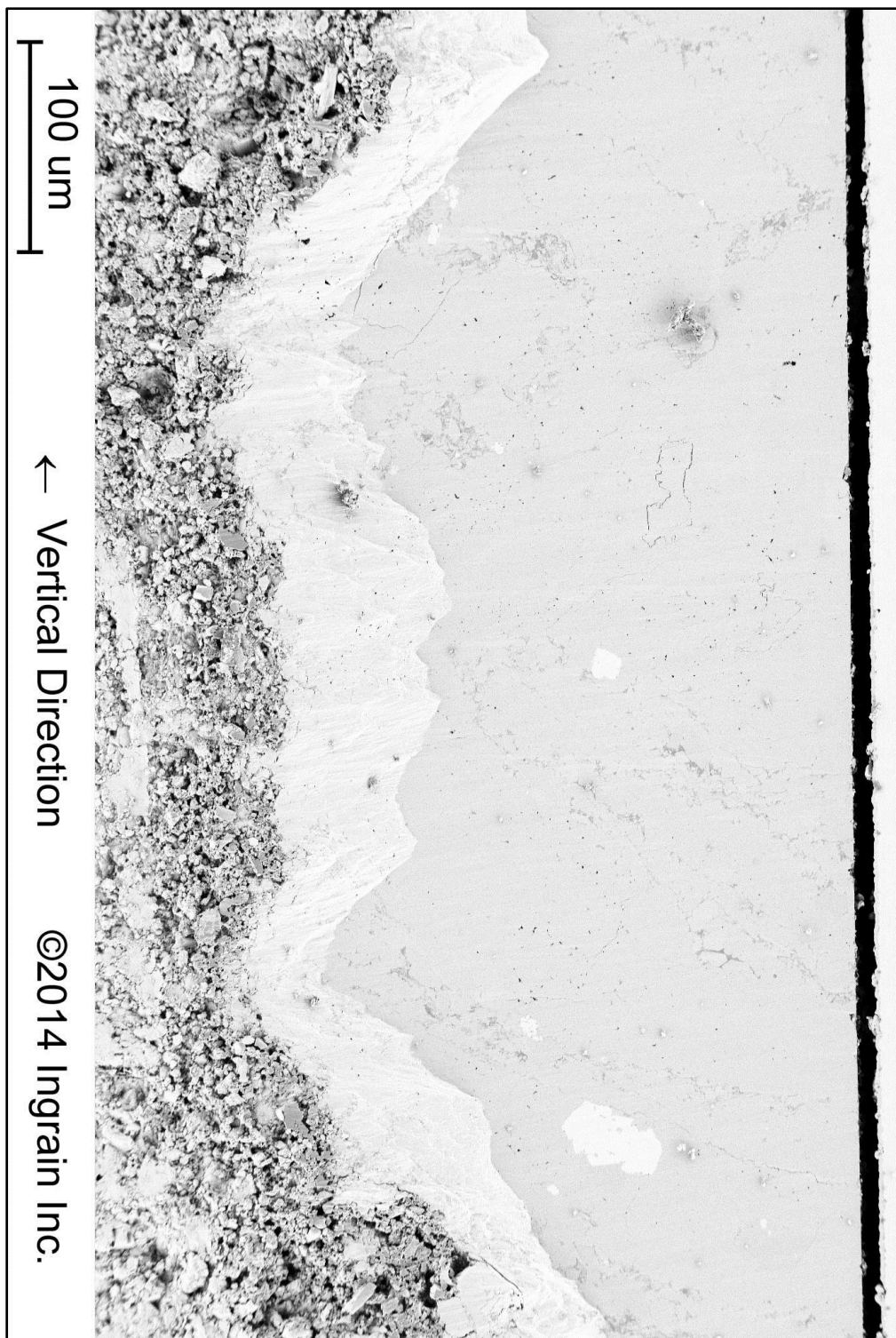


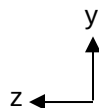
Mineralogy by weight percentage			
Location	Silica	Clay	Carbonate
Location 1	4	2	94
Location 2	4	2	93
Location 3	5	4	91
Location 4	5	4	91
Location 5	5	2	93
Average	5	3	93



XCT Image Resolution - 4 µm per pixel
Location #5 is recommended for 2D-SEM
See attached image file : ARMSTRONG-1-11-7778P15_4X_TILE

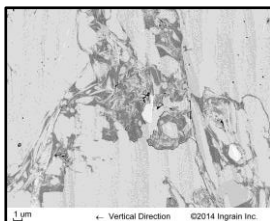
2D SEM Overview



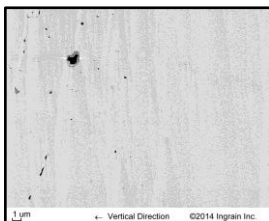


2D SEM Images @ 10 nm per pixel

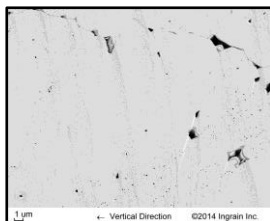
2D01



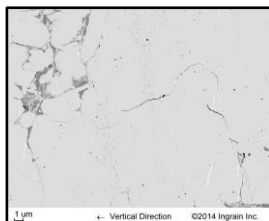
2D02



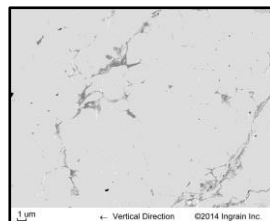
2D03



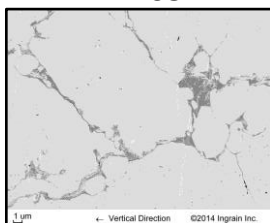
2D07



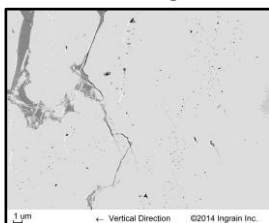
2D08



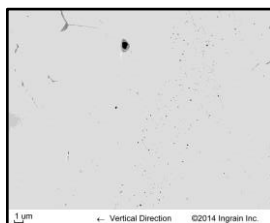
2D09



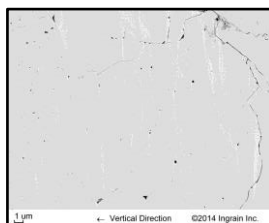
2D10



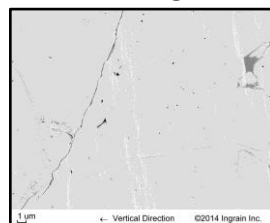
2D11



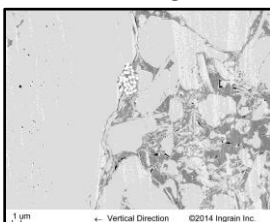
2D14



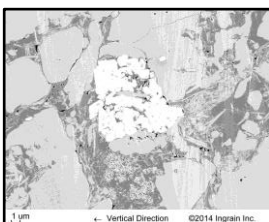
2D15



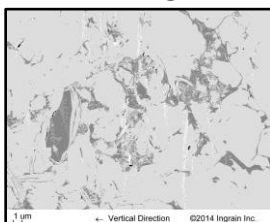
2D16



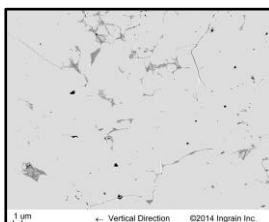
2D17



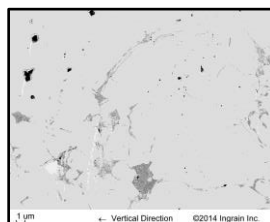
2D19



2D20

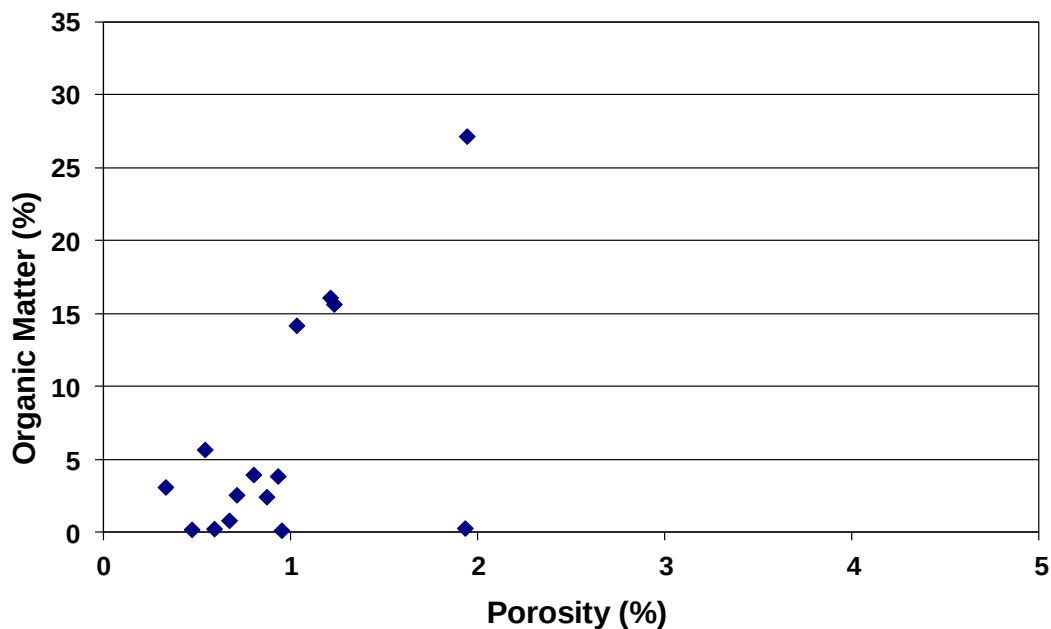


2D21



2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D01	1.2	16.1	0.8	0.3
2D02	0.5	0.2	0.2	0.0
2D03	1.9	0.3	0.3	0.0
2D07	0.7	2.6	0.2	0.0
2D08	0.3	3.1	0.1	0.0
2D09	0.5	5.7	0.3	0.0
2D10	0.8	4.0	0.2	0.0
2D11	0.6	0.3	0.1	0.0
2D14	1.0	0.1	0.2	0.0
2D15	0.7	0.8	0.2	0.0
2D16	1.2	15.7	0.9	0.5
2D17	1.9	27.2	1.5	7.8
2D19	1.0	14.2	0.6	0.1
2D20	0.9	2.4	0.3	0.0
2D21	0.93	3.86	0.33	0

2D SEM Summary



2D SEM Number	Porosity (%)	Organic Matter (%)	Porosity in Organic Matter (%)	High Density (%)
2D01	1.2	16.1	0.8	0.3
2D02	0.5	0.2	0.2	0.0
2D03	1.9	0.3	0.3	0.0
2D07	0.7	2.6	0.2	0.0
2D08	0.3	3.1	0.1	0.0
2D09	0.5	5.7	0.3	0.0
2D10	0.8	4.0	0.2	0.0
2D11	0.6	0.3	0.1	0.0
2D14	1.0	0.1	0.2	0.0
2D15	0.7	0.8	0.2	0.0
2D16	1.2	15.7	0.9	0.5
2D17	1.9	27.2	1.5	7.8
2D19	1.0	14.2	0.6	0.1
2D20	0.9	2.4	0.3	0.0
2D21	0.93	3.86	0.33	0