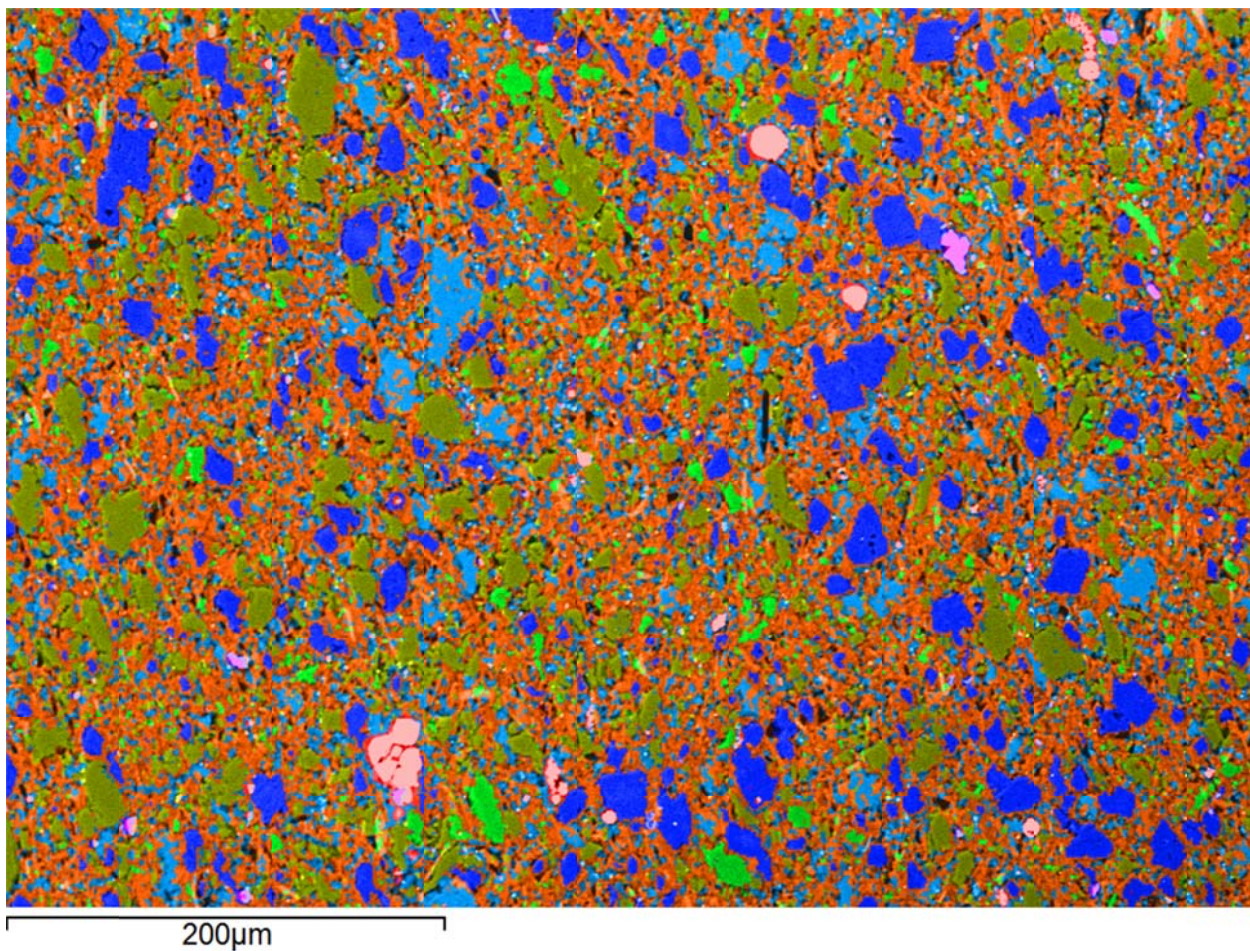


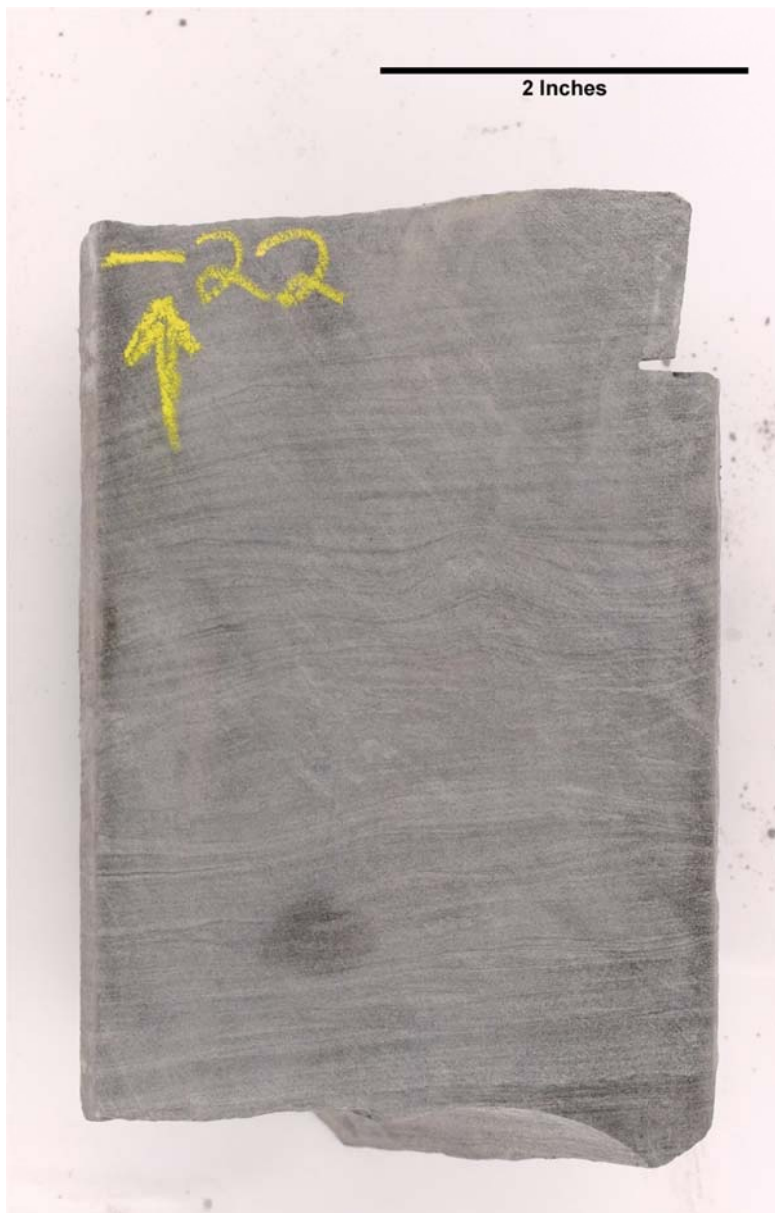
	Applied Geology Laboratory		ID: 117010
	Well Name: NDIC No. 20552	Middle Bakken 8	Grenora Field
	API No.: 33-105-02157-00-02	Lithology: Silty, argillaceous dolostone	Depth: 9616.0'

SEM Mineral Map Image Overlaid on BSE Image with Mineral Phase 2D Area Percentages



	Applied Geology Laboratory		ID: 117012
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-04	Lithology: Argillaceous, silty limestone	Depth: 9622.0'

SAMPLE PHOTOGRAPH



PHYSICAL PROPERTIES

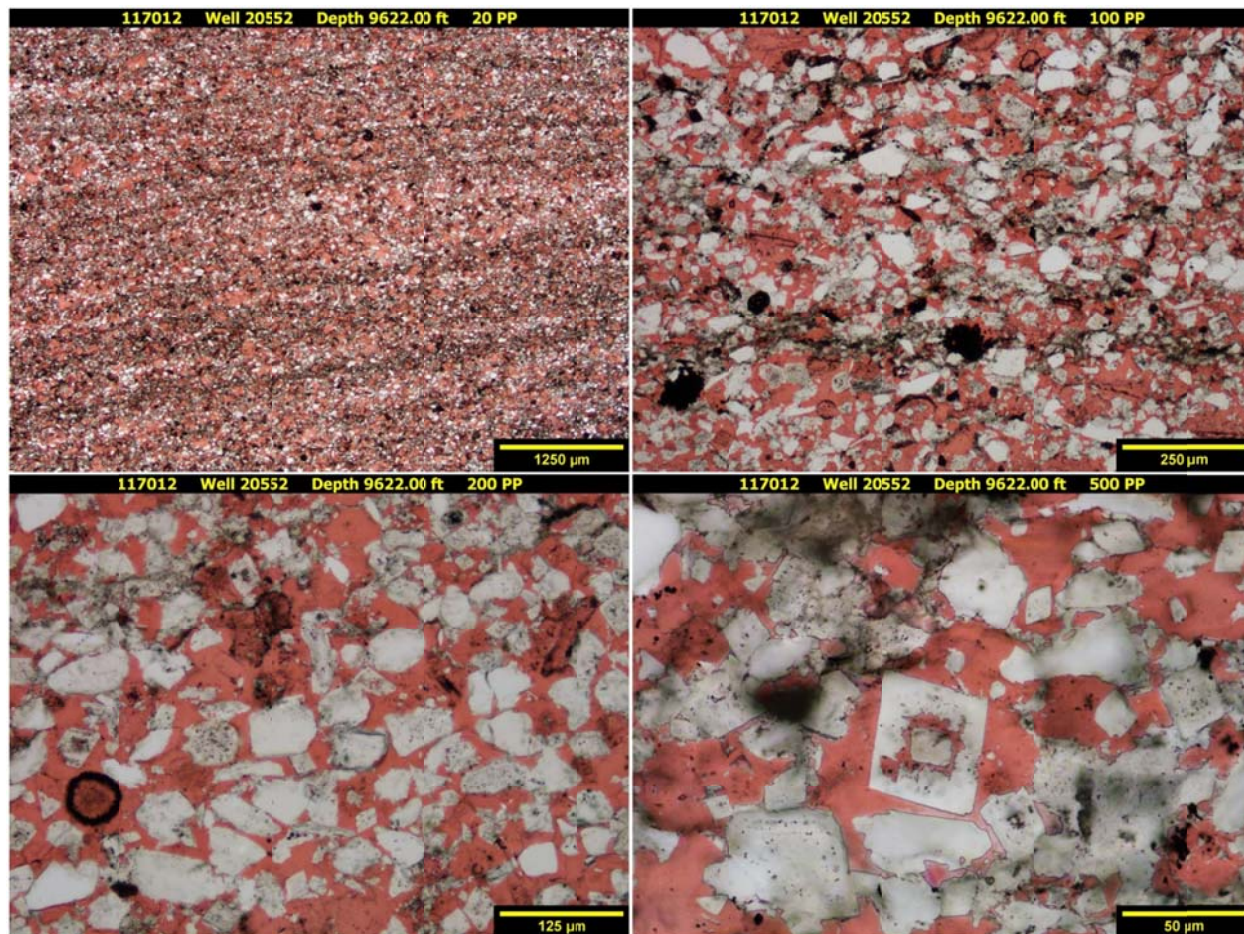
Porosity and Grain Density by Core Laboratories

Pycnometer Effective Porosity, vol%	Grain Density, g/cm ³
3.12	2.727

	Applied Geology Laboratory		ID: 117012
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-04	Lithology: Argillaceous, silty limestone	Depth: 9622.0'

PHOTOMICROGRAPHS

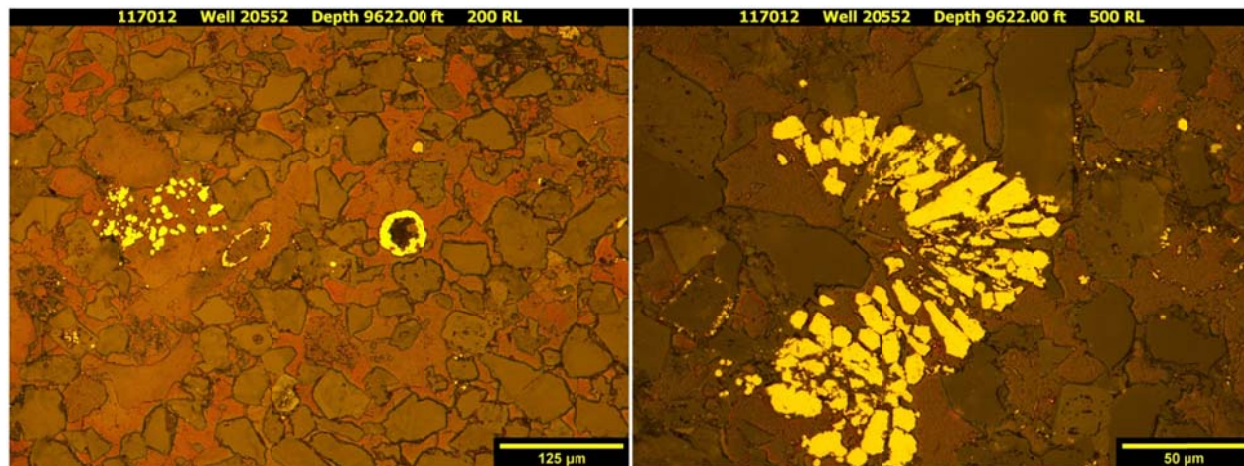
Transmission



The sample from a depth of 9622.00 ft is a laminated, weakly bioturbated, argillaceous, silty limestone. Very fine grained, angular to subangular, monocrystalline quartz is speckled throughout the sample. Additional detrital minerals found at traces amounts are muscovite and feldspars. Calcareous skeletal and non-skeletal grains commonly occur throughout the sample. The matrix is composed predominantly of sparry calcite cement and lesser amounts of clays and anhedral and euhedral dolomite. Disseminated pore-filling and replacement pyrite is observed. No particle-based porosity or fractures are detected using standard petrographic methods.

	Applied Geology Laboratory		ID: 117012
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-04	Lithology: Argillaceous, silty limestone	Depth: 9622.0'

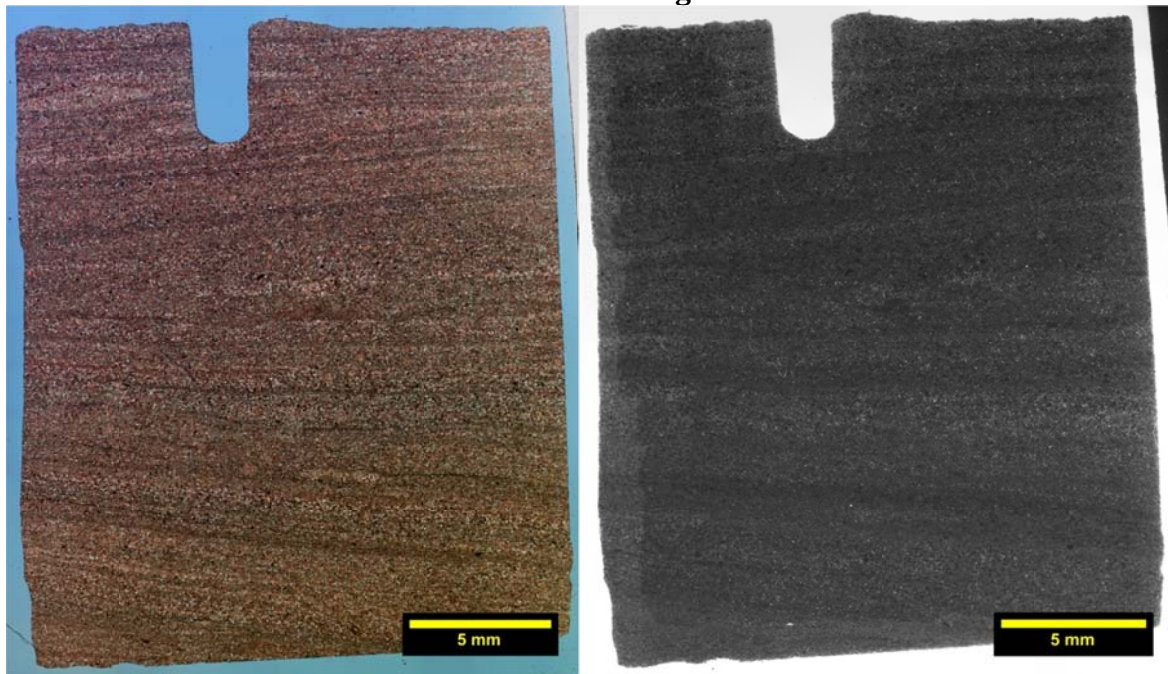
Reflection



The sample from a depth of 9622.00 ft displays only euhedral mineralization speckled at lesser amounts. This diagenetic mineralization replaces grains (skeletal and non-skeletal) and fills micropores. Rarely observed organics are typically associated with euhedral pyrite.

	Applied Geology Laboratory		ID: 117012
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-04	Lithology: Argillaceous, silty limestone	Depth: 9622.0'

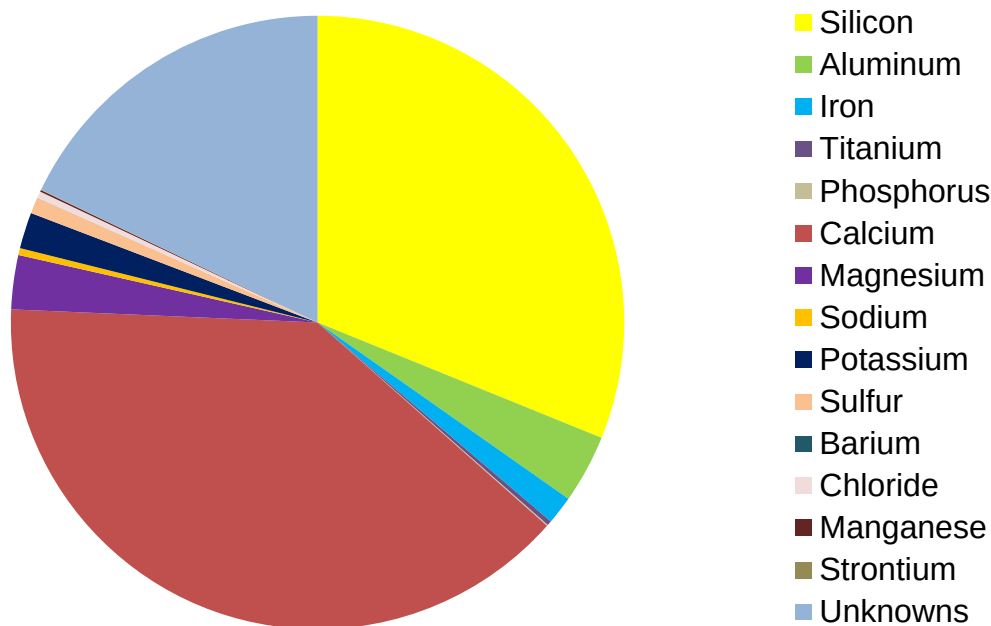
Transmission and Fluorescence Whole-Slide Images



The image collected from depth 9622.00 ft shows a laminated sample. Effective porosity is reported at 3.12 vol%. Overall, the sample is well-cemented. Inter-particle-based micro-porosity mainly exists within quartz and euhedral dolomite-rich laminations. Lesser amounts of porosity are detected within areas of smaller, mostly anhedral dolomite grains and clay concentrations. Overall, pore sizes appear to be very small (far less than 30 μm). No natural or induced fractures are observed.

	Applied Geology Laboratory		ID: 117012
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-04	Lithology: Argillaceous, silty limestone	Depth: 9622.0'

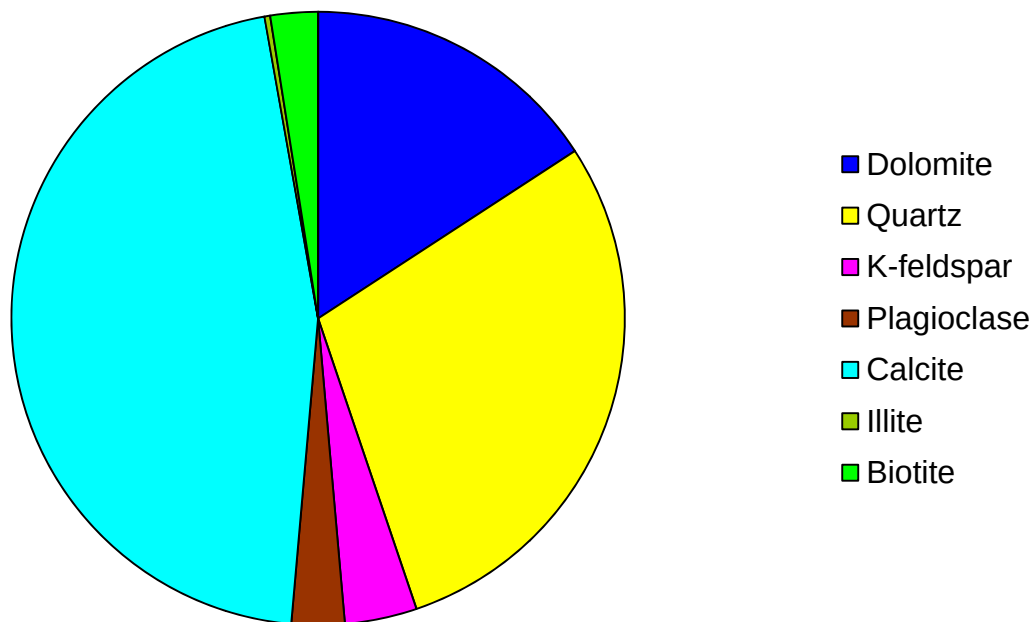
XRF BULK CHEMICAL COMPOSITION



Element	Reporting Convention (Oxide)	Weight %
Si (silicon)	SiO ₂	31.14
Al (aluminum)	Al ₂ O ₃	3.61
Fe (iron)	Fe ₂ O ₃	1.49
Ti (titanium)	TiO ₂	0.24
P (phosphorus)	P ₂ O ₅	0.06
Ca (calcium)	CaO	39.14
Mg (magnesium)	MgO	2.85
Na (sodium)	Na ₂ O	0.37
K (potassium)	K ₂ O	1.91
S (sulfur)	SO ₃	0.84
Ba (barium)	BaO	0.01
Cl (chloride)	Cl	0.36
Mn (manganese)	MnO	0.09
Sr (strontium)	SrO	0.02
Unknowns	Due to the presence of carbonates	17.87
Total		100.00

	Applied Geology Laboratory		ID: 117012
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-04	Lithology: Argillaceous, silty limestone	Depth: 9622.0'

XRD MINERAL PHASE DISTRIBUTION



Mineral Phase	Formula	Weight %
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	15.8
Quartz	SiO_2	29.0
K-feldspar	KAlSi_3O_8	3.8
Plagioclase	$\text{Na}_{0.5}\text{Ca}_{0.5}\text{Al}_{1.5}\text{Si}_{2.5}\text{O}_8$	2.8
Calcite	CaCO_3	45.8
Illite	$(\text{K},\text{H}_3\text{O})(\text{Al},\text{Mg},\text{Fe})_2(\text{Si},\text{Al})_4\text{O}_{10}[(\text{OH})_2,(\text{H}_2\text{O})]$	0.3
Biotite	$\text{K}(\text{Mg},\text{Fe})_3[(\text{OH})_2\text{AlSi}_3\text{O}_{10}]$	2.5

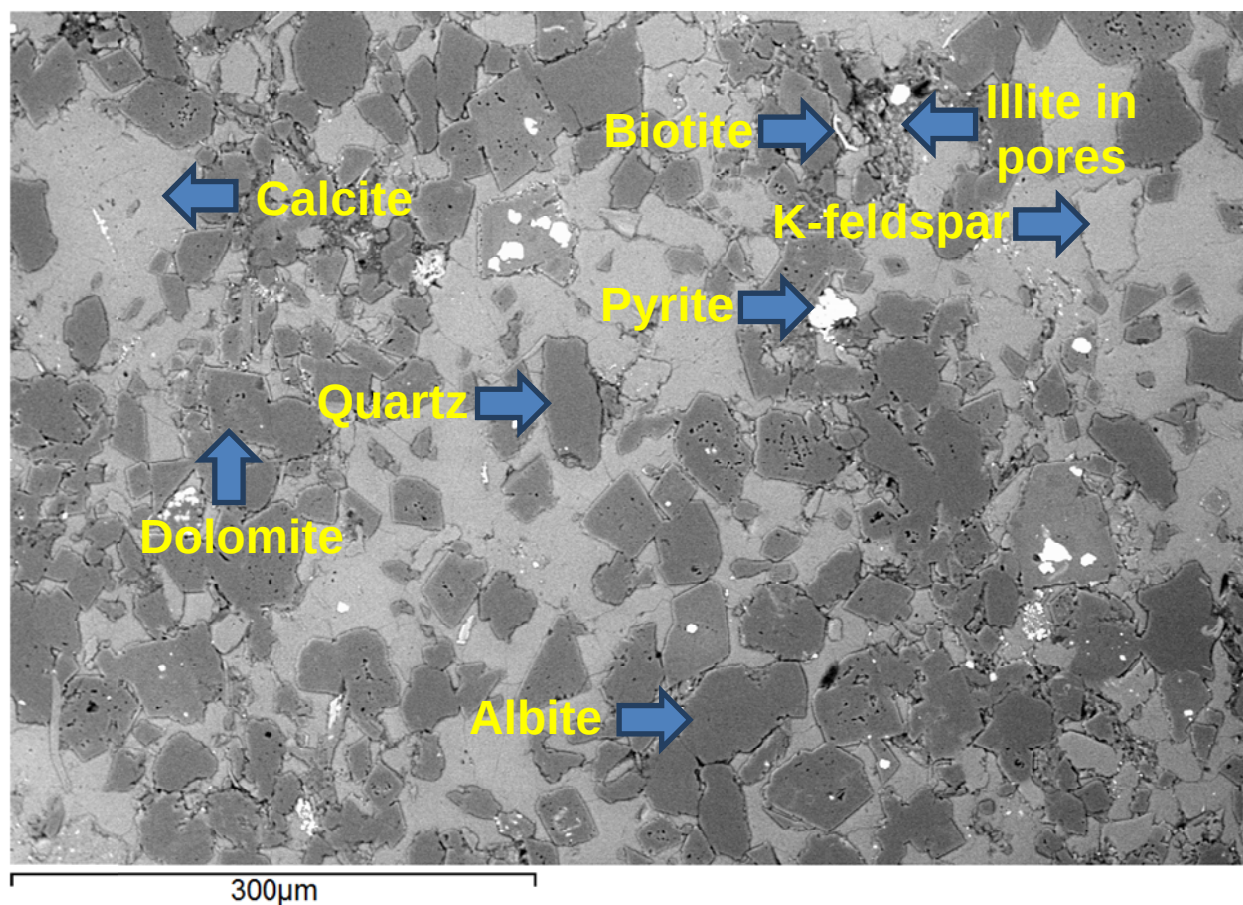
	Applied Geology Laboratory		ID: 117012
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-04	Lithology: Argillaceous, silty limestone	Depth: 9622.0'

SEM

Observed Minerals

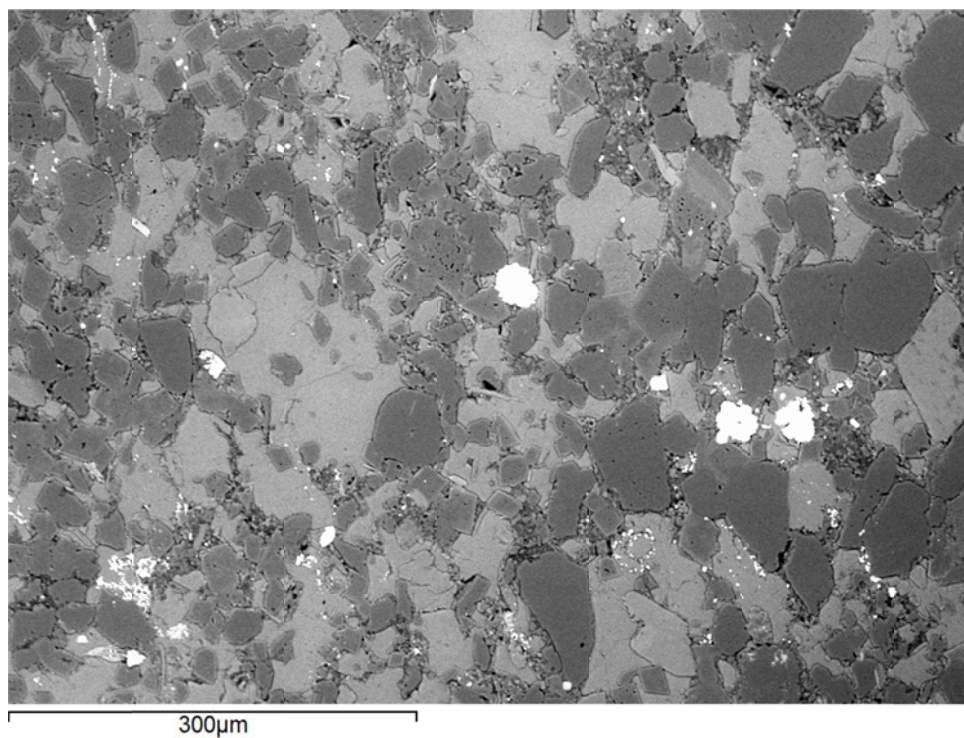
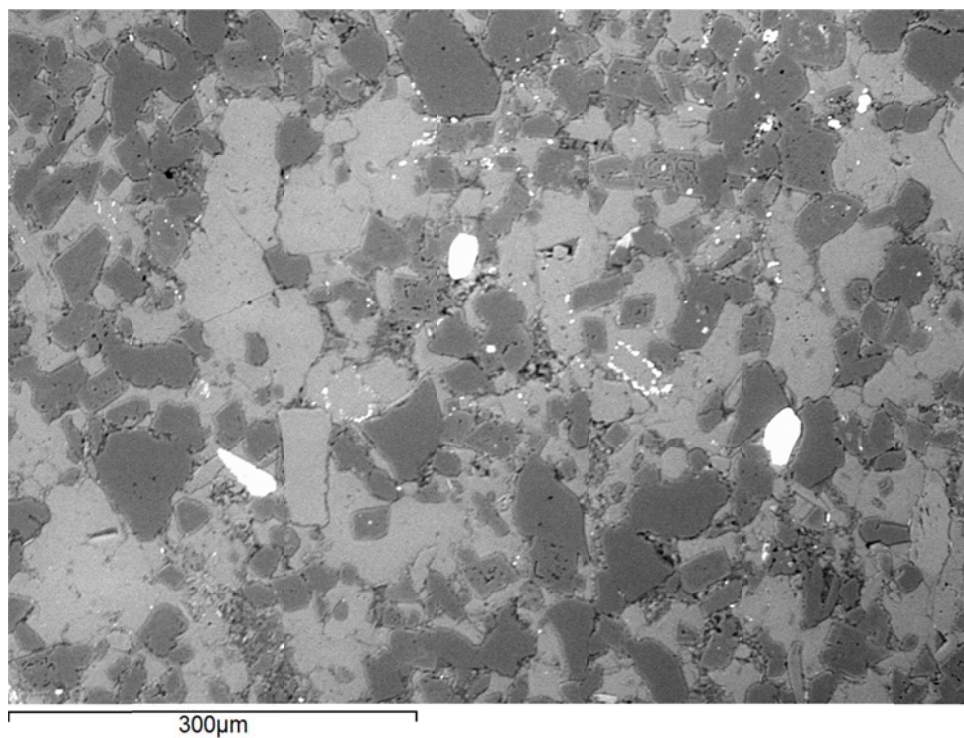
Mineral Phase	Mineral Phase
Calcite	K-feldspar
Quartz	Apatite
Dolomite	Zircon
Illite	Rutile
Pyrite	Biotite

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified

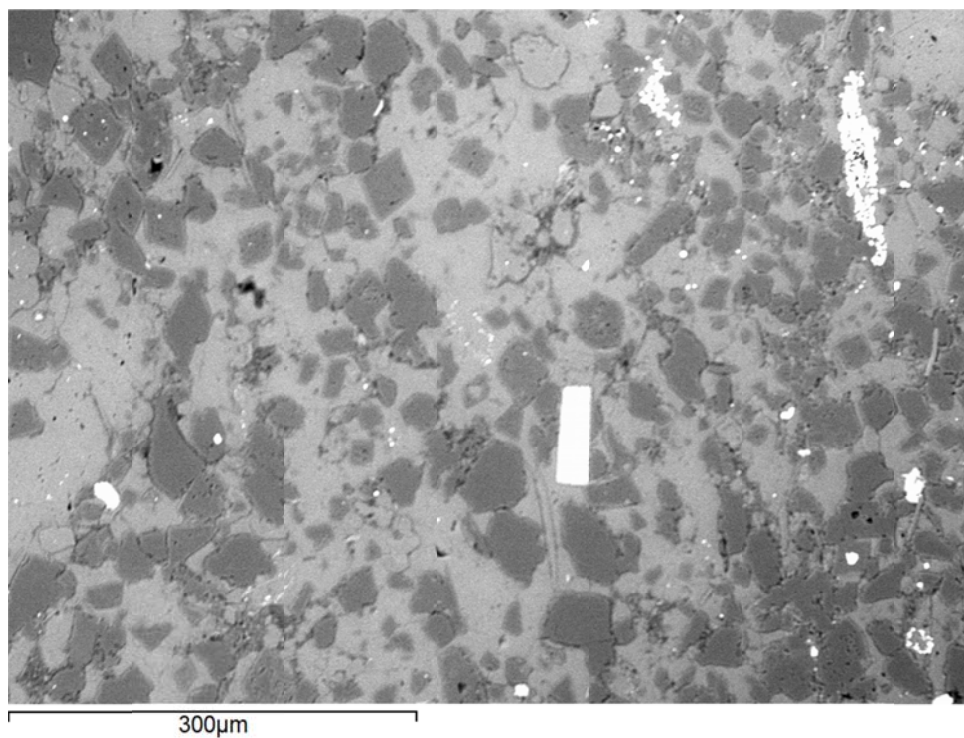


	Applied Geology Laboratory		ID: 117012
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-04	Lithology: Argillaceous, silty limestone	Depth: 9622.0'

Additional High-Magnification BSE Images

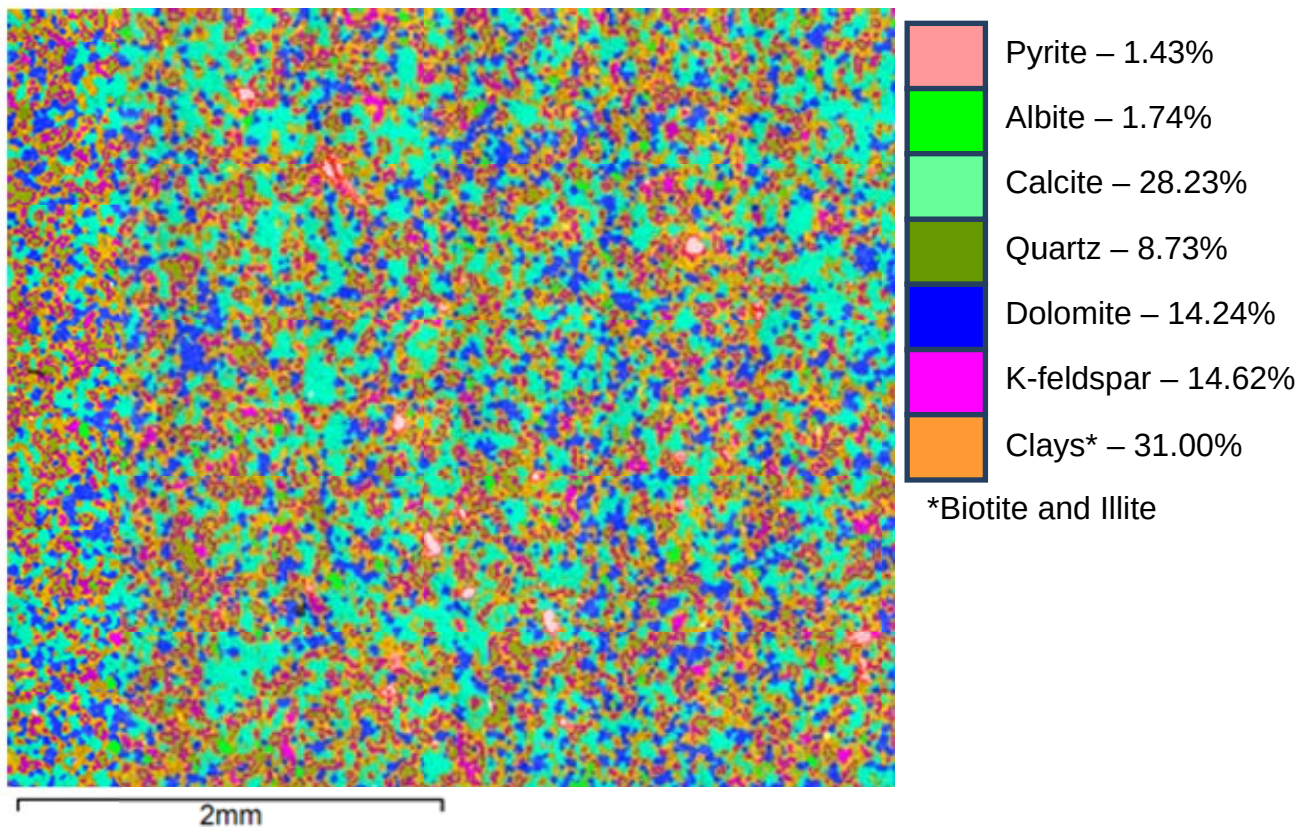


	Applied Geology Laboratory		ID: 117012
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-04	Lithology: Argillaceous, silty limestone	Depth: 9622.0'



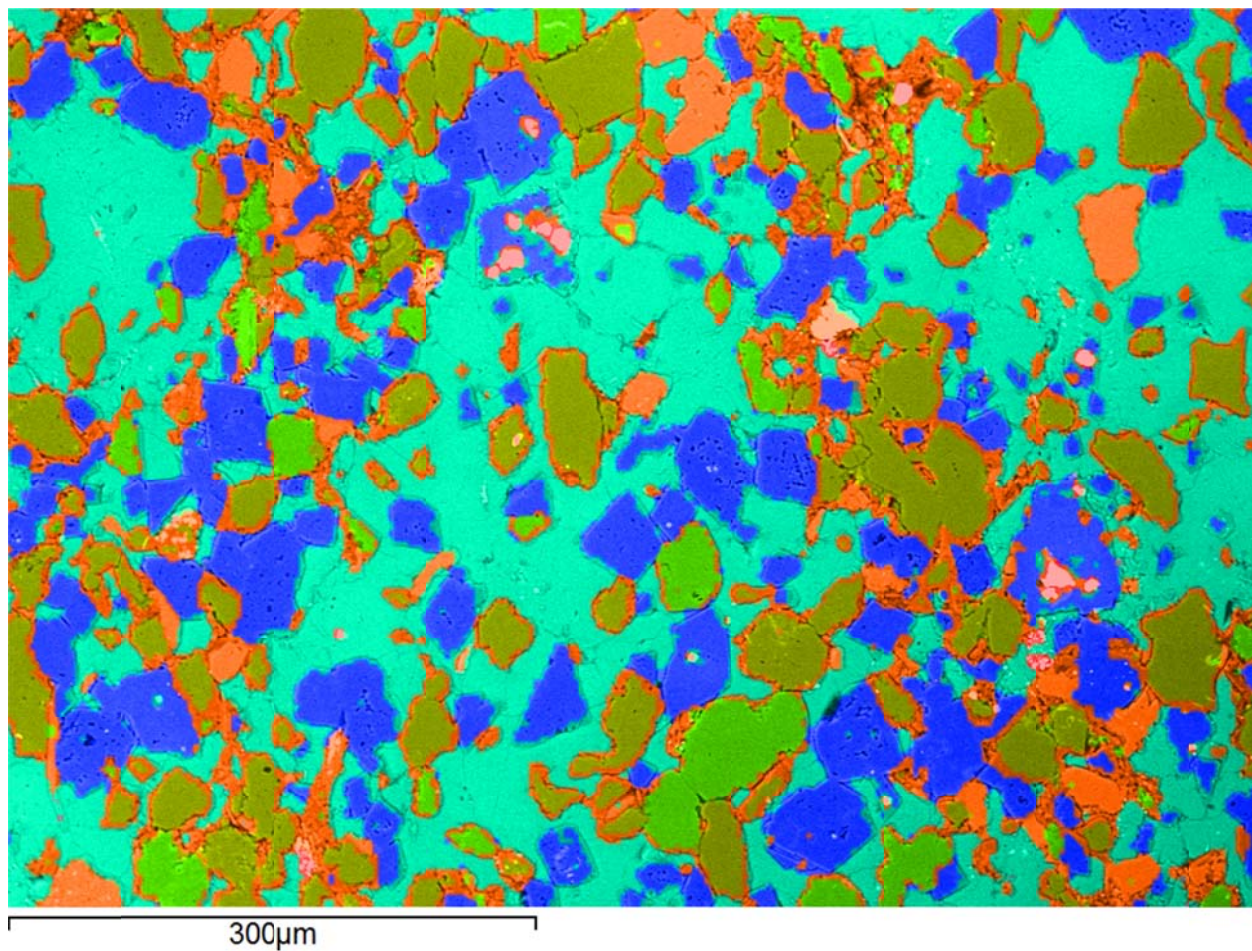
	Applied Geology Laboratory		ID: 117012
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-04	Lithology: Argillaceous, silty limestone	Depth: 9622.0'

SEM Digital Composite Mineral Map Image Overlaid on BSE Image with Mineral Phase 2D Area Percentages



	Applied Geology Laboratory		ID: 117012
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-04	Lithology: Argillaceous, silty limestone	Depth: 9622.0'

SEM Mineral Map Image Overlaid on BSE Image **with Mineral Phase 2D Area Percentages**



	Applied Geology Laboratory		ID: 117013
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-05	Lithology: Silty dolostone	Depth: 9623.0'

SAMPLE PHOTOGRAPH



PHYSICAL PROPERTIES

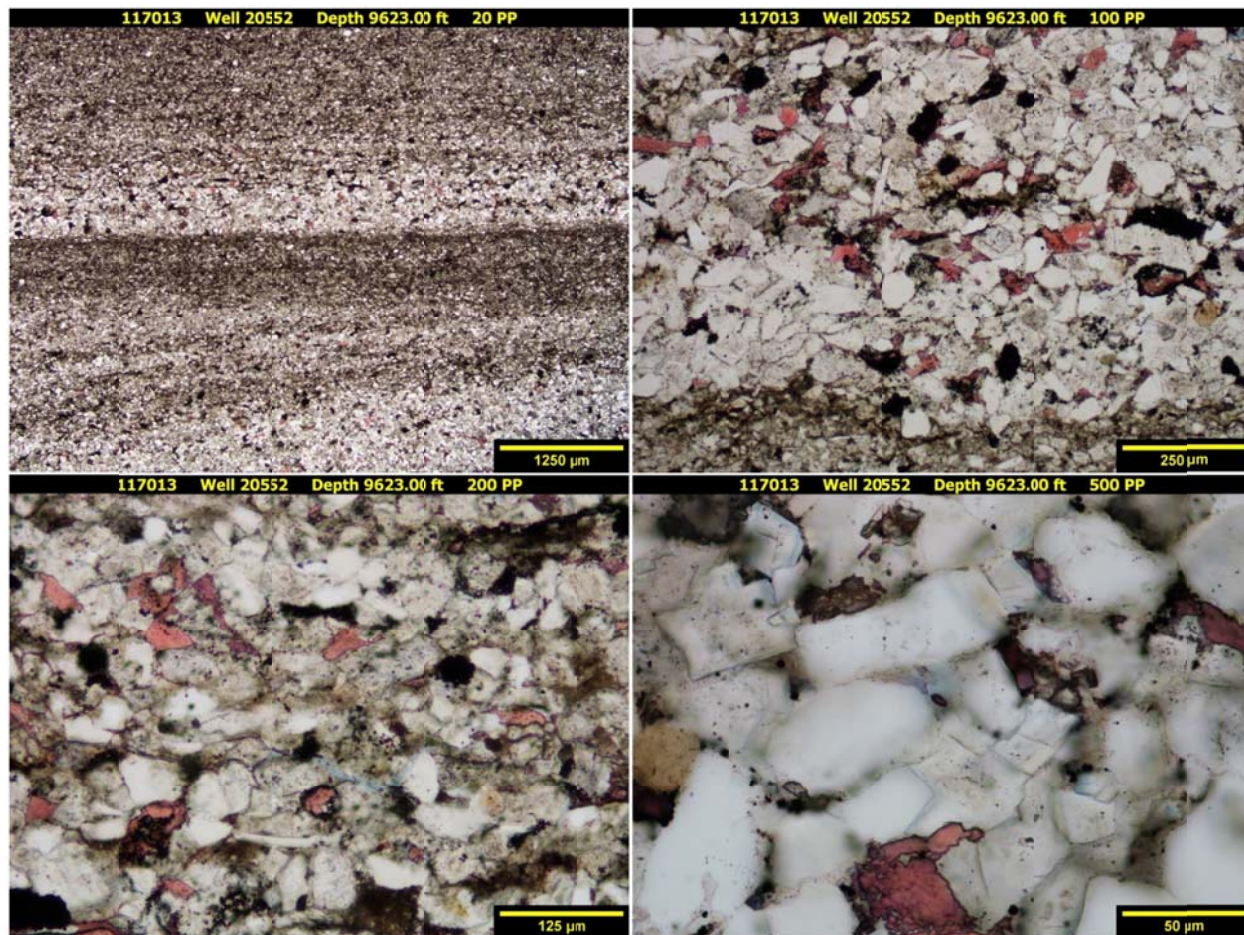
Porosity and Grain Density by Core Laboratories

Pycnometer Effective Porosity, vol%	Grain Density, g/cm ³
6.27	2.760

	Applied Geology Laboratory		ID: 117013
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-05	Lithology: Silty dolostone	Depth: 9623.0'

PHOTOMICROGRAPHS

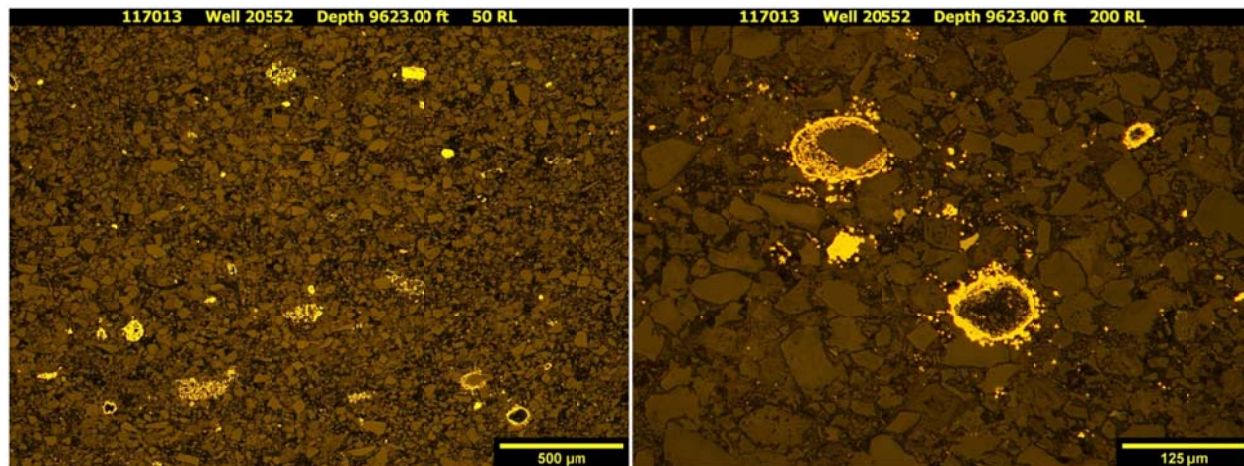
Transmission



The sample from a depth of 9623.00 ft shows a silty dolostone. A slight degree of bioturbation and horizontal to wispy laminations are present. Very fine grained, angular to subrounded, monocrystalline quartz grains and trace amounts of muscovite and feldspars are disseminated throughout. Extensive anhedral to euhedral dolomitization has occurred throughout the sample. Very rare calcareous non-skeletal grains remain. Disseminated pore-filling and replacement pyrite grains are observed. An additional matrical component is clay, found at moderate quantities assisting in creating laminations. Open fractures, predominately horizontal, observed are likely the result of the sample process. Organics are observed and typically associated with pyrite. A trace amount of intra-particle porosity is observed using standard petrographic techniques.

	Applied Geology Laboratory		ID: 117013
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-05	Lithology: Silty dolostone	Depth: 9623.0'

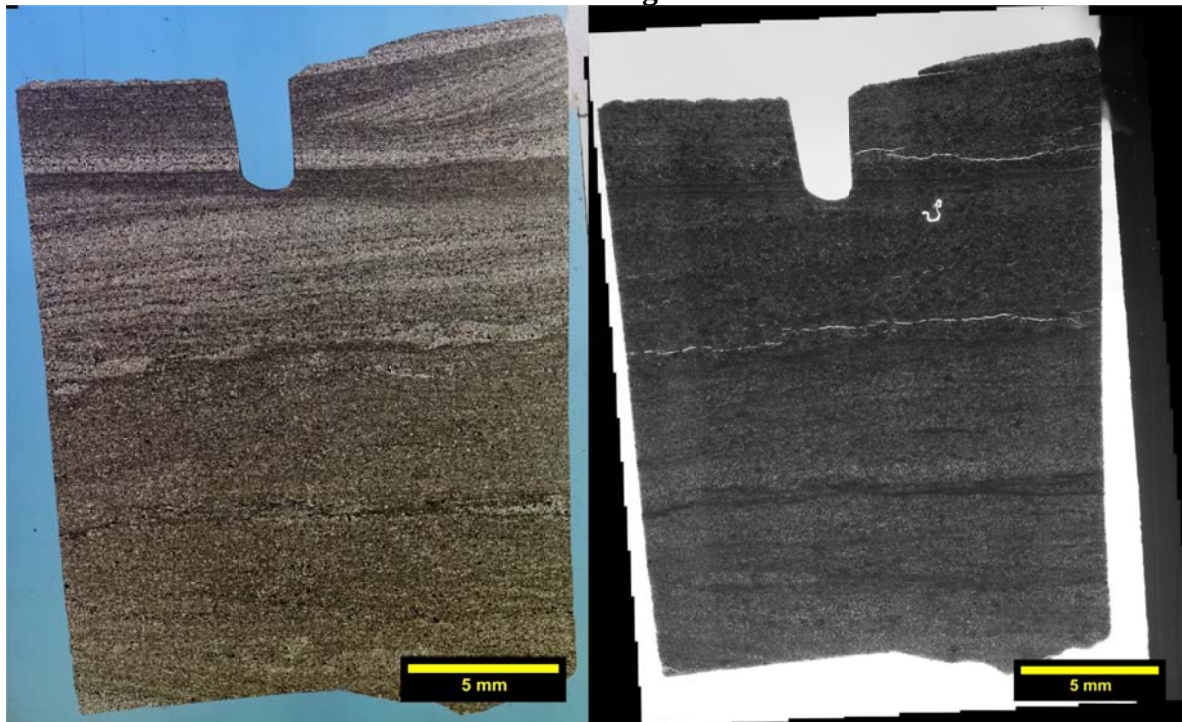
Reflection



The sample from a depth of 9623.00 ft displays a moderately strong pyrite presence. Mostly euhedral and trace quantities of framboidal pyrite growth are detected. Both pore filling and grain replacement are observed. Multiple partially (outer) euhedral allochem replacement is observed throughout the sample, leaving the center area non-pyritized. Trace framboidal pyrite is immature, displaying no larger aggregate sphere assemblages.

	Applied Geology Laboratory		ID: 117013
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-05	Lithology: Silty dolostone	Depth: 9623.0'

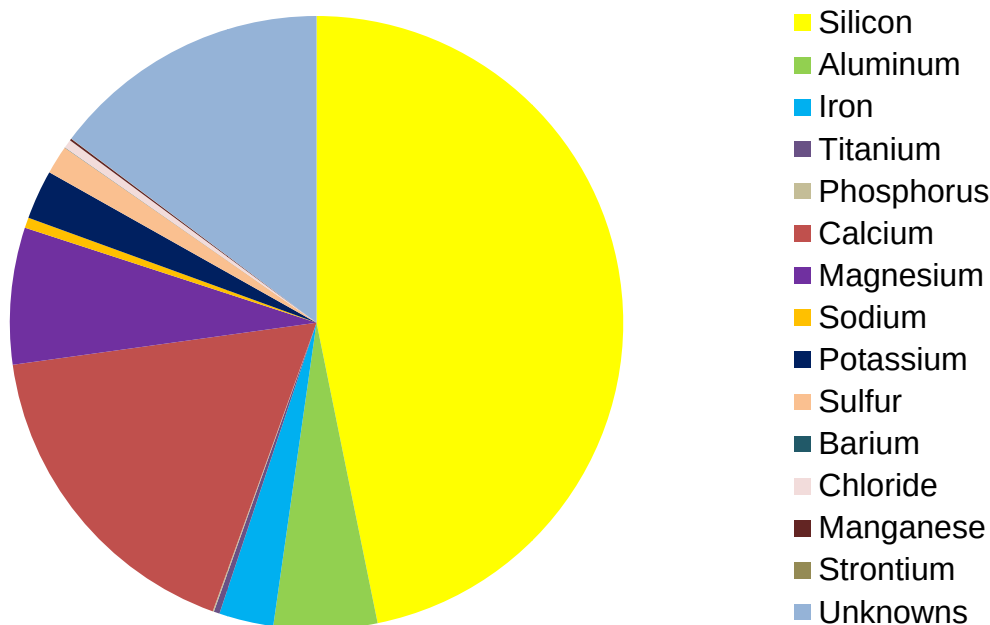
Transmission and Fluorescence Whole-Slide Images



The image collected from a depth of 9623.00 ft shows a slight degree of bioturbation and horizontal-to-wispy laminations within the sample. Effective porosity is reported at 6.27 vol%. Overall, the sample is well-cemented. Inter-particle-based micro-porosity mainly exists within quartz and euhedral dolomite-rich laminations. Lesser amounts of porosity are detected within areas of smaller, mostly anhedral dolomite grains and clay concentrations. Overall, pore sizes appear to be very small (far less than 30 μm). Horizontal induced fractures are observed and are likely because of the sampling process. Though the open fractures are not naturally-occurring, predictions of how the interval may behave under stress may be characterized.

	Applied Geology Laboratory		ID: 117013
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-05	Lithology: Silty dolostone	Depth: 9623.0'

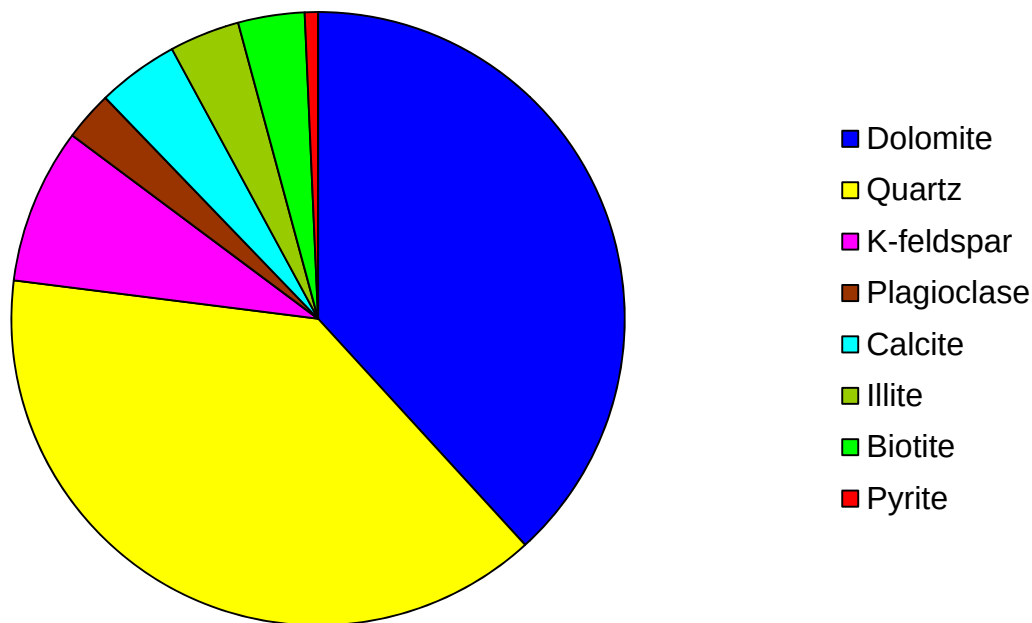
XRF BULK CHEMICAL COMPOSITION



Element	Reporting Convention (Oxide)	Weight %
Si (silicon)	SiO ₂	46.81
Al (aluminum)	Al ₂ O ₃	5.45
Fe (iron)	Fe ₂ O ₃	2.87
Ti (titanium)	TiO ₂	0.31
P (phosphorus)	P ₂ O ₅	0.06
Ca (calcium)	CaO	17.32
Mg (magnesium)	MgO	7.20
Na (sodium)	Na ₂ O	0.55
K (potassium)	K ₂ O	2.60
S (sulfur)	SO ₃	1.51
Ba (barium)	BaO	0.02
Cl (chloride)	Cl	0.45
Mn (manganese)	MnO	0.10
Sr (strontium)	SrO	0.01
Unknowns	Due to the presence of carbonates	14.75
Total		100.01

	Applied Geology Laboratory		ID: 117013
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-05	Lithology: Silty dolostone	Depth: 9623.0'

XRD MINERAL PHASE DISTRIBUTION



Mineral Phase	Formula	Weight %
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	38.2
Quartz	SiO_2	38.8
K-feldspar	KAlSi_3O_8	8.2
Plagioclase	$\text{Na}_{0.5}\text{Ca}_{0.5}\text{Al}_{1.5}\text{Si}_{2.5}\text{O}_8$	2.6
Calcite	CaCO_3	4.3
Illite	$(\text{K},\text{H}_3\text{O})(\text{Al},\text{Mg},\text{Fe})_2(\text{Si},\text{Al})_4\text{O}_{10}[(\text{OH})_2,(\text{H}_2\text{O})]$	3.7
Biotite	$\text{K}(\text{Mg},\text{Fe})_3[(\text{OH})_2\text{AlSi}_3\text{O}_{10}]$	3.5
Pyrite	FeS_2	0.7

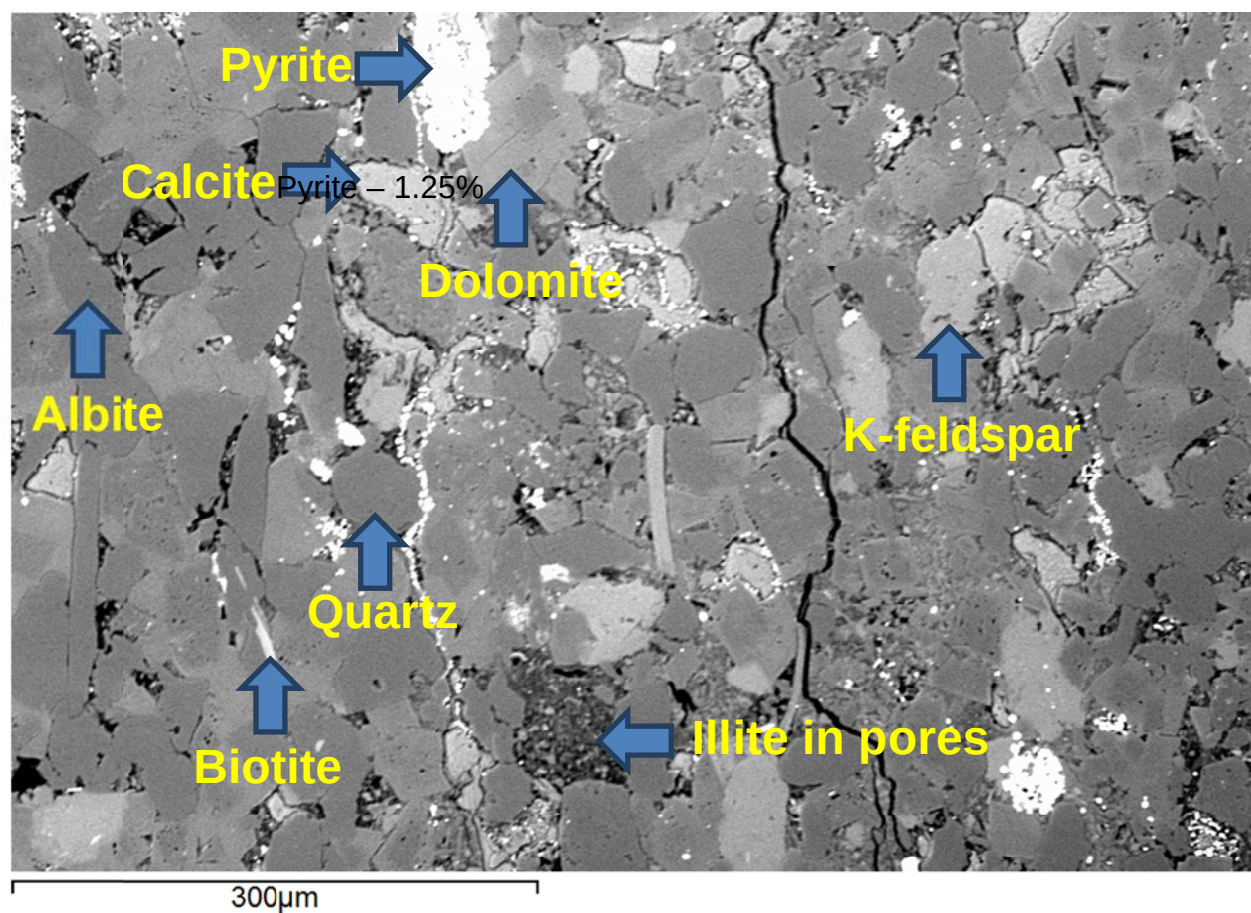
	Applied Geology Laboratory		ID: 117013
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-05	Lithology: Silty dolostone	Depth: 9623.0'

SEM

Observed Minerals

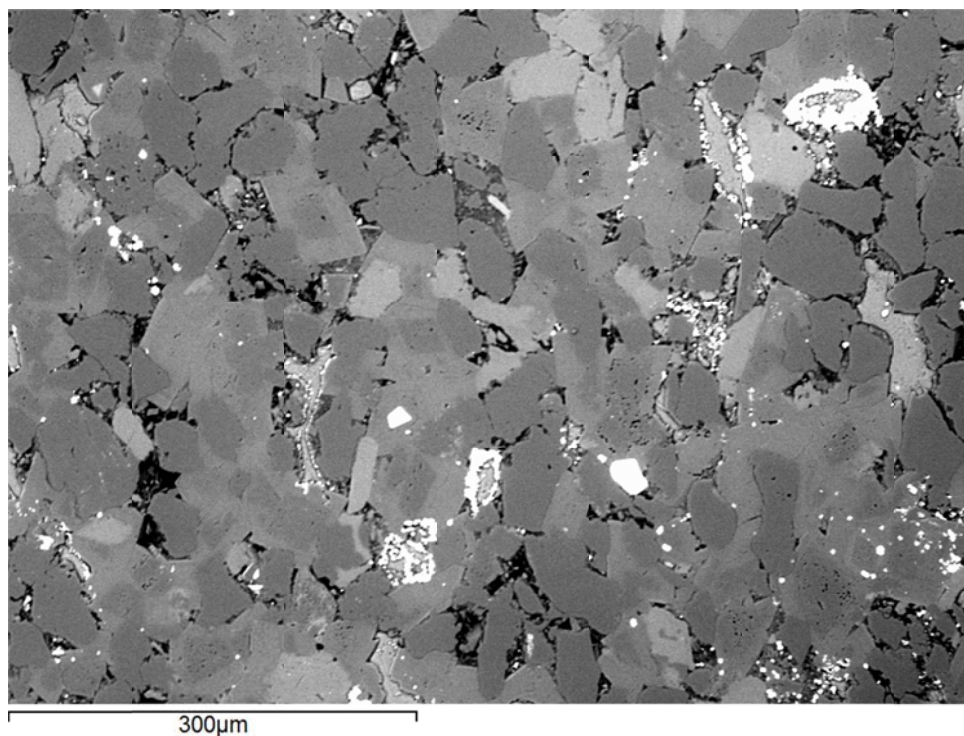
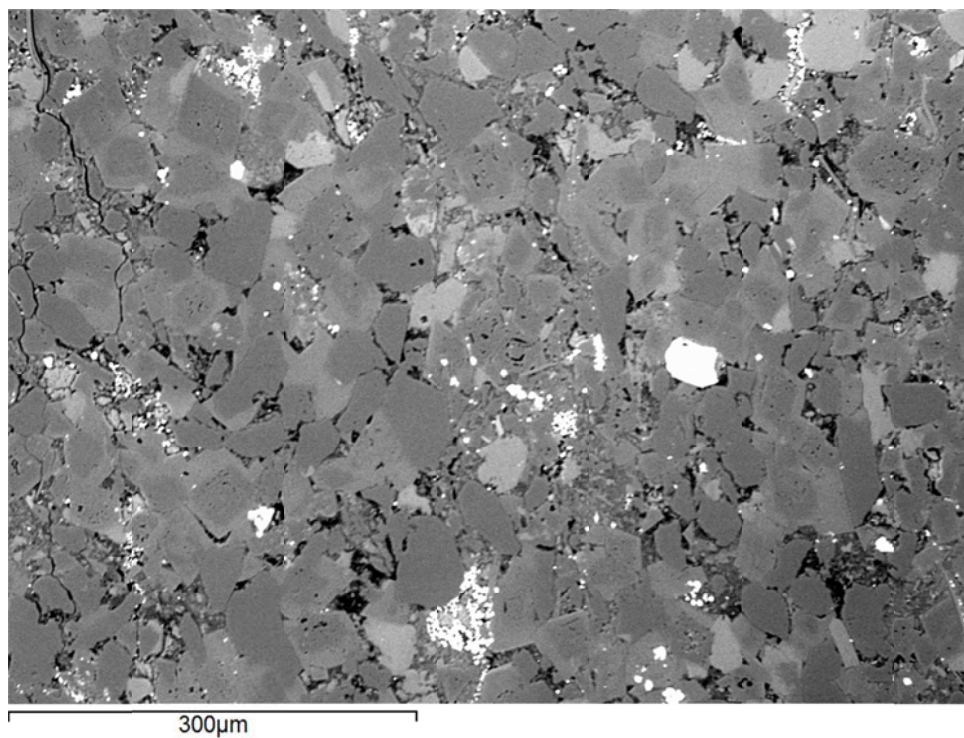
Mineral Phase	Mineral Phase
Calcite	Albite
Quartz	Rutile
Dolomite	Illite
Pyrite	K-feldspar
Zircon	Biotite

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified

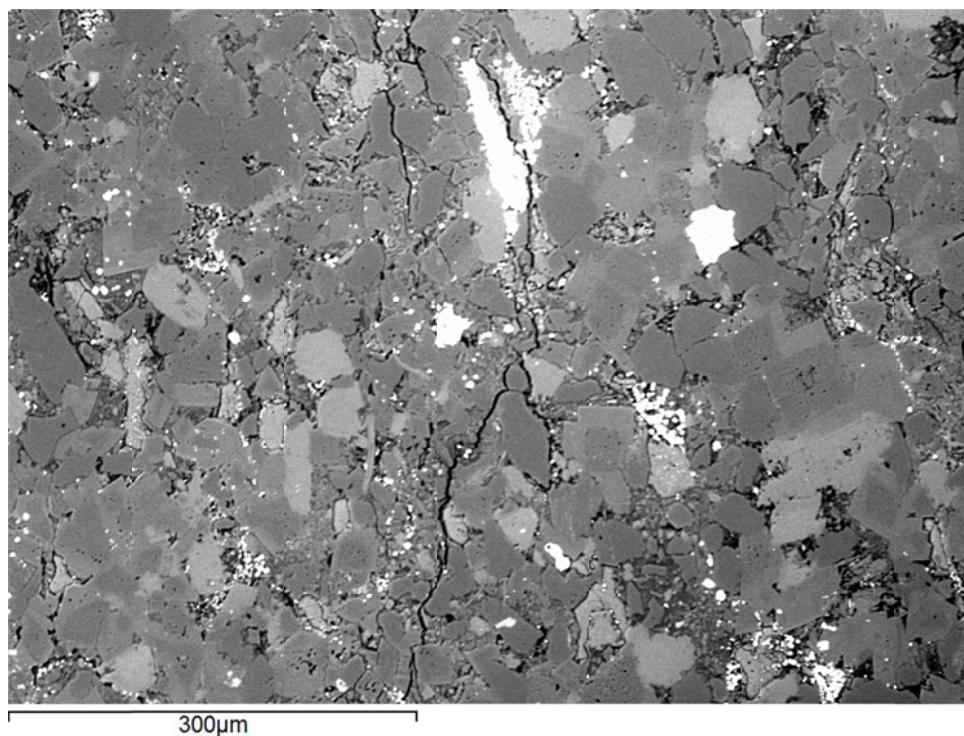
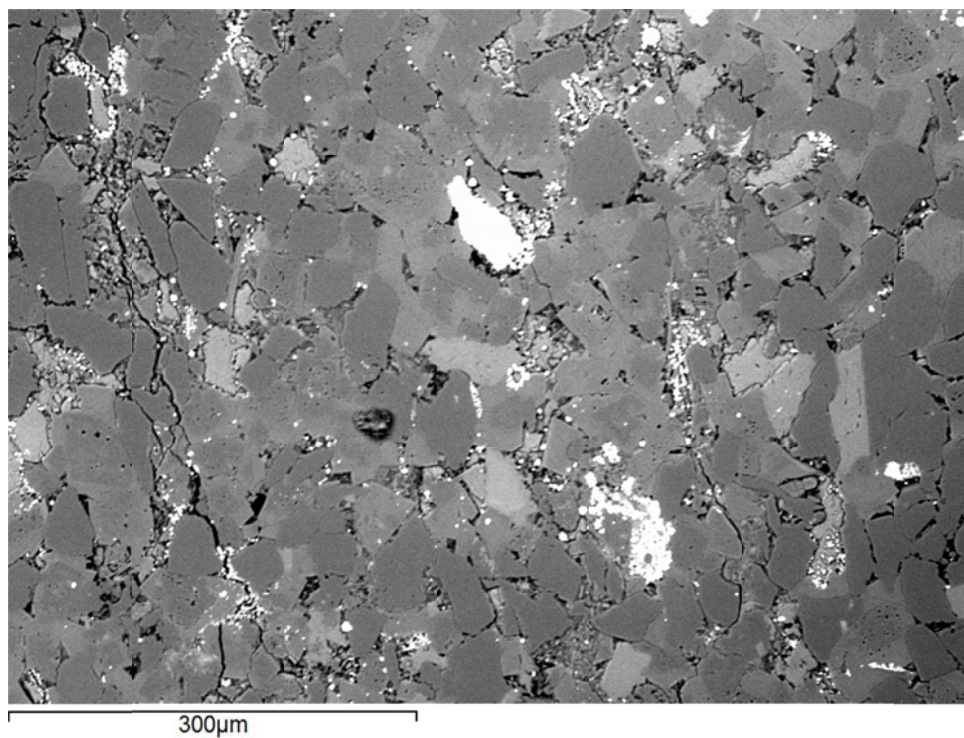


	Applied Geology Laboratory		ID: 117013
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-05	Lithology: Silty dolostone	Depth: 9623.0'

Additional High-Magnification BSE Images

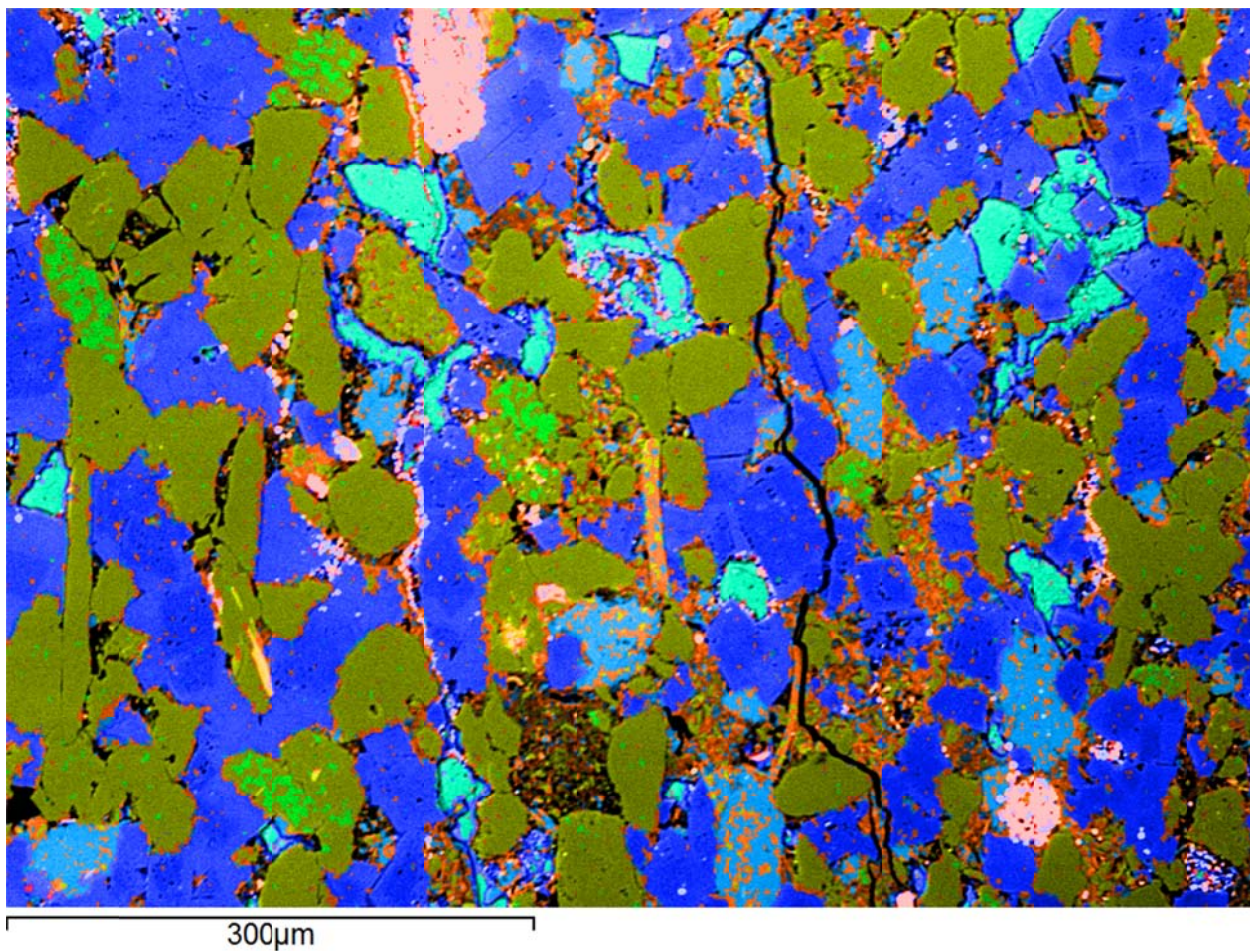


	Applied Geology Laboratory		ID: 117013
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-05	Lithology: Silty dolostone	Depth: 9623.0'



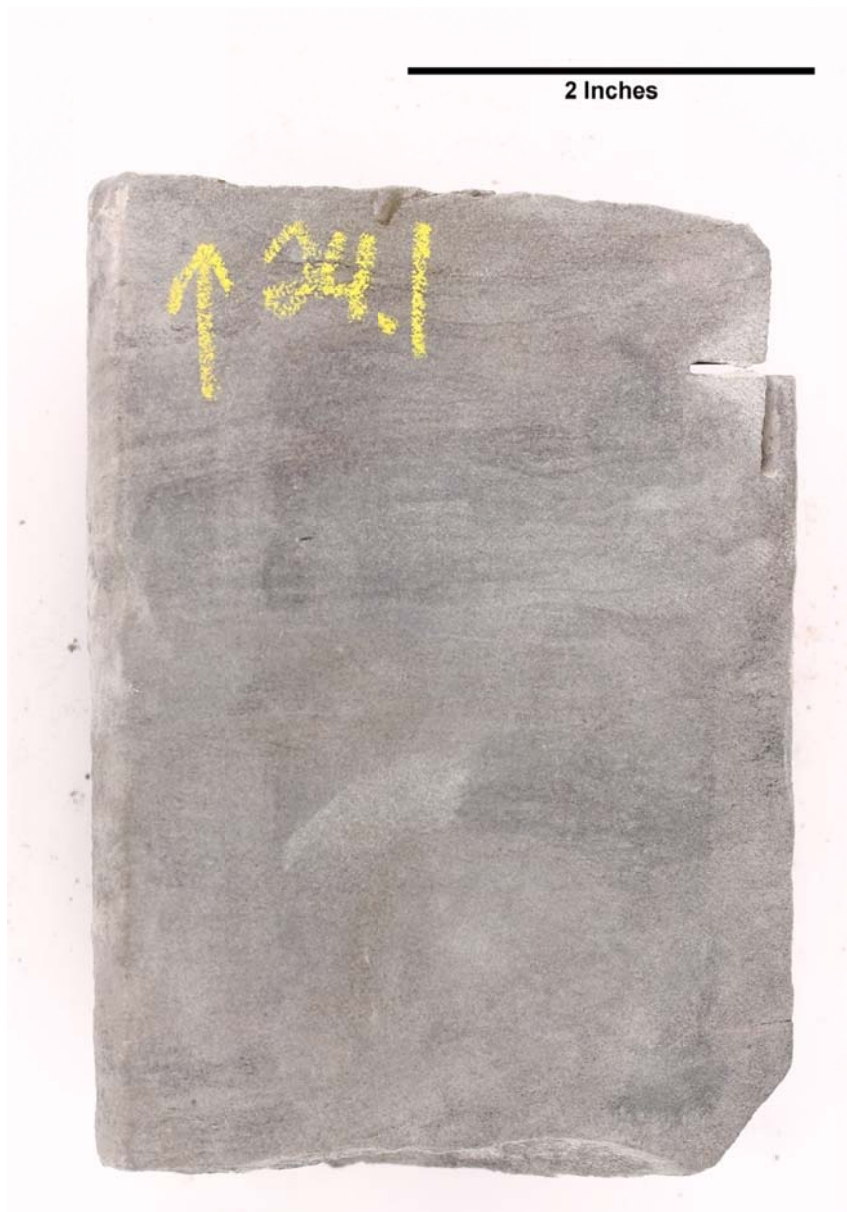
	Applied Geology Laboratory		ID: 117013
	Well Name: NDIC No. 20552	Middle Bakken 5	Grenora Field
	API No.: 33-105-02157-00-05	Lithology: Silty dolostone	Depth: 9623.0'

SEM Mineral Map Image Overlaid on BSE Image with Mineral Phase 2D Area Percentages



	Applied Geology Laboratory		ID: 117014
	Well Name: NDIC No. 20552	Middle Bakken 4	Grenora Field
	API No.: 33-105-02157-00-06	Lithology: Calcareous siltstone	Depth: 9624.0'

SAMPLE PHOTOGRAPH



PHYSICAL PROPERTIES

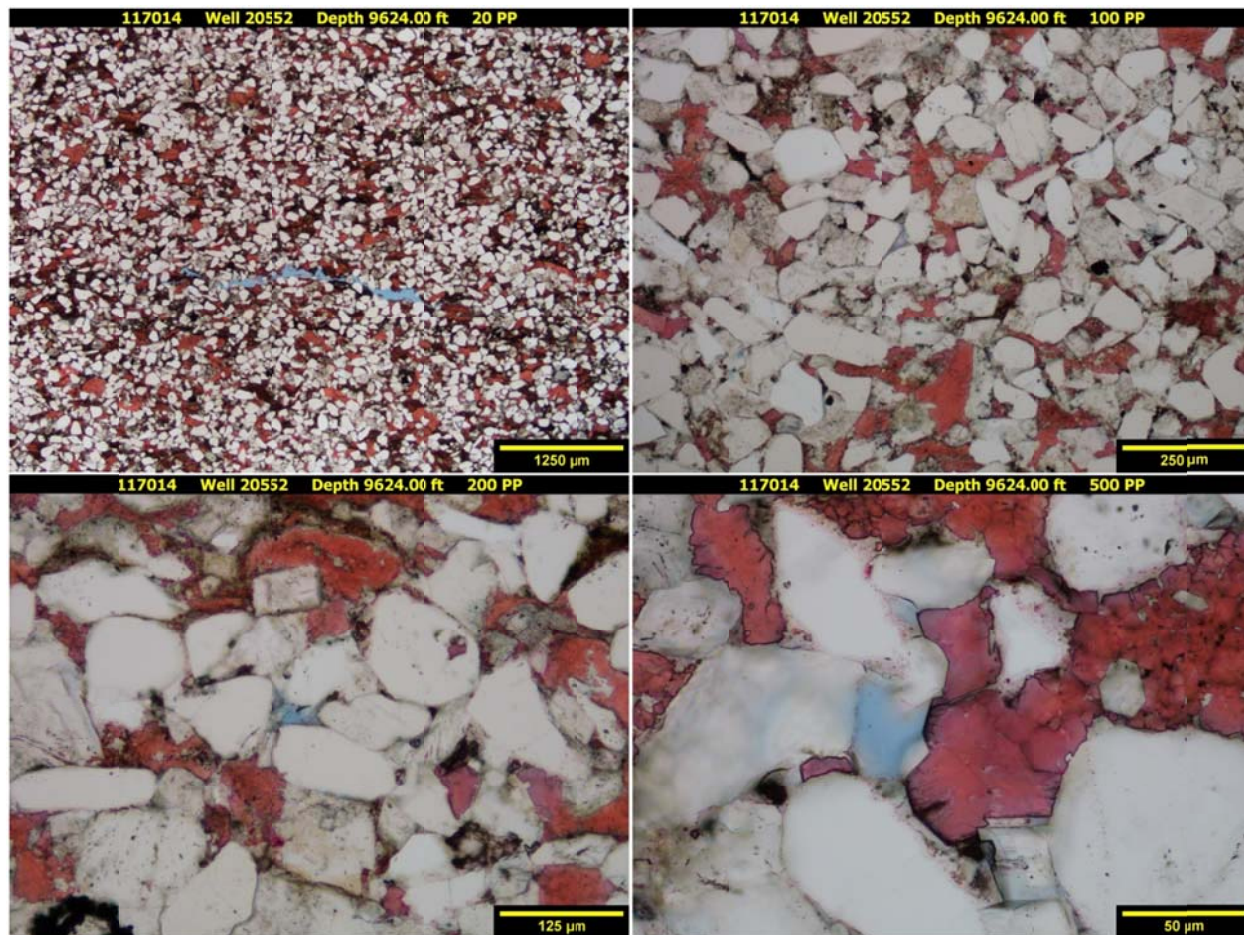
Porosity and Grain Density by Core Laboratories

Pycnometer Effective Porosity, vol%	Grain Density, g/cm ³
5.20	2.717

	Applied Geology Laboratory		ID: 117014
	Well Name: NDIC No. 20552	Middle Bakken 4	Grenora Field
	API No.: 33-105-02157-00-06	Lithology: Calcareous siltstone	Depth: 9624.0'

PHOTOMICROGRAPHS

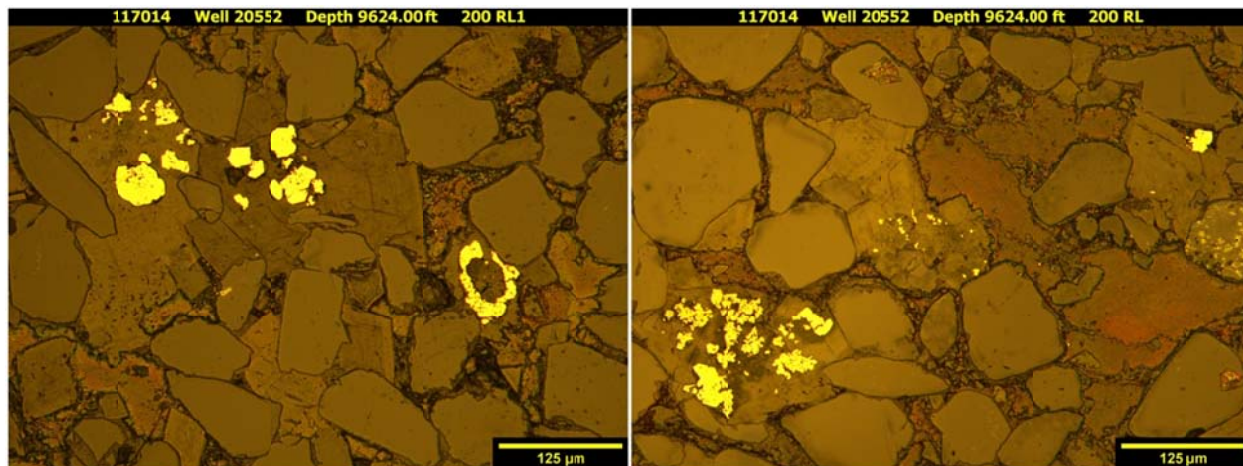
Transmission



The sample captured at a depth of 9624.00 ft is a calcareous siltstone. It is a very massive sample expressing very little bedding structures. Fine-grained, subangular to subrounded, monocrystalline quartz grains are prevalent. Trace amounts of muscovite, rutile, and feldspars are disseminated throughout. Anhydrous to euhedral dolomitization has occurred throughout the sample. Rare skeletal and common non-skeletal calcite remains. Disseminated pore-filling and replacement pyrite grains exist throughout. Cementing agents are composed of a combination of clays, dolomite, and sparry calcite. Organics detection is rare and is usually associated with pyrite grains. Small occurrences of inter-particle-based porosity are detected likely because of dolomitization. No natural fractures are detected.

	Applied Geology Laboratory		ID: 117014
	Well Name: NDIC No. 20552	Middle Bakken 4	Grenora Field
	API No.: 33-105-02157-00-06	Lithology: Calcareous siltstone	Depth: 9624.0'

Reflection



The sample from a depth of 9624.00 ft displays a lesser pyrite presence. Mostly euhedral and trace quantities of framboidal pyrite growth are detected. Both pore filling and grain replacement are likely observed. Euhedral grains are very fine grained and individual framboidal grains are observed at a fraction of that size. Trace framboidal pyrite is immature, displaying no sphere assemblages. Occasional complete to nearly complete pyritization of precursor grains and organics have occurred.

	Applied Geology Laboratory		ID: 117014
	Well Name: NDIC No. 20552	Middle Bakken 4	Grenora Field
	API No.: 33-105-02157-00-06	Lithology: Calcareous siltstone	Depth: 9624.0'

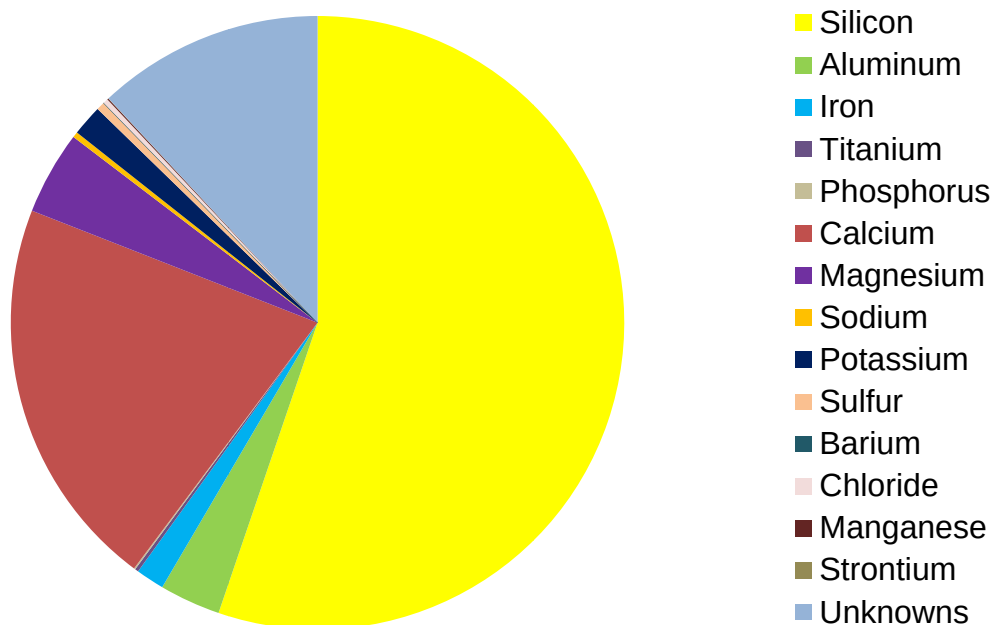
Transmission and Fluorescence Whole-Slide Images



The sample collected at a depth of 9624.00 ft displays a relatively homogeneous calcareous siltstone representing very few bedding features. The sample is well-cemented with calcite and dolomite. Zones of increased dolomite are less cemented, thus allowing for more inter-particle pore space than calcite-rich zones. The observed micro-inter-particle porosity may be because of incomplete dolomitization and/or mineral dissolution (feldspar/calcite) or leaching (pyrite). Variability in pore sizes are observed, but nearly all appear well under 30 μm . No legitimate open fractures are detected. Induced horizontal fractures are noted.

	Applied Geology Laboratory		ID: 117014
	Well Name: NDIC No. 20552	Middle Bakken 4	Grenora Field
	API No.: 33-105-02157-00-06	Lithology: Calcareous siltstone	Depth: 9624.0'

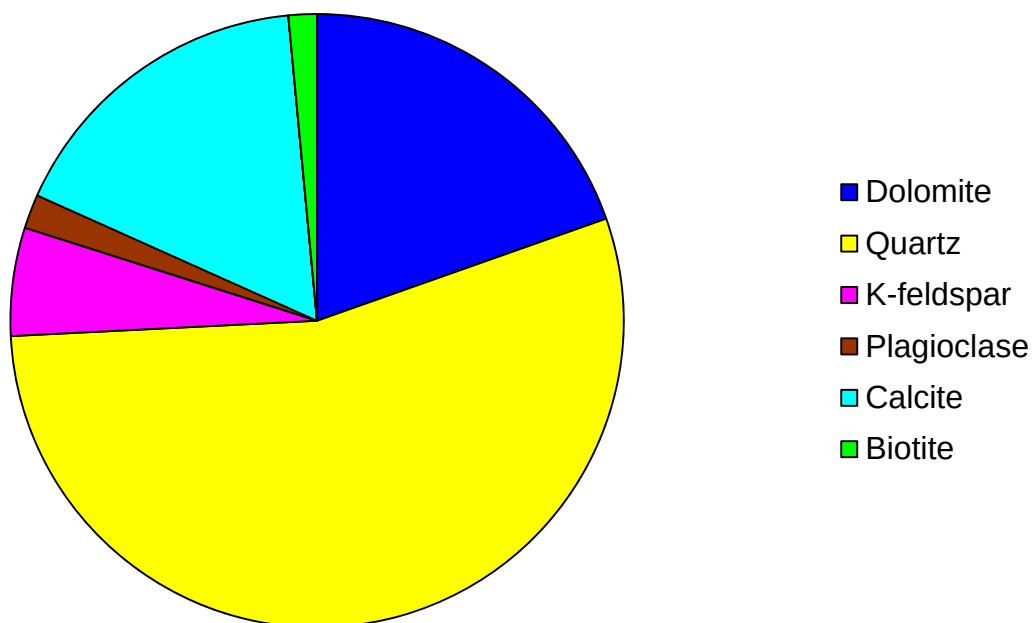
XRF BULK CHEMICAL COMPOSITION



Element	Reporting Convention (Oxide)	Weight %
Si (silicon)	SiO ₂	55.24
Al (aluminum)	Al ₂ O ₃	3.22
Fe (iron)	Fe ₂ O ₃	1.50
Ti (titanium)	TiO ₂	0.18
P (phosphorus)	P ₂ O ₅	0.07
Ca (calcium)	CaO	20.75
Mg (magnesium)	MgO	4.40
Na (sodium)	Na ₂ O	0.30
K (potassium)	K ₂ O	1.62
S (sulfur)	SO ₃	0.45
Ba (barium)	BaO	0.00
Cl (chloride)	Cl	0.26
Mn (manganese)	MnO	0.07
Sr (strontium)	SrO	0.01
Unknowns	Due to the presence of carbonates	11.94
Total		100.01

	Applied Geology Laboratory		ID: 117014
	Well Name: NDIC No. 20552	Middle Bakken 4	Grenora Field
	API No.: 33-105-02157-00-06	Lithology: Calcareous siltstone	Depth: 9624.0'

XRD MINERAL PHASE DISTRIBUTION



Mineral Phase	Formula	Weight %
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	19.6
Quartz	SiO_2	54.6
K-feldspar	KAlSi_3O_8	5.7
Plagioclase	$\text{Na}_{0.5}\text{Ca}_{0.5}\text{Al}_{1.5}\text{Si}_{2.5}\text{O}_8$	1.8
Calcite	CaCO_3	16.8
Biotite	$\text{K}(\text{Mg,Fe})_3[(\text{OH})_2\text{AlSi}_3\text{O}_{10}]$	1.5

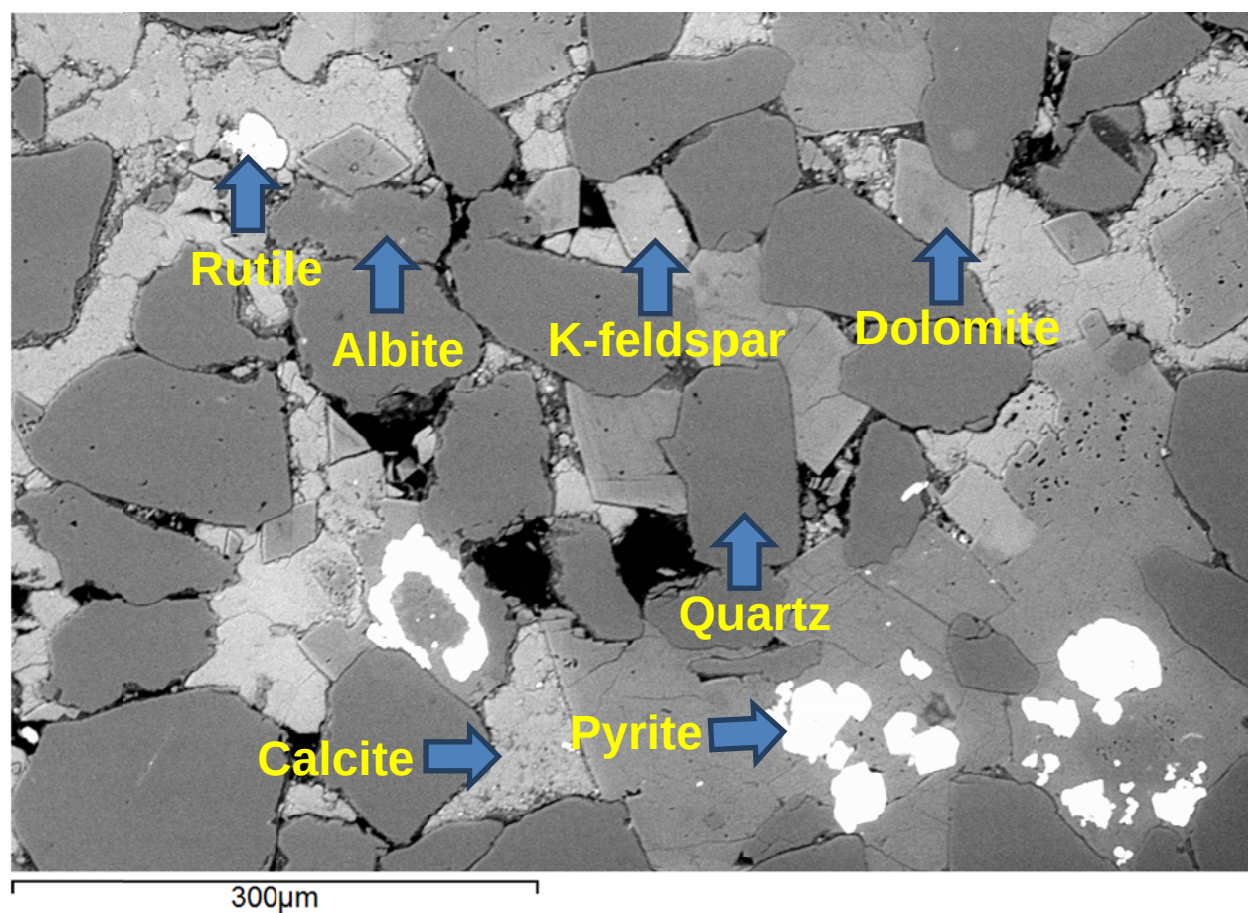
	Applied Geology Laboratory		ID: 117014
	Well Name: NDIC No. 20552	Middle Bakken 4	Grenora Field
	API No.: 33-105-02157-00-06	Lithology: Calcareous siltstone	Depth: 9624.0'

SEM

Observed Minerals

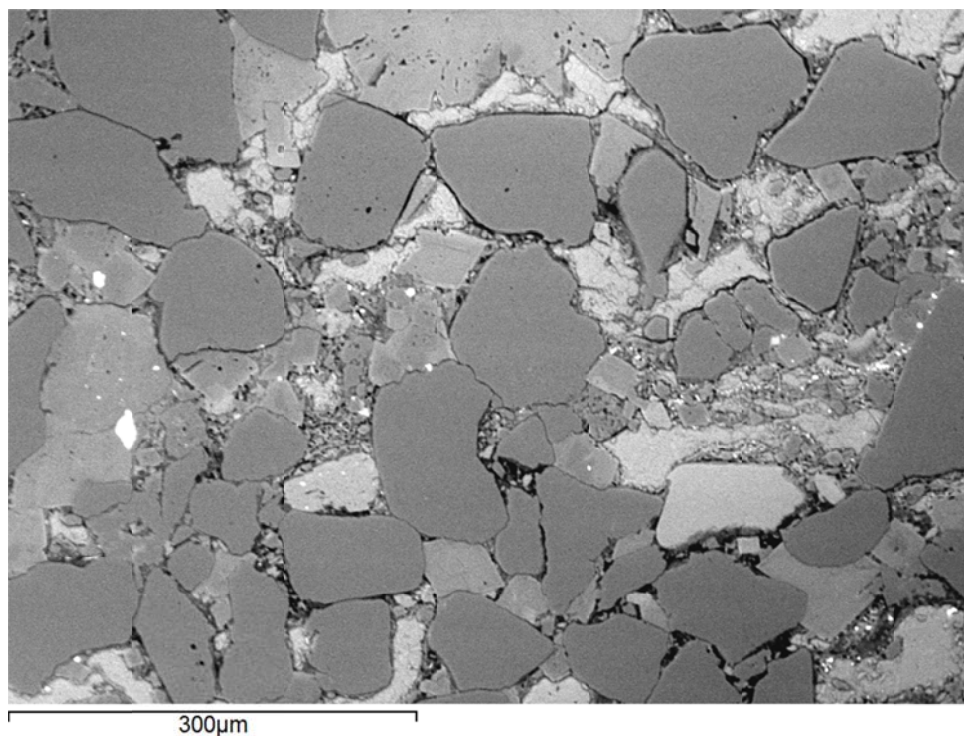
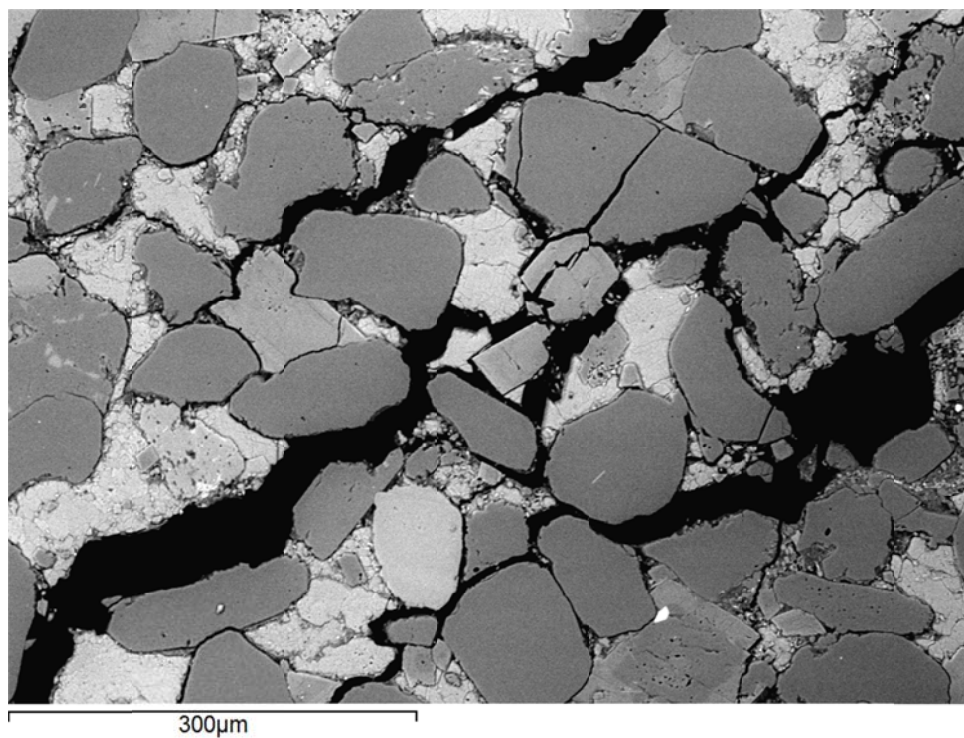
Mineral Phase	Mineral Phase
Calcite	K-feldspar
Dolomite	Albite
Quartz	Rutile
Pyrite	Apatite
Illite	Monazite

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified

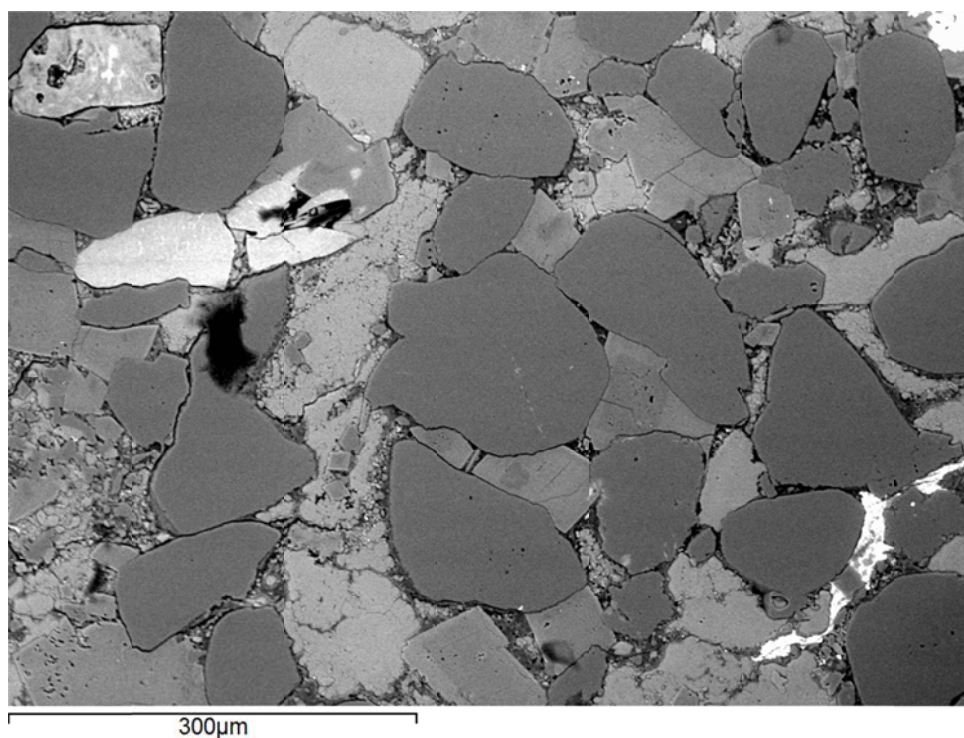
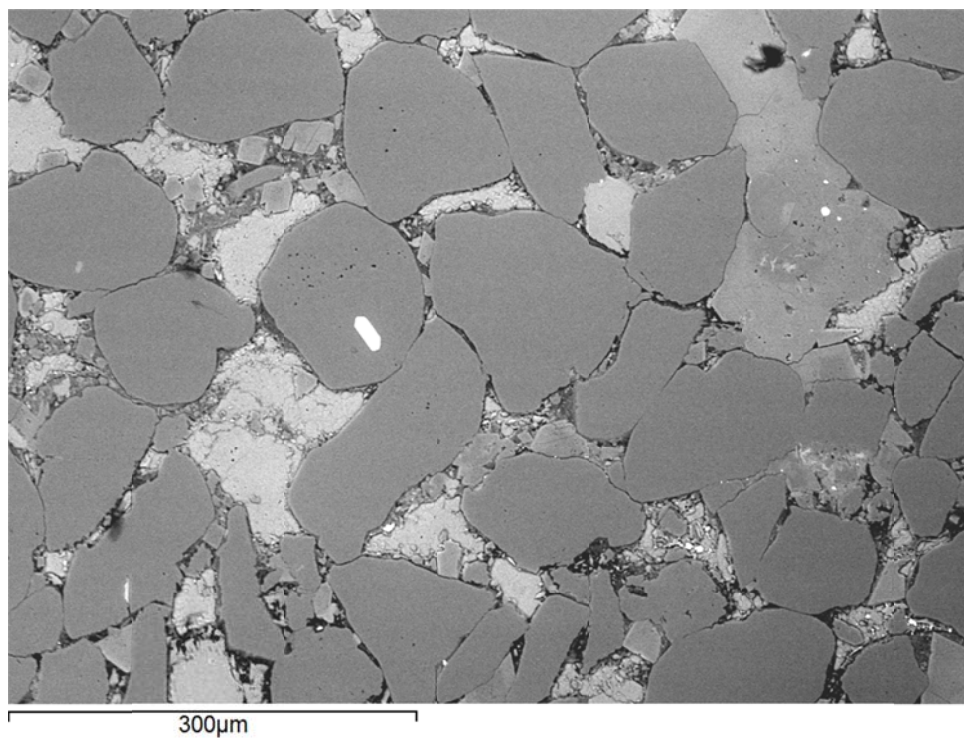


	Applied Geology Laboratory		ID: 117014
	Well Name: NDIC No. 20552	Middle Bakken 4	Grenora Field
	API No.: 33-105-02157-00-06	Lithology: Calcareous siltstone	Depth: 9624.0'

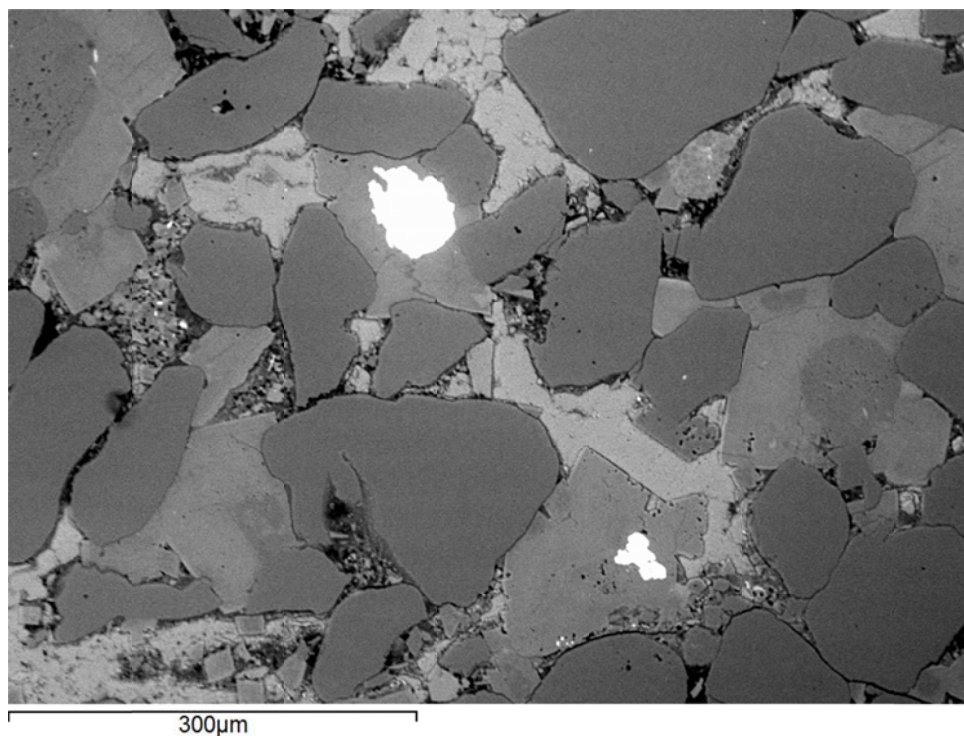
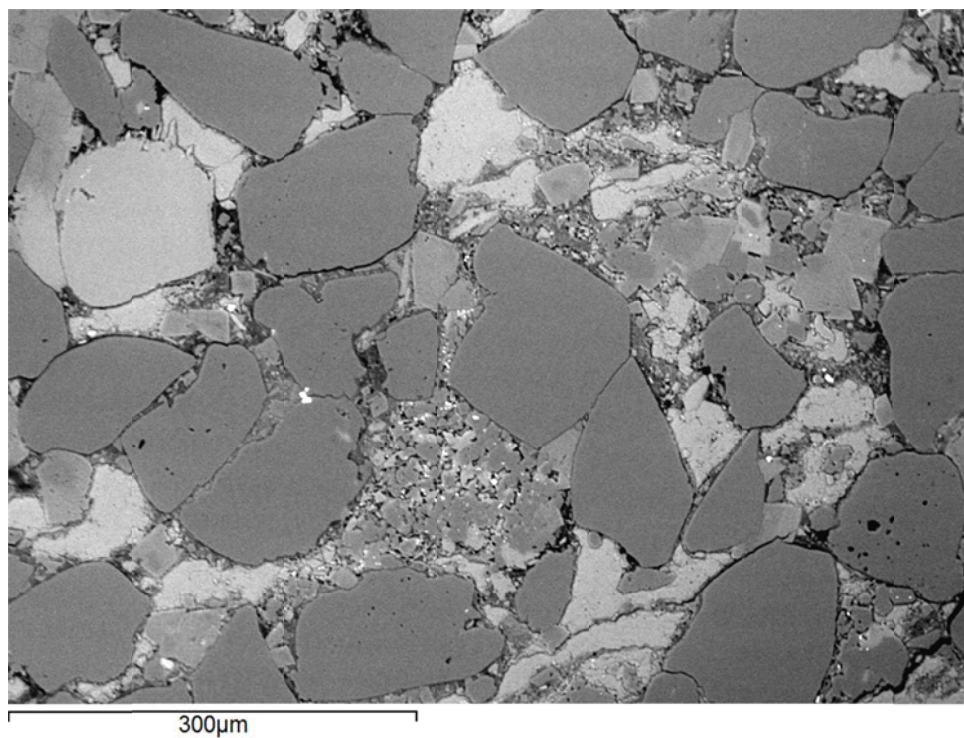
Additional High-Magnification BSE Images



	Applied Geology Laboratory		ID: 117014
	Well Name: NDIC No. 20552	Middle Bakken 4	Grenora Field
	API No.: 33-105-02157-00-06	Lithology: Calcareous siltstone	Depth: 9624.0'

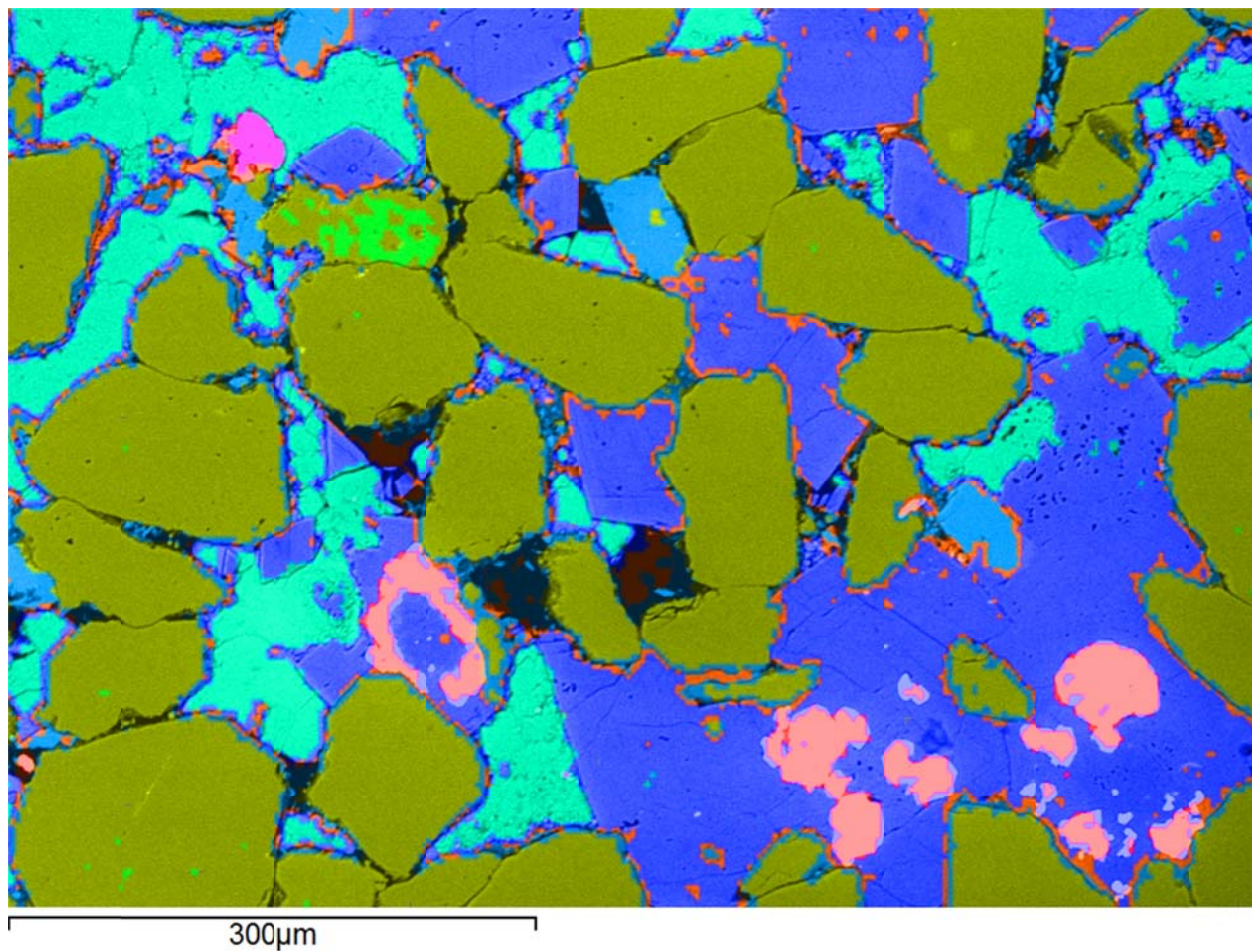


	Applied Geology Laboratory		ID: 117014
	Well Name: NDIC No. 20552	Middle Bakken 4	Grenora Field
	API No.: 33-105-02157-00-06	Lithology: Calcareous siltstone	Depth: 9624.0'



	Applied Geology Laboratory		ID: 117014
	Well Name: NDIC No. 20552	Middle Bakken 4	Grenora Field
	API No.: 33-105-02157-00-06	Lithology: Calcareous siltstone	Depth: 9624.0'

SEM Mineral Map Image Overlaid on BSE Image with Mineral Phase 2D Area Percentages



	Applied Geology Laboratory		ID: 117014
	Well Name: NDIC No. 20552	Middle Bakken 4	Grenora Field
	API No.: 33-105-02157-00-06	Lithology: Calcareous siltstone	Depth: 9624.0'

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	Applied Geology Laboratory		ID: 117016
	Well Name: NDIC No. 20552	Middle Bakken 1	Grenora Field
	API No.: 33-105-02157-00-08	Lithology: Calcareous, argillaceous siltstone	Depth: 9646.5'

SAMPLE PHOTOGRAPH



PHYSICAL PROPERTIES

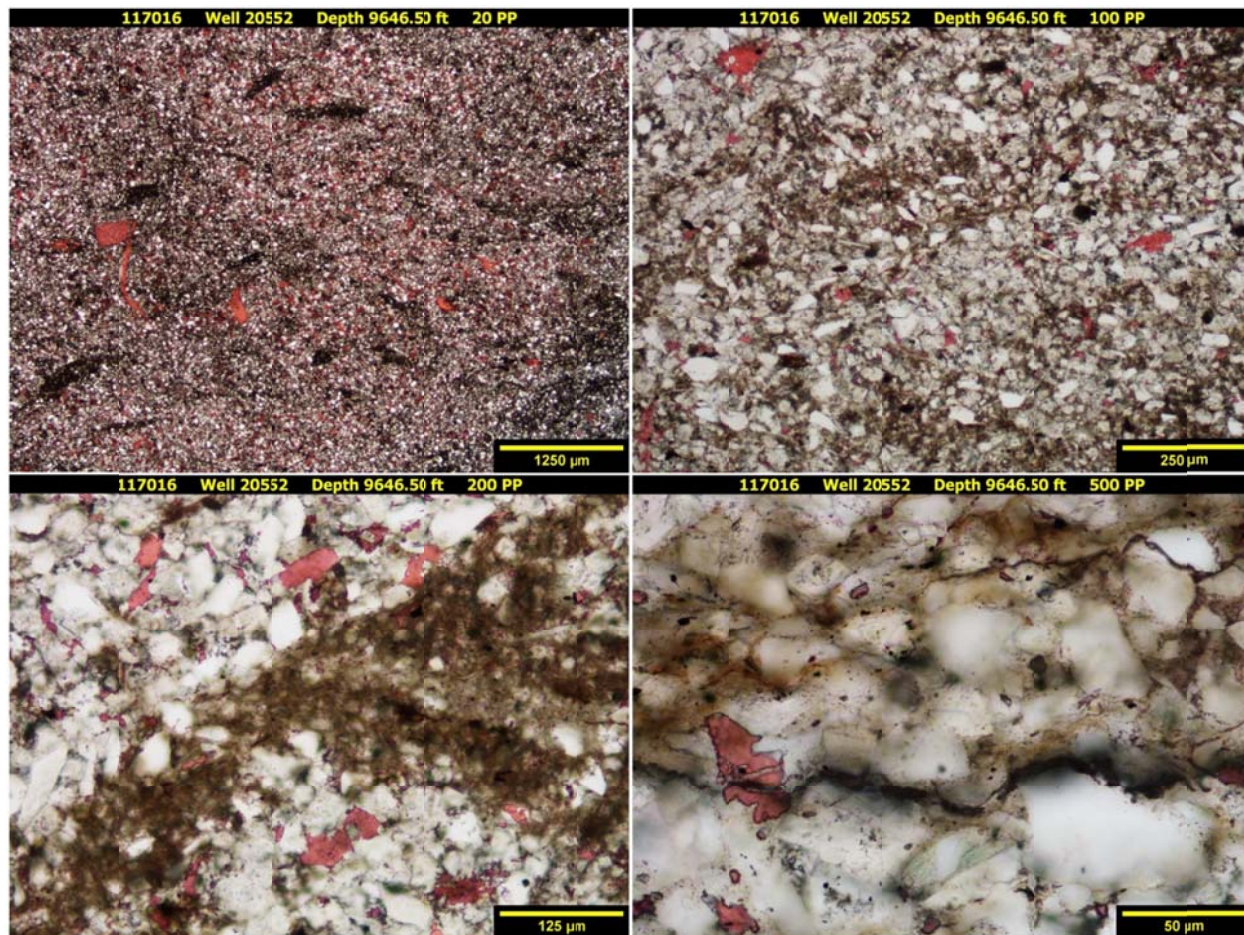
Porosity and Grain Density by Core Laboratories

Pycnometer Effective Porosity, vol%	Grain Density, g/cm ³
6.61	2.729

	Applied Geology Laboratory		ID: 117016
	Well Name: NDIC No. 20552	Middle Bakken 1	Grenora Field
	API No.: 33-105-02157-00-08	Lithology: Calcareous, argillaceous siltstone	Depth: 9646.5'

PHOTOMICROGRAPHS

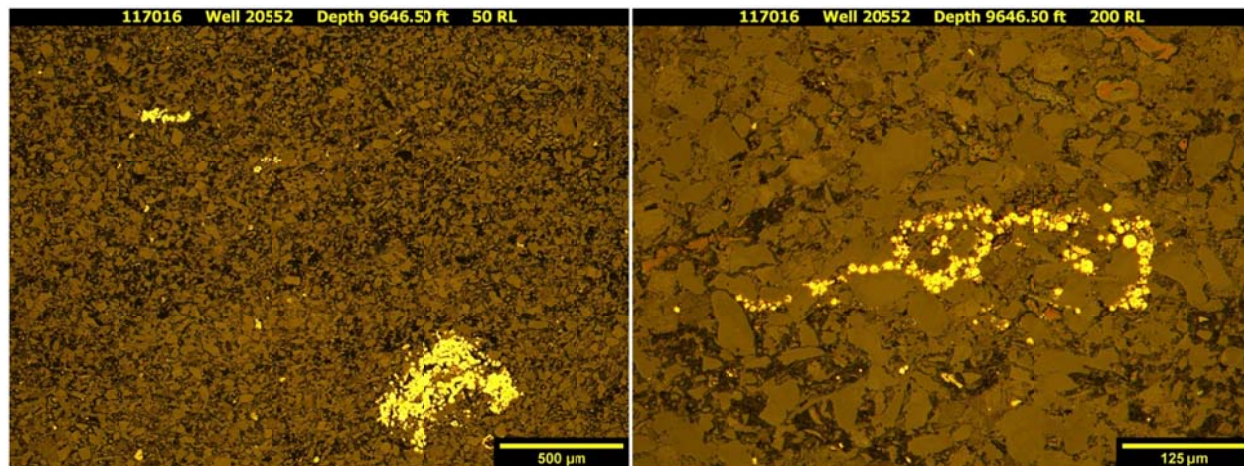
Transmission



The sample from a depth of 9646.50 ft shows a predominantly massive calcareous, argillaceous siltstone. A moderate degree of bioturbation and no laminations are present. Very fine grained, angular to subangular, monocrystalline quartz grains and trace amounts of muscovite and feldspars are disseminated throughout. Extensive anhedral to euhedral dolomitization has occurred throughout the sample. Common skeletal and non-skeletal calcareous grains remain. Disseminated pore-filling and replacement pyrite grains are present. An additional matricial component is clay, found at moderate quantities concentrating zonally to assist in lensing and burrowing structures. Rare organically and clay-filled microfractures are present; no open fractures are noted. Organics are rarely observed and typically associated with pyrite. No porosity is observed using standard petrographic techniques.

	Applied Geology Laboratory		ID: 117016
	Well Name: NDIC No. 20552	Middle Bakken 1	Grenora Field
	API No.: 33-105-02157-00-08	Lithology: Calcareous, argillaceous siltstone	Depth: 9646.5'

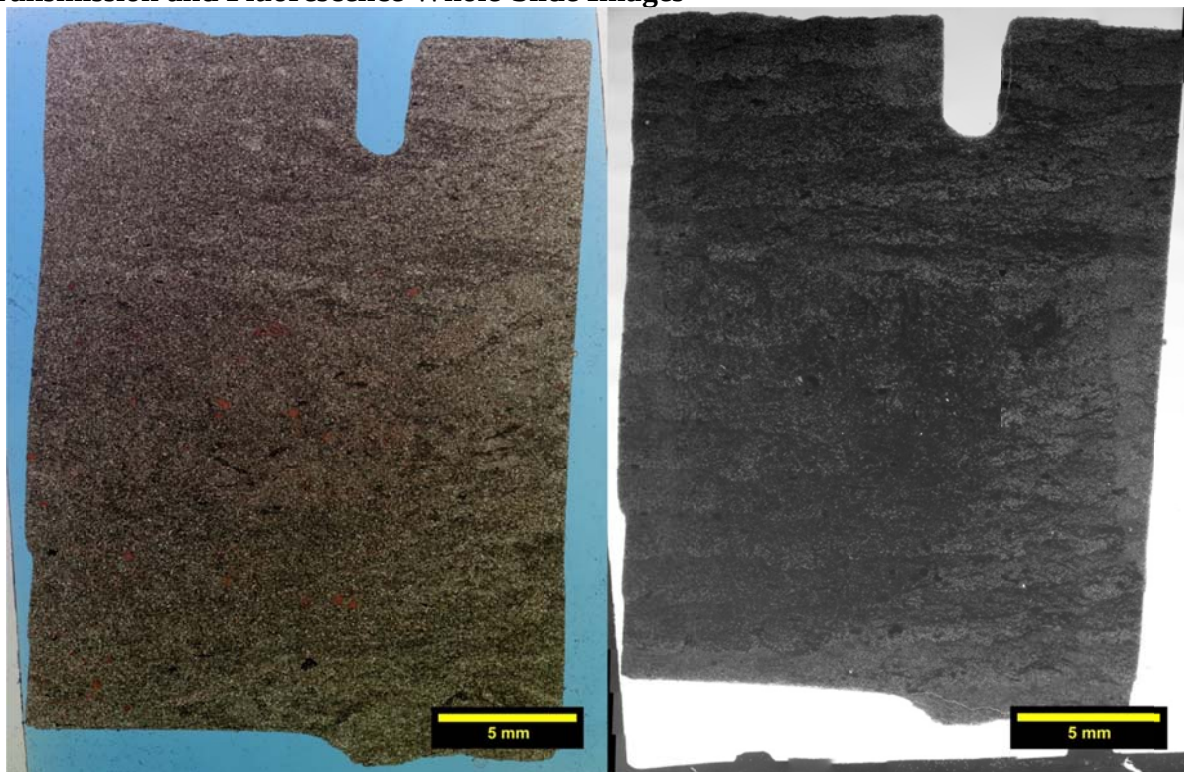
Reflection



The sample from a depth of 9646.50 ft displays a moderately prevalent pyrite presence. A combination of euhedral and framboidal pyrite mineralization exists. Both pore filling and grain replacement are observed. Both euhedral and framboidal mineralization appear concentrated with clay-rich and organic areas. Filling of micropores appears likely by euhedral pyrite. Very little grain replacement is noted.

	Applied Geology Laboratory		ID: 117016
	Well Name: NDIC No. 20552	Middle Bakken 1	Grenora Field
	API No.: 33-105-02157-00-08	Lithology: Calcareous, argillaceous siltstone	Depth: 9646.5'

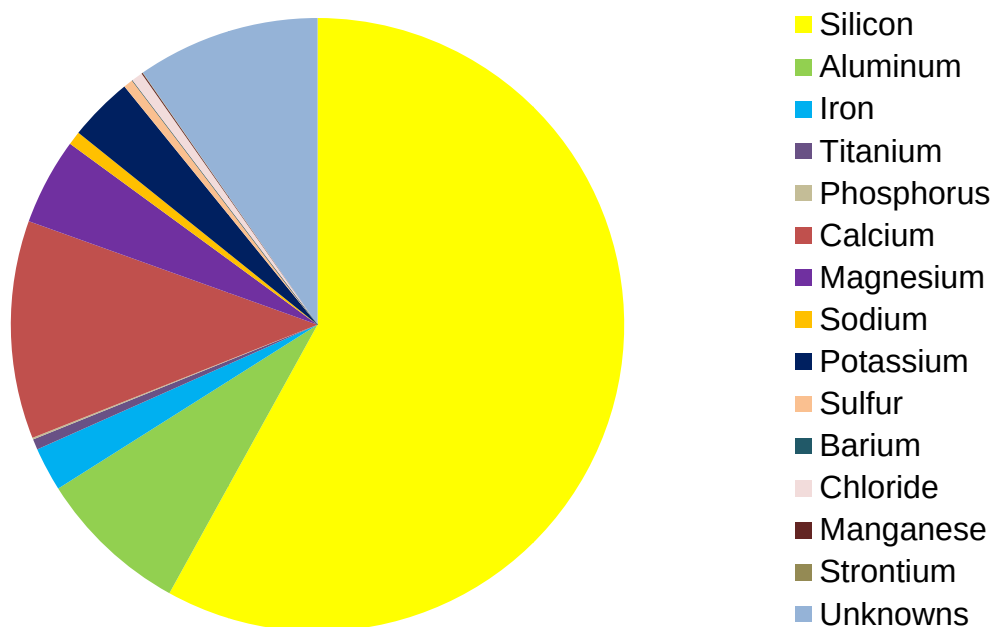
Transmission and Fluorescence Whole-Slide Images



The image collected from a depth of 9646.50 ft is a moderately burrowed siltstone. Effective porosity is reported at 6.61 vol%. Extensive interlocking anhedral to euhedral dolomitization and some pyritization has occurred. These diagenetic events along consistent, very fine grain sizes (except for skeletal and skeletal calcite grains and pyrite) are limiting factors of pore size ($<30\text{ }\mu\text{m}$) and distribution. No natural or induced fractures are observed.

	Applied Geology Laboratory		ID: 117016
	Well Name: NDIC No. 20552	Middle Bakken 1	Grenora Field
	API No.: 33-105-02157-00-08	Lithology: Calcareous, argillaceous siltstone	Depth: 9646.5'

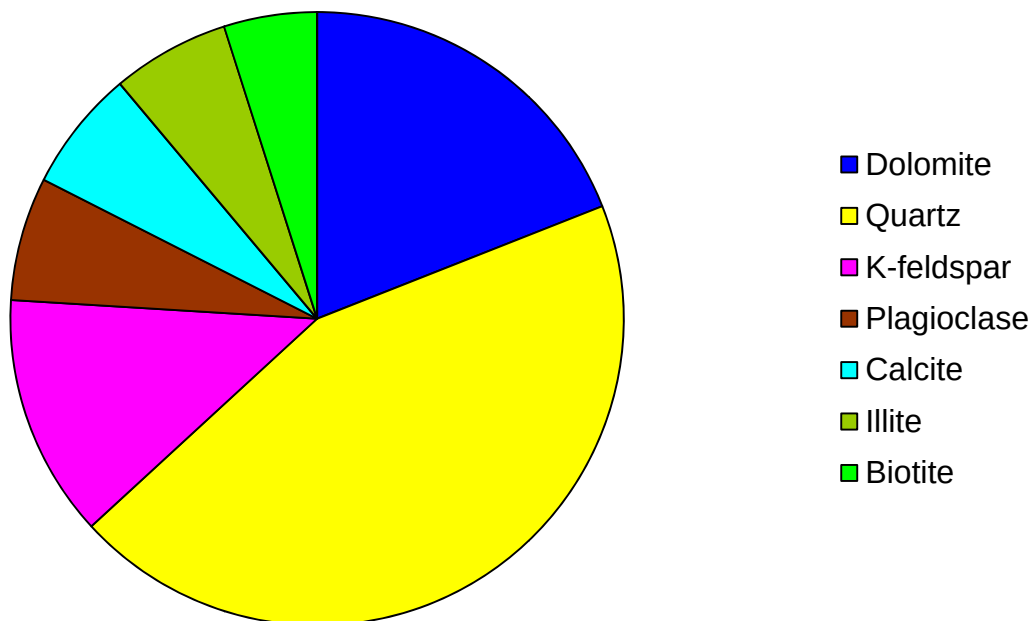
XRF BULK CHEMICAL COMPOSITION



Element	Reporting Convention (Oxide)	Weight %
Si (silicon)	SiO ₂	58.02
Al (aluminum)	Al ₂ O ₃	8.01
Fe (iron)	Fe ₂ O ₃	2.31
Ti (titanium)	TiO ₂	0.56
P (phosphorus)	P ₂ O ₅	0.09
Ca (calcium)	CaO	11.49
Mg (magnesium)	MgO	4.57
Na (sodium)	Na ₂ O	0.72
K (potassium)	K ₂ O	3.39
S (sulfur)	SO ₃	0.52
Ba (barium)	BaO	0.00
Cl (chloride)	Cl	0.59
Mn (manganese)	MnO	0.07
Sr (strontium)	SrO	0.02
Unknowns	Due to the presence of carbonates	9.64
Total		100.00

	Applied Geology Laboratory		ID: 117016
	Well Name: NDIC No. 20552	Middle Bakken 1	Grenora Field
	API No.: 33-105-02157-00-08	Lithology: Calcareous, argillaceous siltstone	Depth: 9646.5'

XRD MINERAL PHASE DISTRIBUTION



Mineral Phase	Formula	Weight %
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	19.0
Quartz	SiO_2	44.1
K-feldspar	KAlSi_3O_8	12.8
Plagioclase	$\text{Na}_{0.5}\text{Ca}_{0.5}\text{Al}_{1.5}\text{Si}_{2.5}\text{O}_8$	6.5
Calcite	CaCO_3	6.4
Illite	$(\text{K},\text{H}_3\text{O})(\text{Al},\text{Mg},\text{Fe})_2(\text{Si},\text{Al})_4\text{O}_{10}[(\text{OH})_2,(\text{H}_2\text{O})]$	6.2
Biotite	$\text{K}(\text{Mg},\text{Fe})_3[(\text{OH})_2\text{AlSi}_3\text{O}_{10}]$	4.9

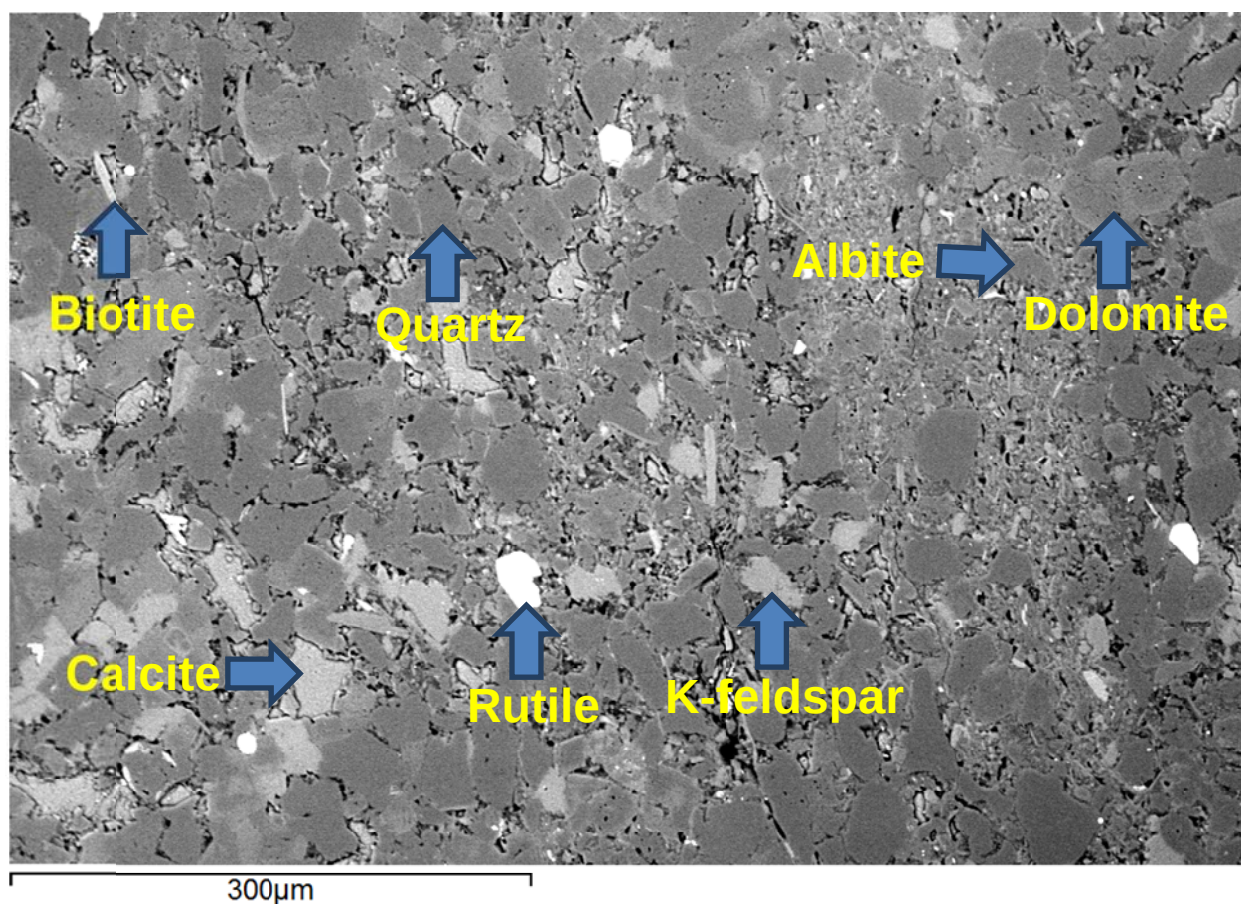
	Applied Geology Laboratory		ID: 117016
	Well Name: NDIC No. 20552	Middle Bakken 1	Grenora Field
	API No.: 33-105-02157-00-08	Lithology: Calcareous, argillaceous siltstone	Depth: 9646.5'

SEM

Observed Minerals

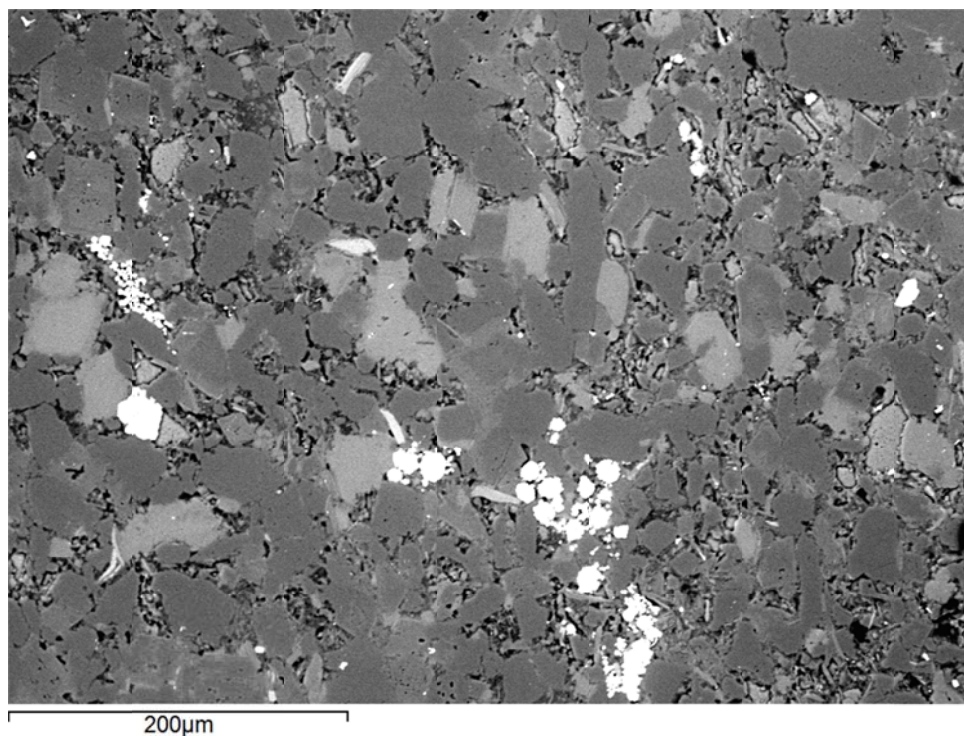
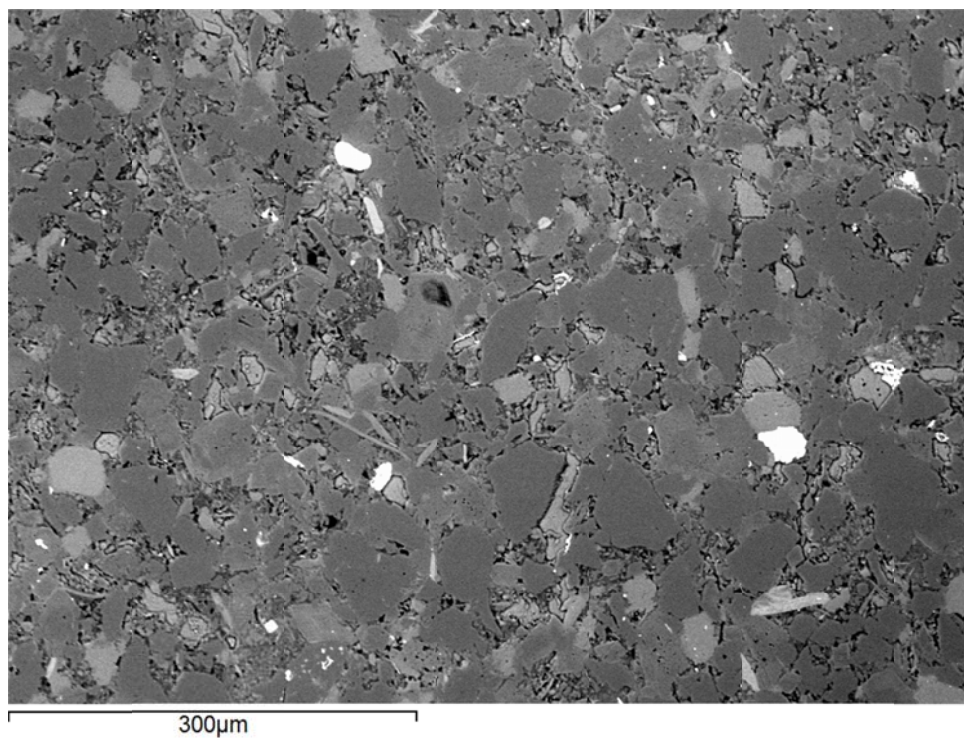
Mineral Phase	Mineral Phase
Calcite	Illite
Dolomite	K-feldspar
Quartz	Rutile
Pyrite	Monazite
Apatite	Albite

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified

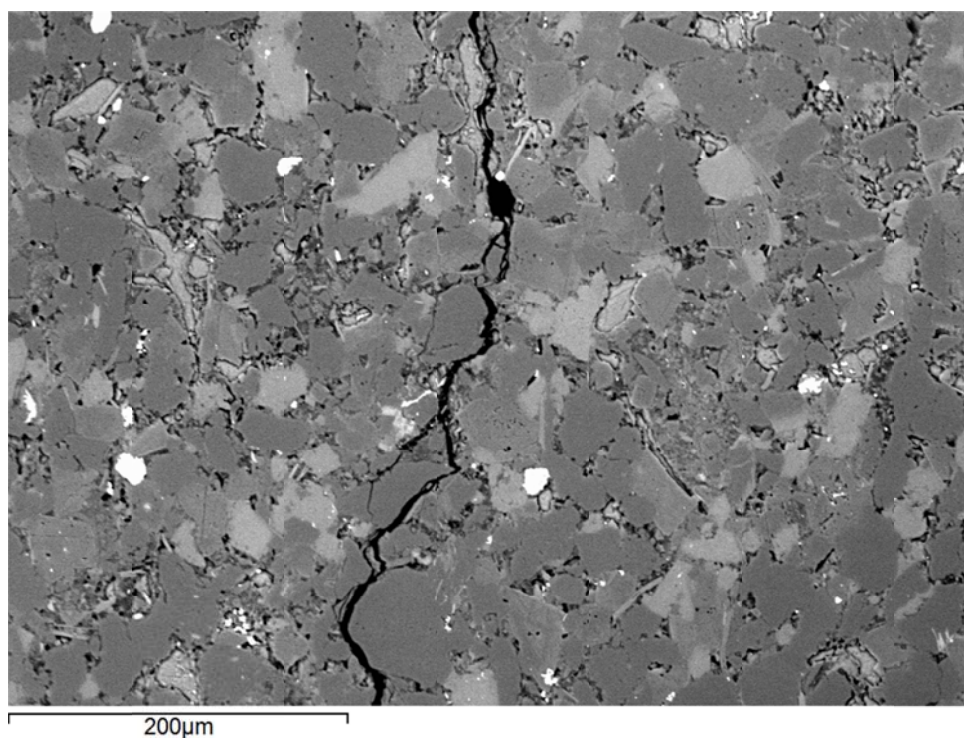
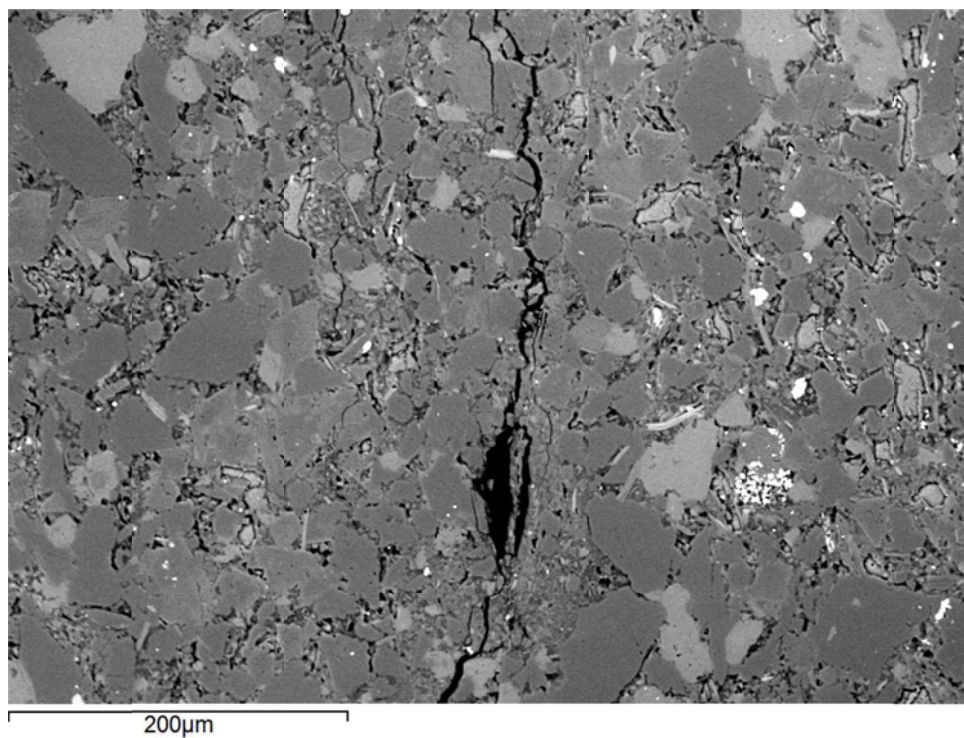


	Applied Geology Laboratory		ID: 117016
	Well Name: NDIC No. 20552	Middle Bakken 1	Grenora Field
	API No.: 33-105-02157-00-08	Lithology: Calcareous, argillaceous siltstone	Depth: 9646.5'

Additional High-Magnification BSE Images

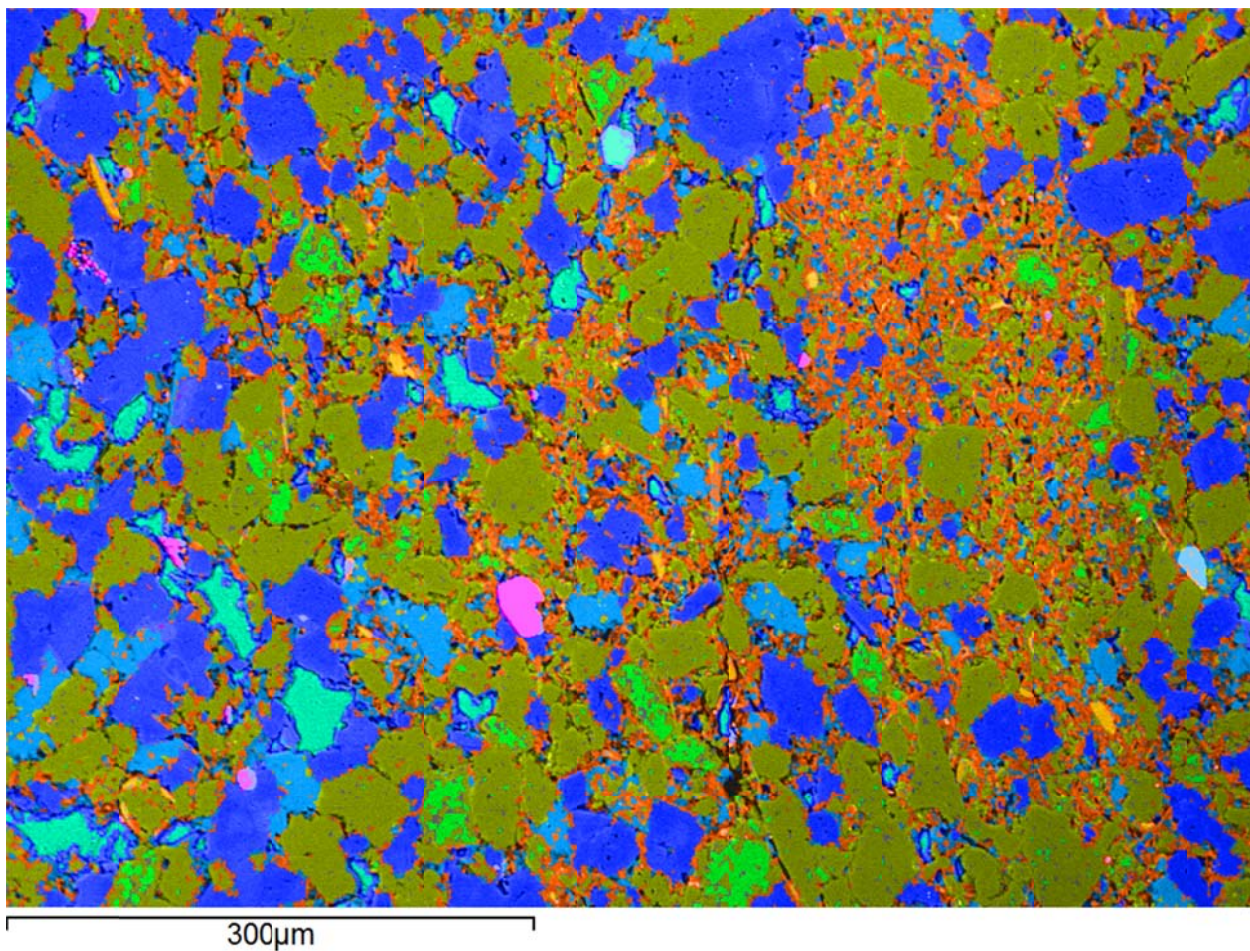


	Applied Geology Laboratory		ID: 117016
	Well Name: NDIC No. 20552	Middle Bakken 1	Grenora Field
	API No.: 33-105-02157-00-08	Lithology: Calcareous, argillaceous siltstone	Depth: 9646.5'



	Applied Geology Laboratory		ID: 117016
	Well Name: NDIC No. 20552	Middle Bakken 1	Grenora Field
	API No.: 33-105-02157-00-08	Lithology: Calcareous, argillaceous siltstone	Depth: 9646.5'

SEM Mineral Map Image Overlaid on BSE Image with Mineral Phase 2D Area Percentages



	Applied Geology Laboratory		ID: 117021
	Well Name: NDIC No. 20844	Middle Bakken 7	Grenora Field
	API No.: 33-105-02204-00-00	Lithology: Silty dolostone	Depth: 10217.0'

SAMPLE PHOTOGRAPH



PHYSICAL PROPERTIES

Porosity and Grain Density by Core Laboratories

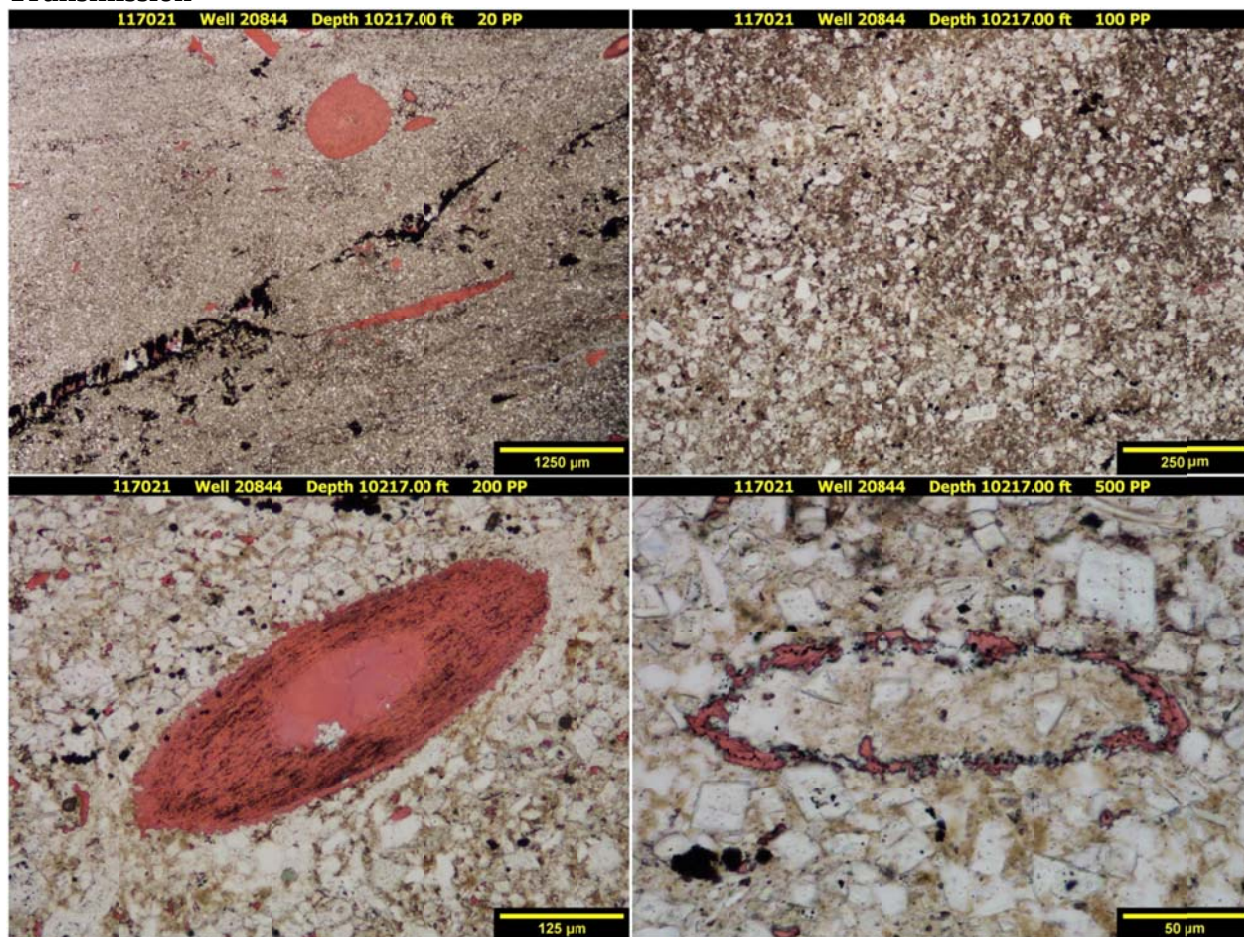
Pycnometer Effective Porosity, vol%	Grain Density, g/cm ³
8.01*	2.750

* The sample was fractured; therefore, the porosity may be optimistic.

	Applied Geology Laboratory		ID: 117021
	Well Name: NDIC No. 20844	Middle Bakken 7	Grenora Field
	API No.: 33-105-02204-00-00	Lithology: Silty dolostone	Depth: 10217.0'

PHOTOMICROGRAPHS

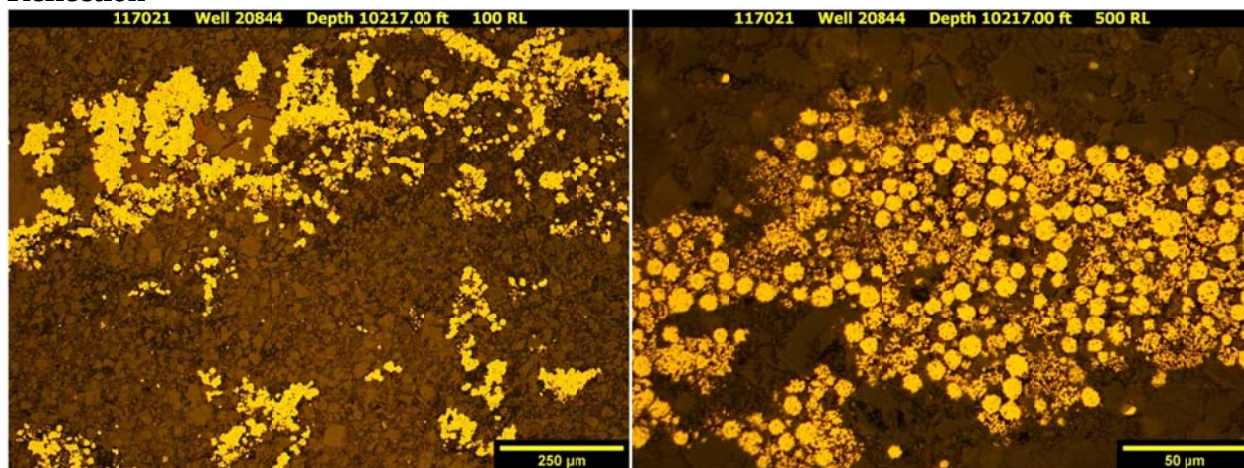
Transmission



The sample from a depth of 10217.00 ft is a predominately massive silty dolostone. Very fine grained, angular to subangular, monocrystalline quartz is speckled throughout the sample. Trace amounts of muscovite and feldspars are detected. Calcareous skeletal and non-skeletal grains commonly occur throughout the sample. The matrix is composed predominantly microcrystalline to cryptocrystalline dolomite and clays. Extensive anhedral to euhedral dolomitization has occurred throughout the sample. Abundant fine-grained crystalline dolomite occurs as replacement of precursor carbonate grains and mud. Disseminated pore-filling and replacement pyrite is observed throughout, concentrating zonally. Gypsum replacement is observed within allochem grains. Small organics specs, typically associated with pyrite, are found sporadically throughout and occasionally congregate. Occasional small closed and open fractures are observed. The open fractures are likely the result of the coring process. No particle-based porosity is detected.

	Applied Geology Laboratory		ID: 117021
	Well Name: NDIC No. 20844	Middle Bakken 7	Grenora Field
	API No.: 33-105-02204-00-00	Lithology: Silty dolostone	Depth: 10217.0'

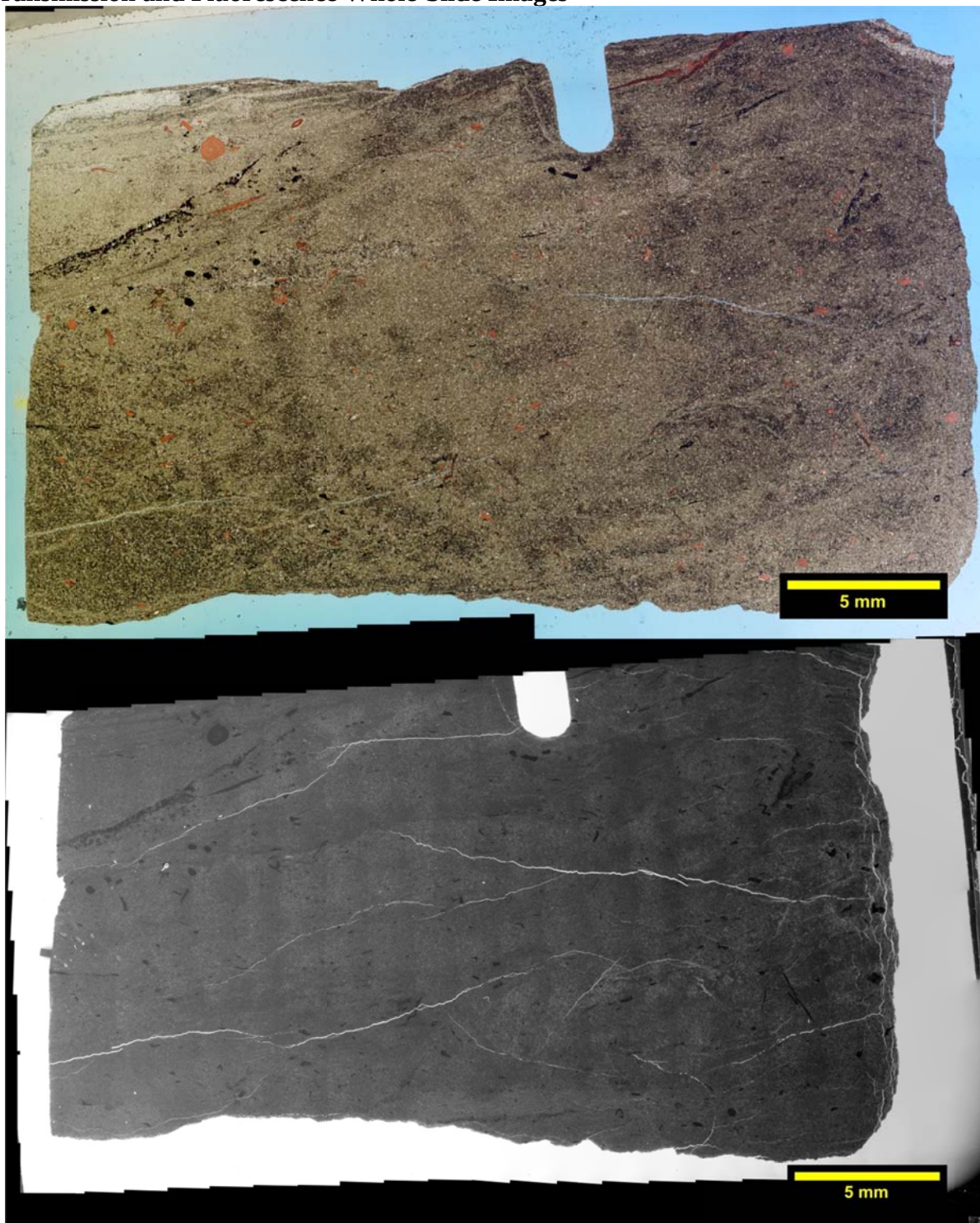
Reflection



The sample from a depth of 10217.00 ft displays a moderately prevalent pyrite presence. A combination of euhedral and framboidal pyrite mineralization exists. Both pore filling and grain replacement are observed. Precursor calcareous grains appear either untouched by pyrite or nearly completely pyritized by predominately euhedral grains. Framboidal grains are typically found within clay and associated with organics.

	Applied Geology Laboratory		ID: 117021
	Well Name: NDIC No. 20844	Middle Bakken 7	Grenora Field
	API No.: 33-105-02204-00-00	Lithology: Silty dolostone	Depth: 10217.0'

Transmission and Fluorescence Whole-Slide Images

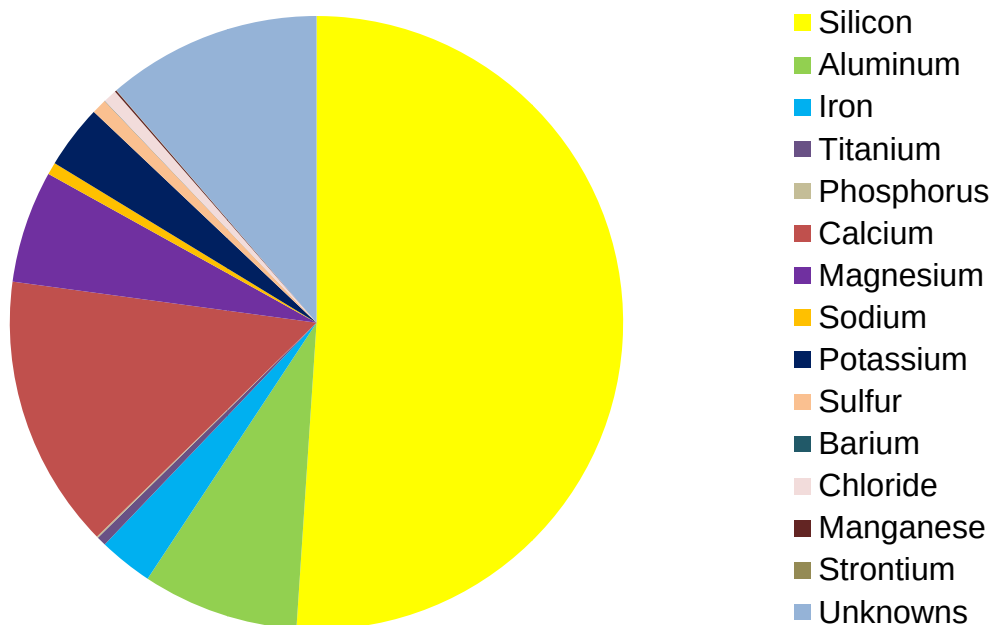


	Applied Geology Laboratory		ID: 117021
	Well Name: NDIC No. 20844	Middle Bakken 7	Grenora Field
	API No.: 33-105-02204-00-00	Lithology: Silty dolostone	Depth: 10217.0'

The image collected from a depth of 10217.00 ft is a silty dolostone. It is a primarily massive sample, displaying some burrowing structures. Effective porosity is reported at 8.01 vol%. Extensive interlocking anhedral to euhedral dolomitization and some pyritization has occurred. These diagenetic events along consistent, very fine grain sizes (except for skeletal and skeletal calcite grains and pyrite) and dispersed clay are limiting factors of pore size and distribution. The left portion of the image depicts occasional relatively larger ($>30\text{ }\mu\text{m}$) inter-particle porosity, but typically, pores are understood to be quite smaller. The reported effective porosity of 8.01 vol% appears high based on the inverted epifluorescent image. No natural fractures are observed. The open fractures observed are likely the result of the sampling process. The noted fractures may depict areas of structural weakness as stress is applied.

	Applied Geology Laboratory		ID: 117021
	Well Name: NDIC No. 20844	Middle Bakken 7	Grenora Field
	API No.: 33-105-02204-00-00	Lithology: Silty dolostone	Depth: 10217.0'

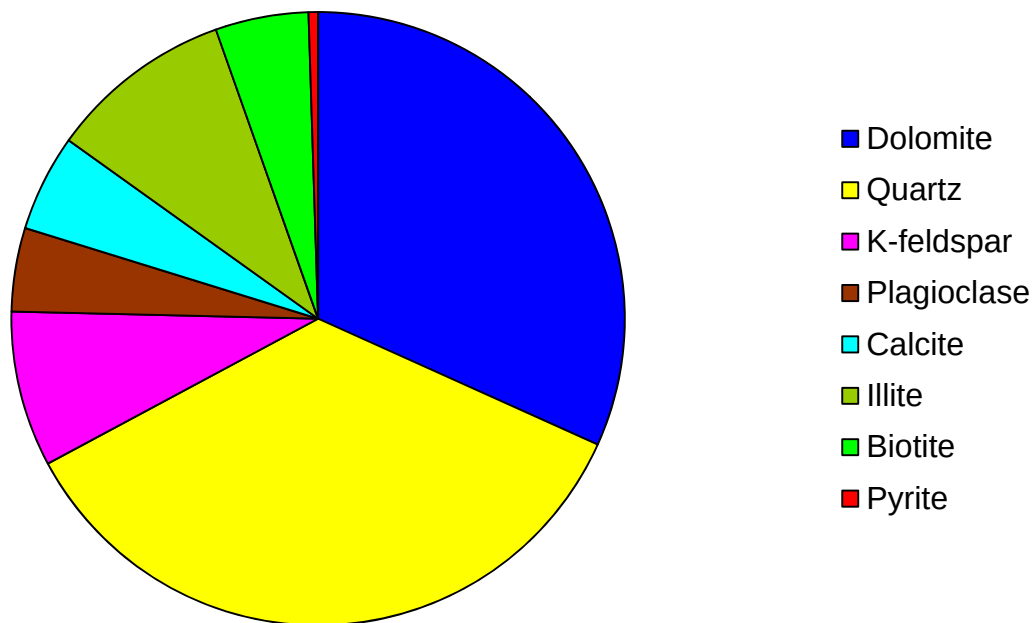
XRF BULK CHEMICAL COMPOSITION



Element	Reporting Convention (Oxide)	Weight %
Si (silicon)	SiO ₂	51.04
Al (aluminum)	Al ₂ O ₃	8.24
Fe (iron)	Fe ₂ O ₃	2.85
Ti (titanium)	TiO ₂	0.50
P (phosphorus)	P ₂ O ₅	0.08
Ca (calcium)	CaO	14.43
Mg (magnesium)	MgO	5.92
Na (sodium)	Na ₂ O	0.65
K (potassium)	K ₂ O	3.36
S (sulfur)	SO ₃	0.79
Ba (barium)	BaO	0.02
Cl (chloride)	Cl	0.71
Mn (manganese)	MnO	0.08
Sr (strontium)	SrO	0.02
Unknowns	Due to the presence of carbonates	11.31
Total		100.00

	Applied Geology Laboratory		ID: 117021
	Well Name: NDIC No. 20844	Middle Bakken 7	Grenora Field
	API No.: 33-105-02204-00-00	Lithology: Silty dolostone	Depth: 10217.0'

XRD MINERAL PHASE DISTRIBUTION



Mineral Phase	Formula	Weight %
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	31.7
Quartz	SiO_2	35.4
K-feldspar	KAlSi_3O_8	8.2
Plagioclase	$\text{Na}_{0.5}\text{Ca}_{0.5}\text{Al}_{1.5}\text{Si}_{2.5}\text{O}_8$	4.4
Calcite	CaCO_3	5.1
Illite	$(\text{K},\text{H}_3\text{O})(\text{Al},\text{Mg},\text{Fe})_2(\text{Si},\text{Al})_4\text{O}_{10}[(\text{OH})_2,(\text{H}_2\text{O})]$	9.7
Biotite	$\text{K}(\text{Mg},\text{Fe})_3[(\text{OH})_2\text{AlSi}_3\text{O}_{10}]$	4.9
Pyrite	FeS_2	0.5

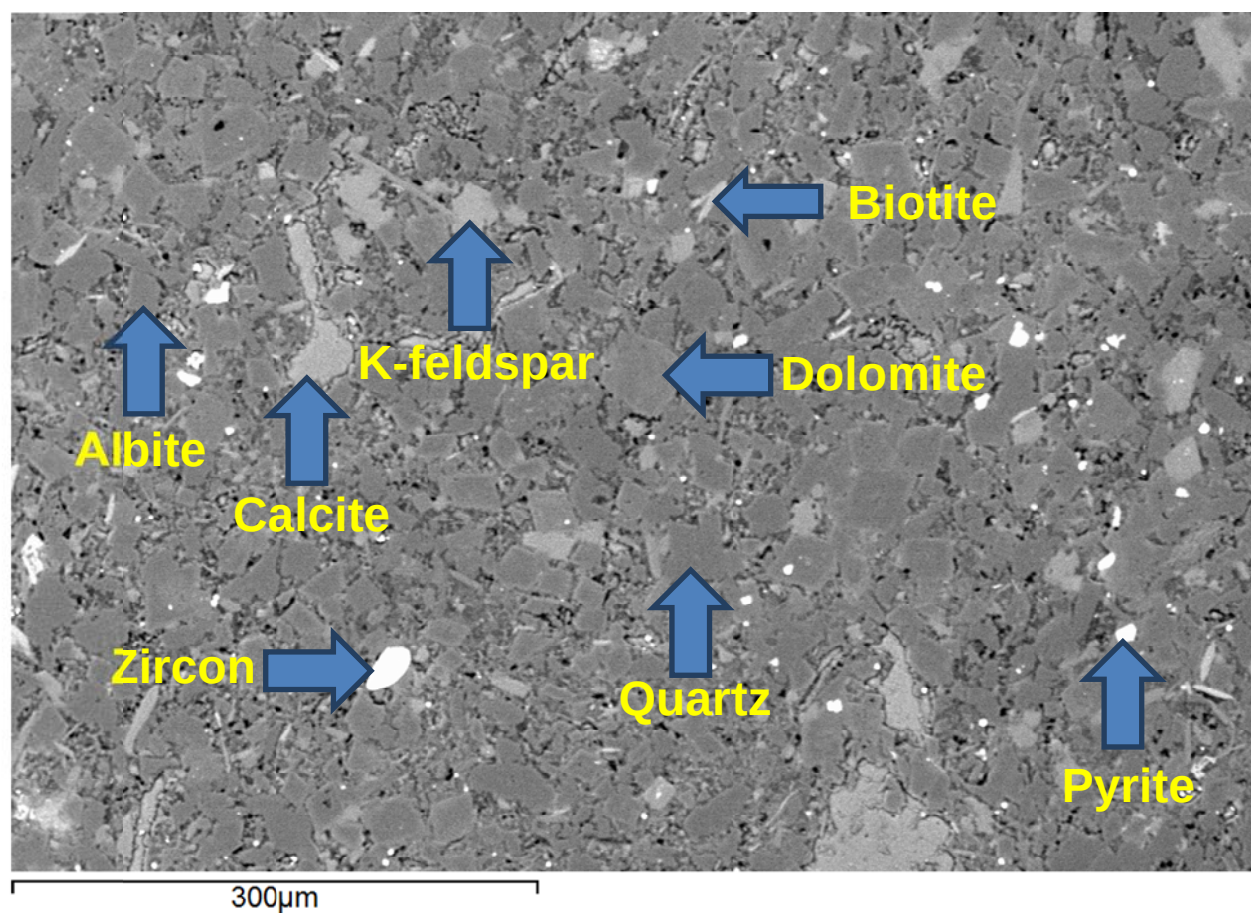
	Applied Geology Laboratory		ID: 117021
	Well Name: NDIC No. 20844	Middle Bakken 7	Grenora Field
	API No.: 33-105-02204-00-00	Lithology: Silty dolostone	Depth: 10217.0'

SEM

Observed Minerals

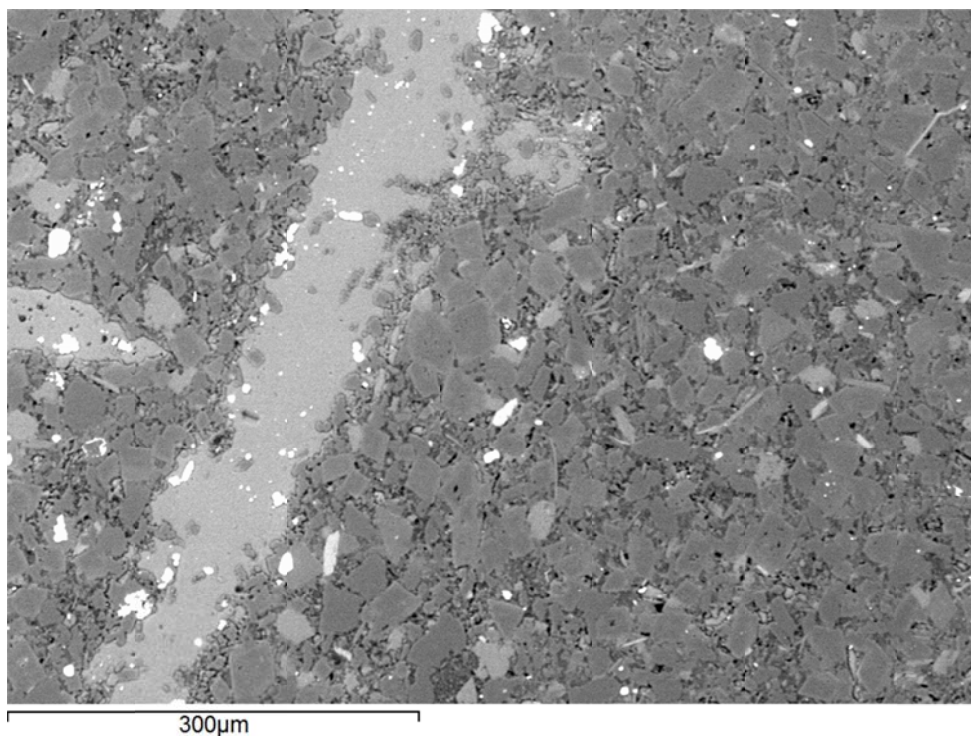
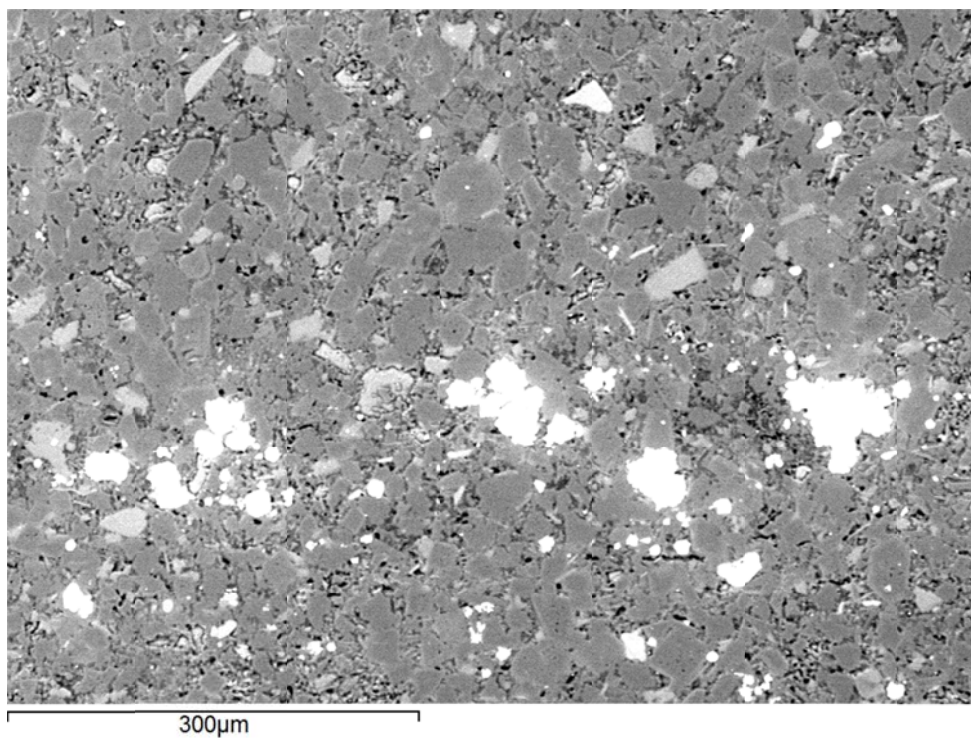
Mineral Phase	Mineral Phase
Quartz	Apatite
Calcite	Rutile
Dolomite	Zircon
Pyrite	Biotite
K-feldspar	Illite

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified

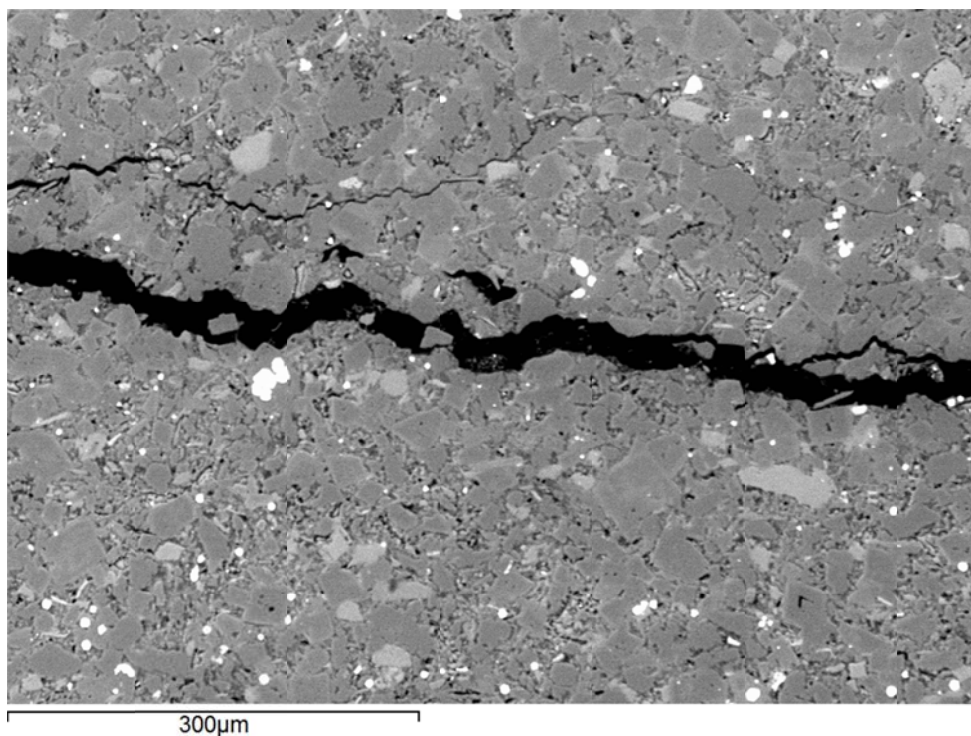
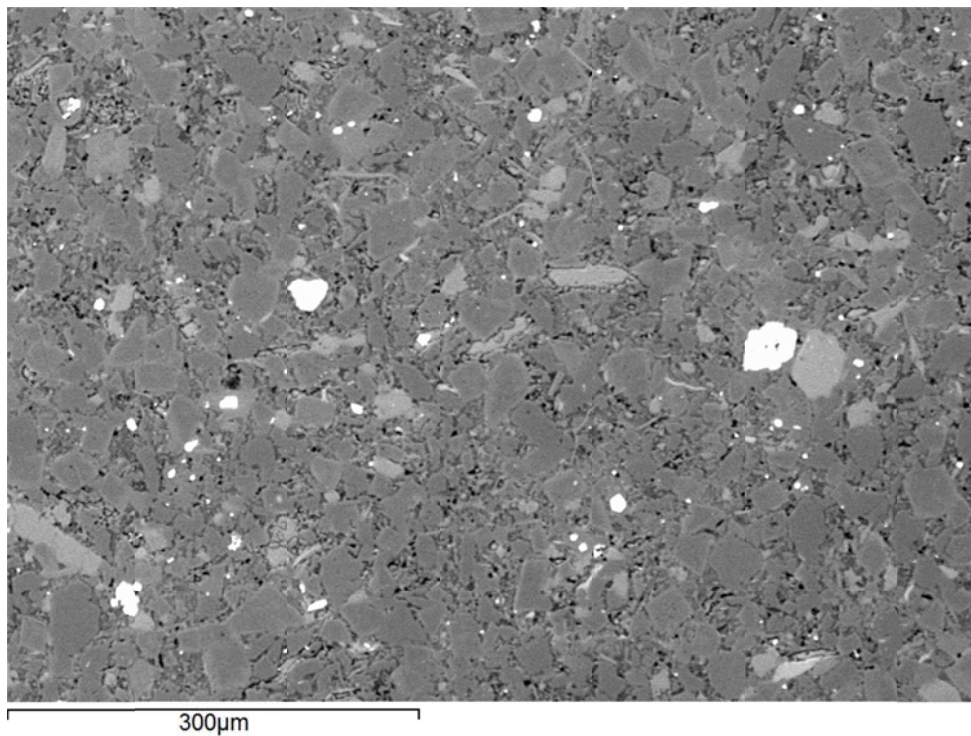


	Applied Geology Laboratory		ID: 117021
	Well Name: NDIC No. 20844	Middle Bakken 7	Grenora Field
	API No.: 33-105-02204-00-00	Lithology: Silty dolostone	Depth: 10217.0'

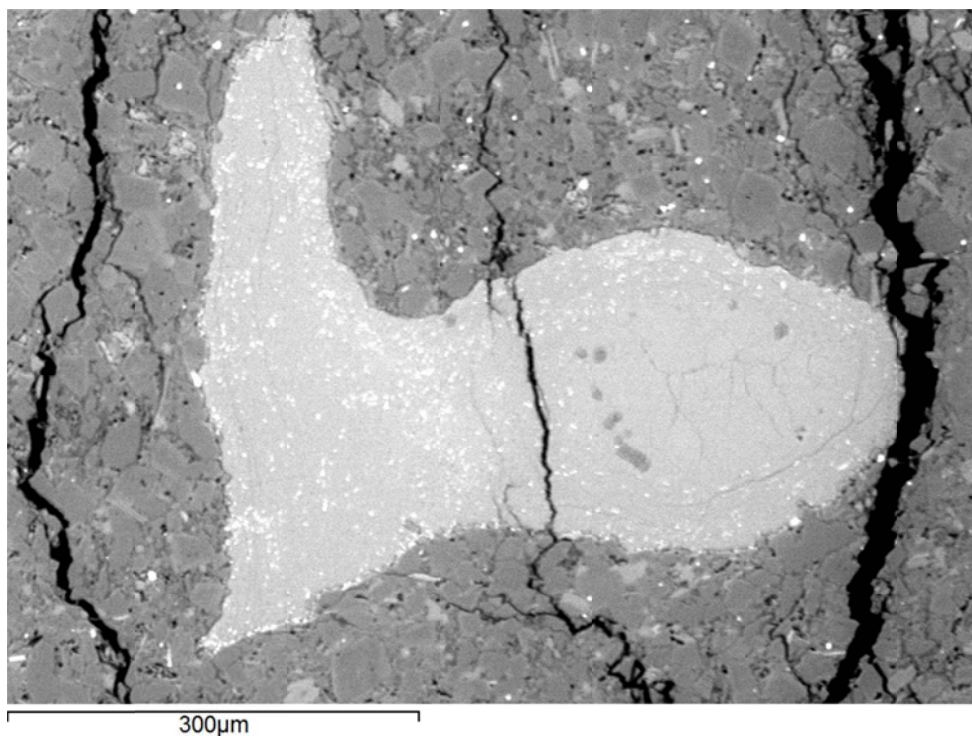
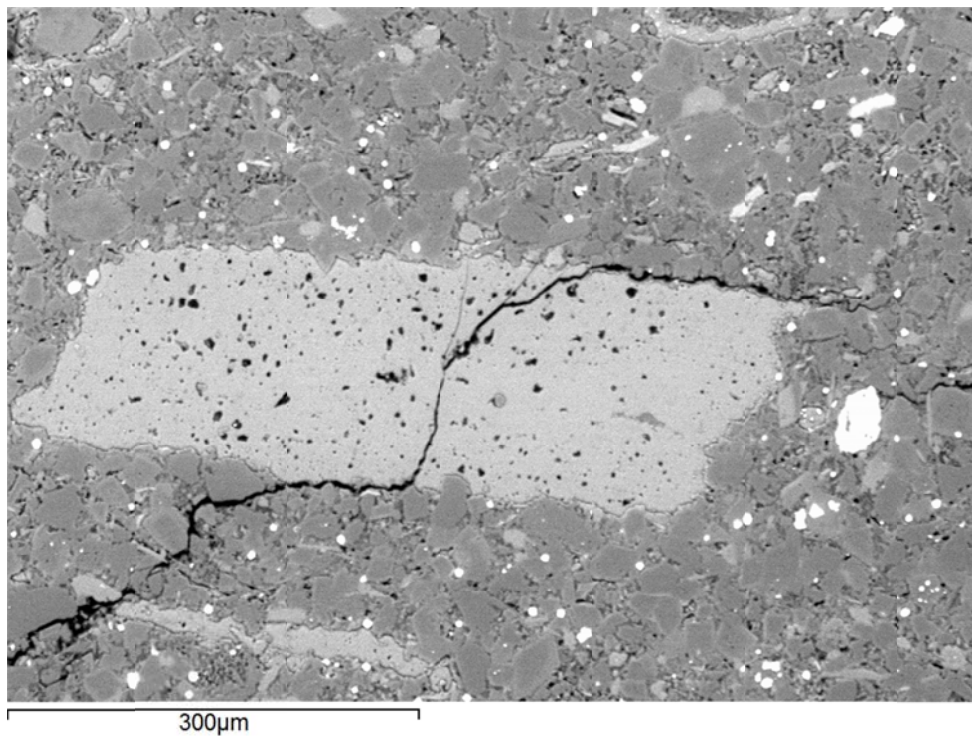
Additional High-Magnification BSE Images



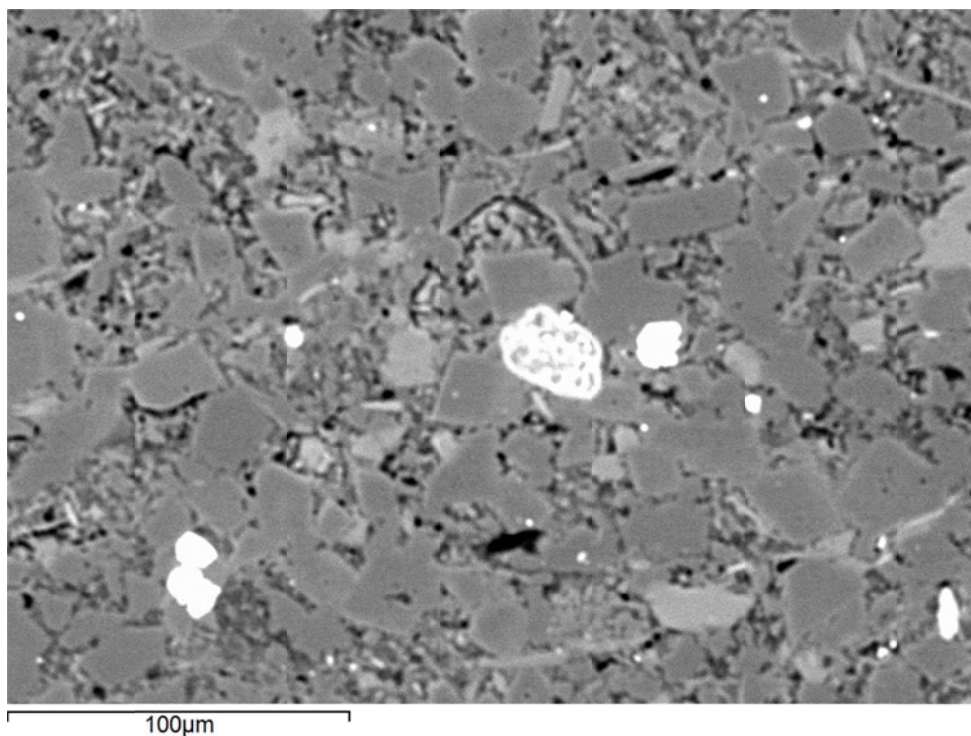
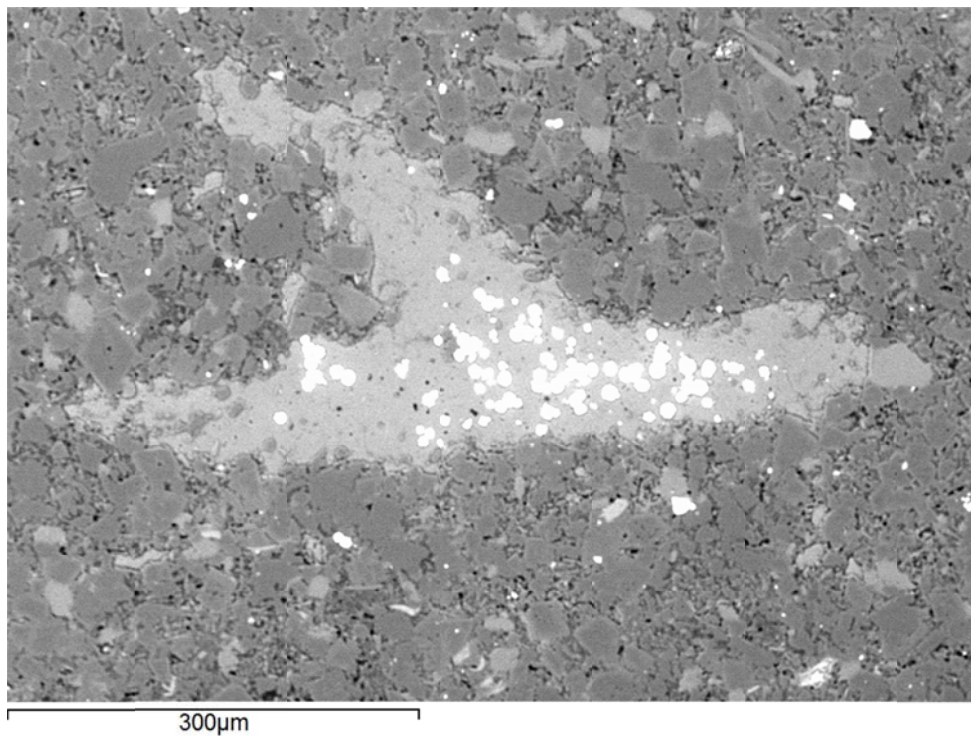
	Applied Geology Laboratory		ID: 117021
	Well Name: NDIC No. 20844	Middle Bakken 7	Grenora Field
	API No.: 33-105-02204-00-00	Lithology: Silty dolostone	Depth: 10217.0'



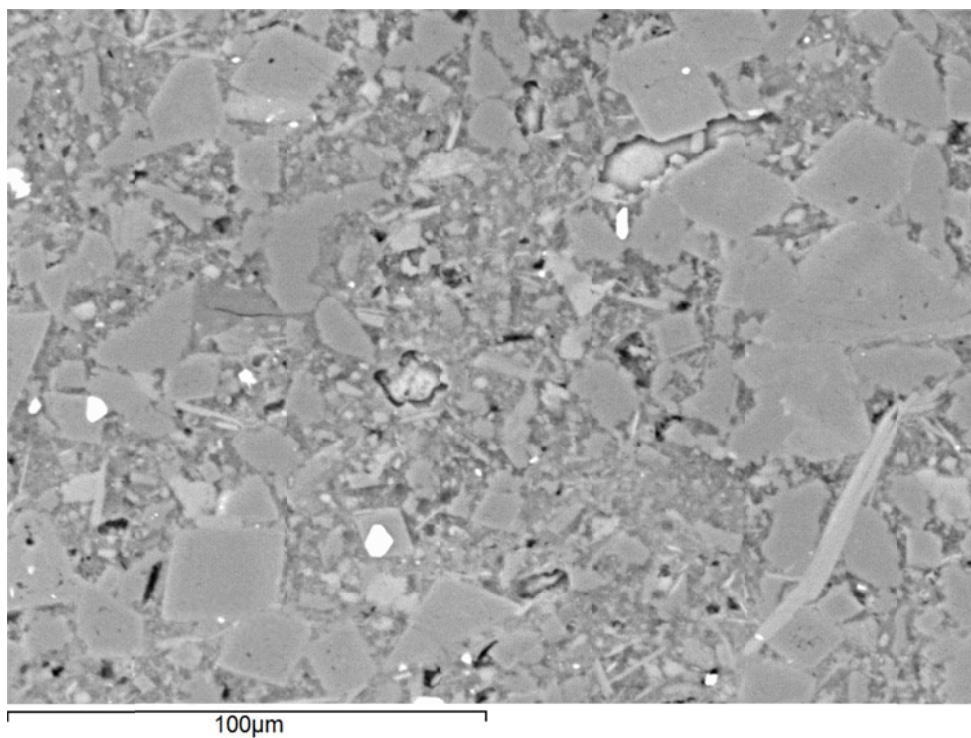
	Applied Geology Laboratory		ID: 117021
	Well Name: NDIC No. 20844	Middle Bakken 7	Grenora Field
	API No.: 33-105-02204-00-00	Lithology: Silty dolostone	Depth: 10217.0'



	Applied Geology Laboratory		ID: 117021
	Well Name: NDIC No. 20844	Middle Bakken 7	Grenora Field
	API No.: 33-105-02204-00-00	Lithology: Silty dolostone	Depth: 10217.0'

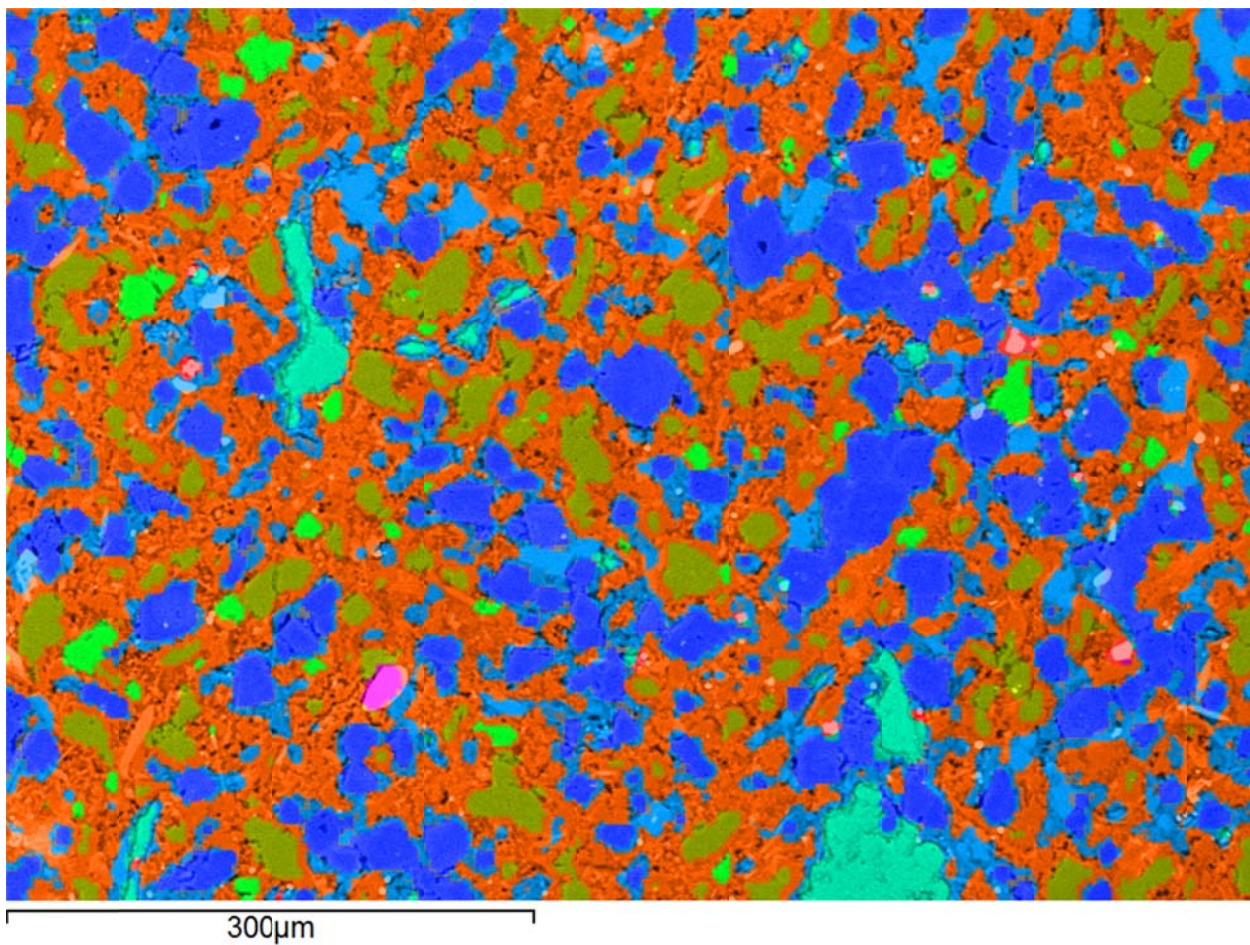


	Applied Geology Laboratory		ID: 117021
	Well Name: NDIC No. 20844	Middle Bakken 7	Grenora Field
	API No.: 33-105-02204-00-00	Lithology: Silty dolostone	Depth: 10217.0'



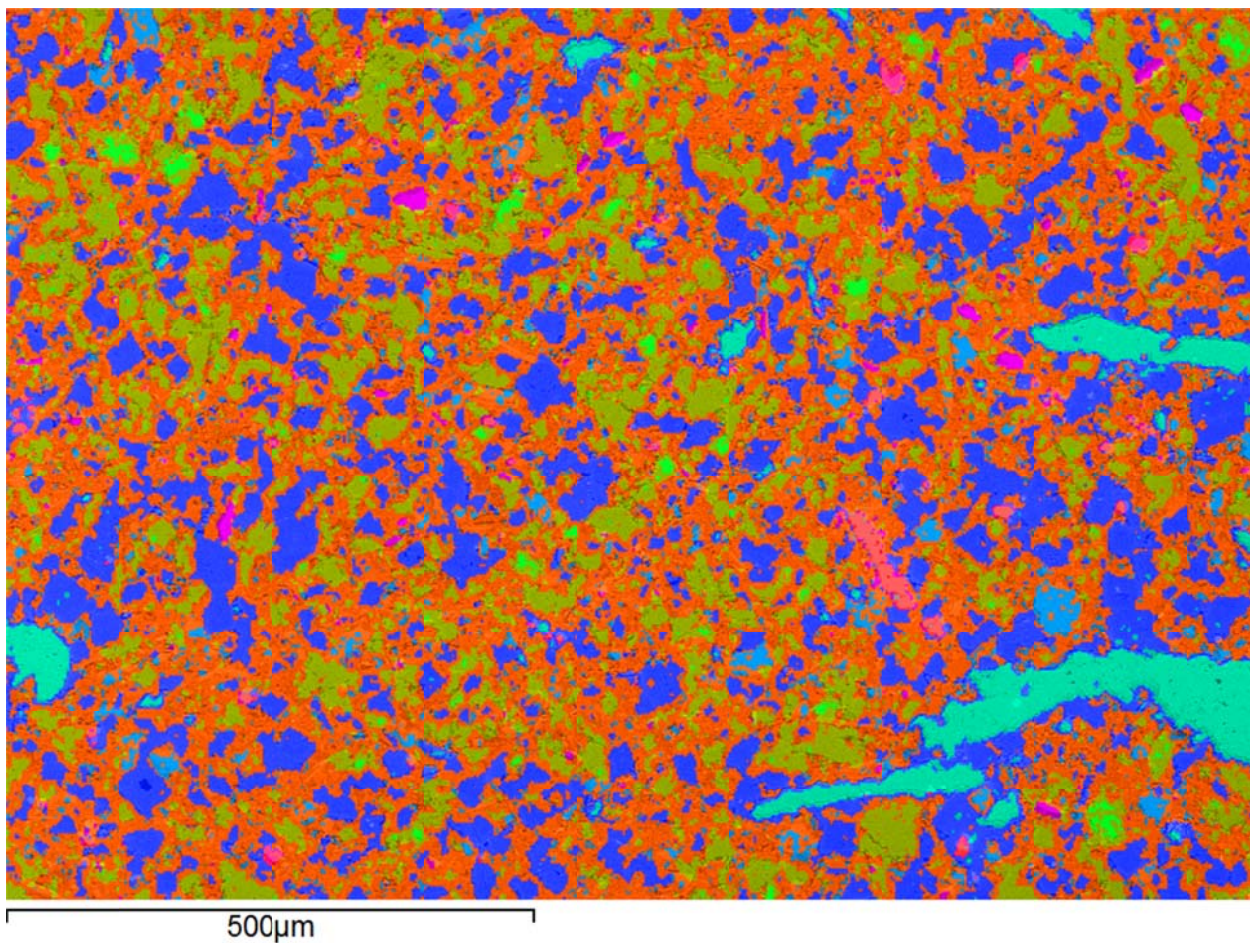
	Applied Geology Laboratory		ID: 117021
	Well Name: NDIC No. 20844	Middle Bakken 7	Grenora Field
	API No.: 33-105-02204-00-00	Lithology: Silty dolostone	Depth: 10217.0'

SEM Mineral Map Image Overlaid on BSE Image with Mineral Phase 2D Area Percentages



	Applied Geology Laboratory		ID: 117021
	Well Name: NDIC No. 20844	Middle Bakken 7	Grenora Field
	API No.: 33-105-02204-00-00	Lithology: Silty dolostone	Depth: 10217.0'

Additional SEM Mineral Map Image Overlaid on BSE Image with Mineral Phase 2D Area Percentages



	Applied Geology Laboratory		ID: 117021
	Well Name: NDIC No. 20844	Middle Bakken 7	Grenora Field
	API No.: 33-105-02204-00-00	Lithology: Silty dolostone	Depth: 10217.0'

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	Applied Geology Laboratory		ID: 117023
	Well Name: NDIC No. 20844	Middle Bakken 5	Grenora Field
	API No.: 33-105-02204-00-02	Lithology: Argillaceous, dolomitic siltstone	Depth: 10227.0'

SAMPLE PHOTOGRAPH



PHYSICAL PROPERTIES

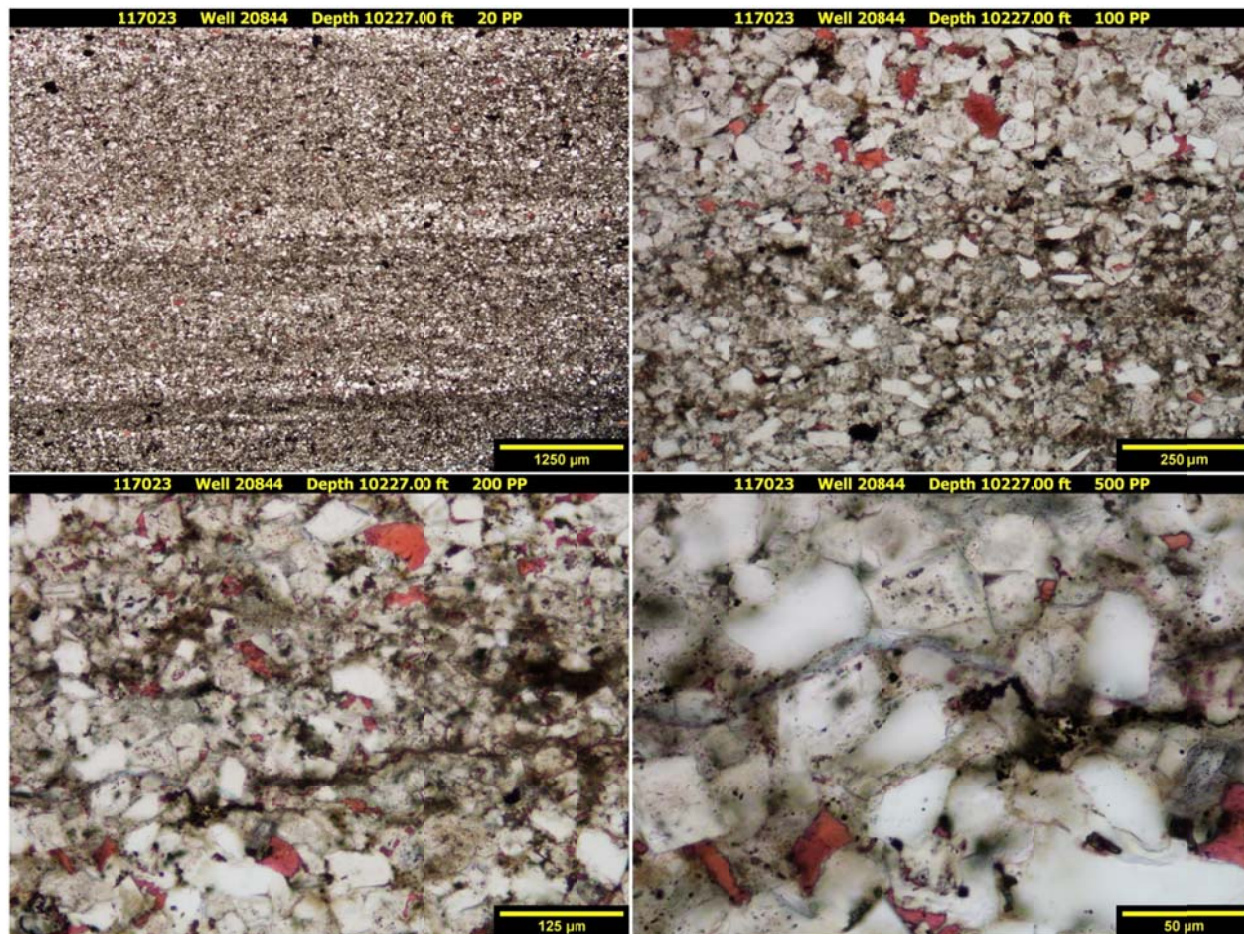
Porosity and Grain Density by Core Laboratories

Pycnometer Effective Porosity, vol%	Grain Density, g/cm ³
7.73	2.757

	Applied Geology Laboratory		ID: 117023
	Well Name: NDIC No. 20844	Middle Bakken 5	Grenora Field
	API No.: 33-105-02204-00-02	Lithology: Argillaceous, dolomitic siltstone	Depth: 10227.0'

PHOTOMICROGRAPHS

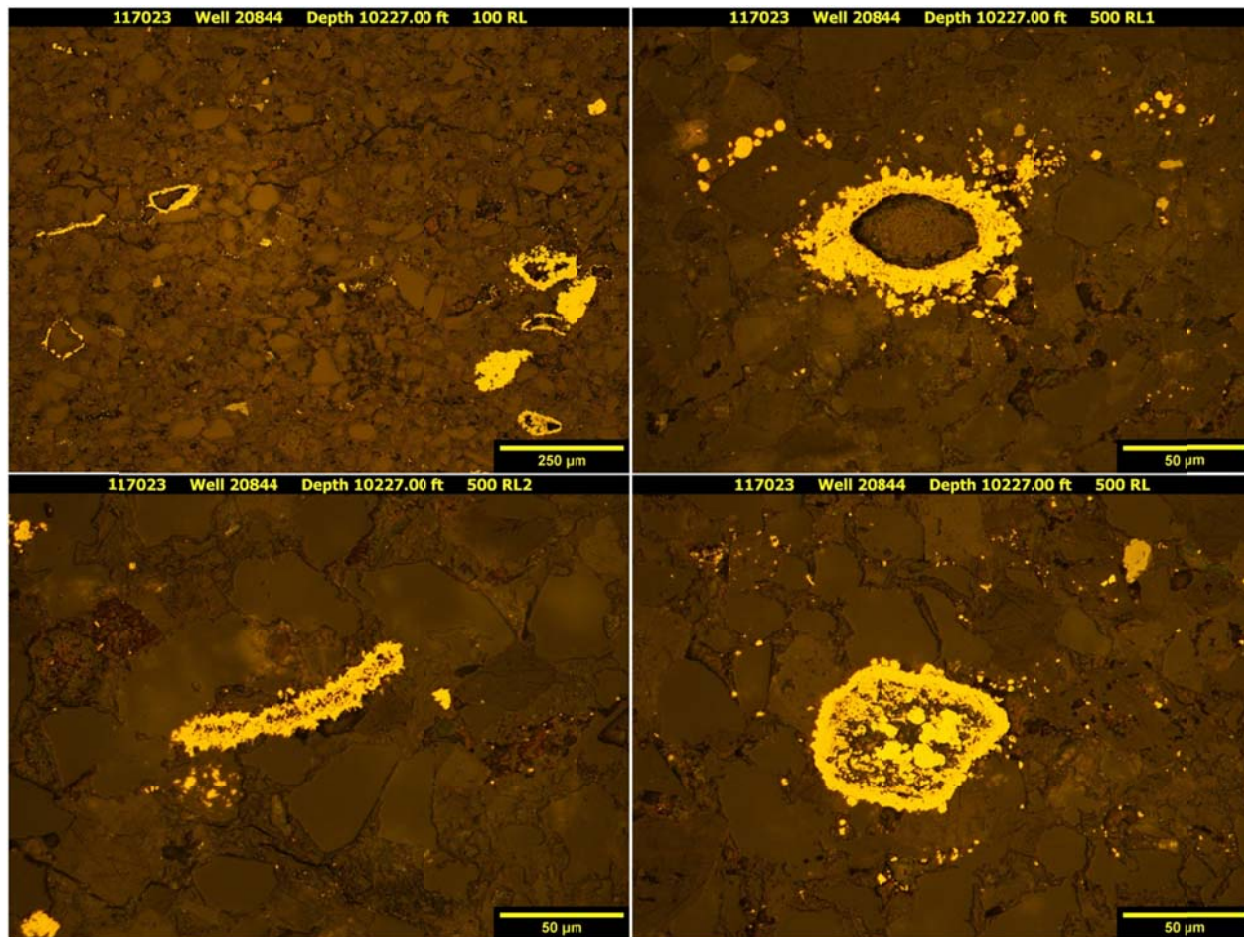
Transmission



The sample from a depth of 10227.00 ft shows a laminated argillaceous, dolomitic siltstone. Very fine grained, subangular to subrounded, monocrystalline quartz grains (displaying slight overgrowths) and trace amounts of muscovite, rutile, and feldspars are disseminated throughout. Extensive anhedral to euhedral dolomitization has occurred throughout the sample. Abundant, fine-grained, crystalline dolomite occurs as replacement of precursor carbonate grains and mud. Occasional sparry calcite cement and calcareous grains remain. Disseminated pore-filling and replacement pyrite grains are observed throughout. The matrix is composed of a combination of clays and micro- to cryptocrystalline dolomite and occasional calcite cement. Partially filled horizontal fractures are detected. These fractures are likely legitimate because of the noted partially filling. It is unclear if the lack of material shown is natural or has been lost during the sampling process. Other than potential open fractures, no porosity is observed using standard petrographic techniques.

	Applied Geology Laboratory		ID: 117023
	Well Name: NDIC No. 20844	Middle Bakken 5	Grenora Field
	API No.: 33-105-02204-00-02	Lithology: Argillaceous, dolomitic siltstone	Depth: 10227.0'

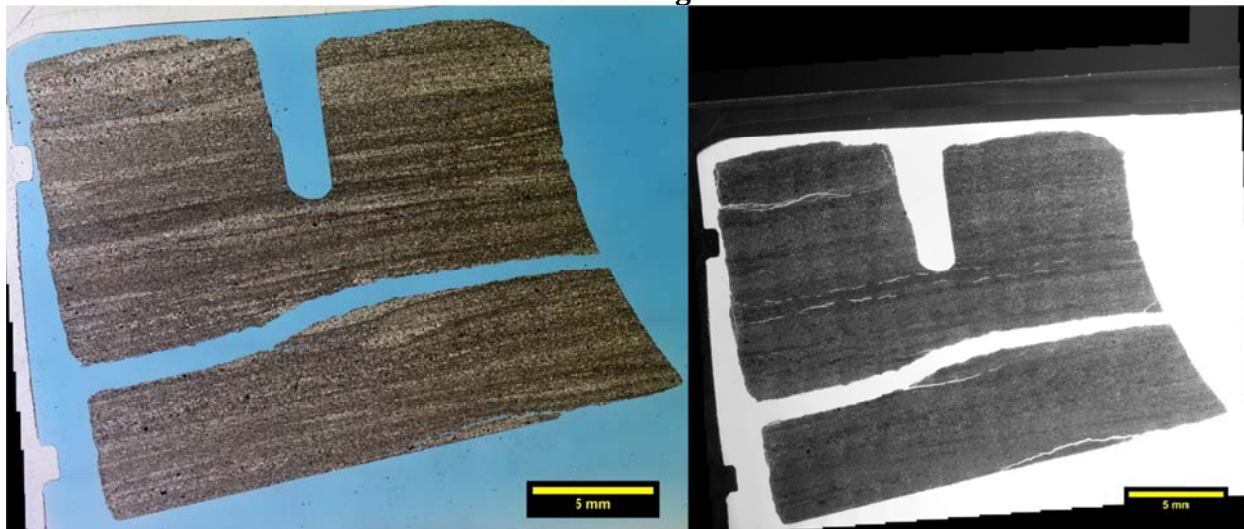
Reflection



The sample from a depth of 10227.00 ft displays both euhedral and framboidal pyrite grains. Within this sample, euhedral grains are typically replacing calcareous skeletal grains and filling micropores. Framboidal grains normally reside within precursor pore and organic spaces. Occasional aggregates of semi-mature framboidal pyrite spheres are observed. Partial to nearly complete pyritization of precursor grains and organics have occurred. Organics observed are typically associated with framboidal pyrite.

	Applied Geology Laboratory		ID: 117023
	Well Name: NDIC No. 20844	Middle Bakken 5	Grenora Field
	API No.: 33-105-02204-00-02	Lithology: Argillaceous, dolomitic siltstone	Depth: 10227.0'

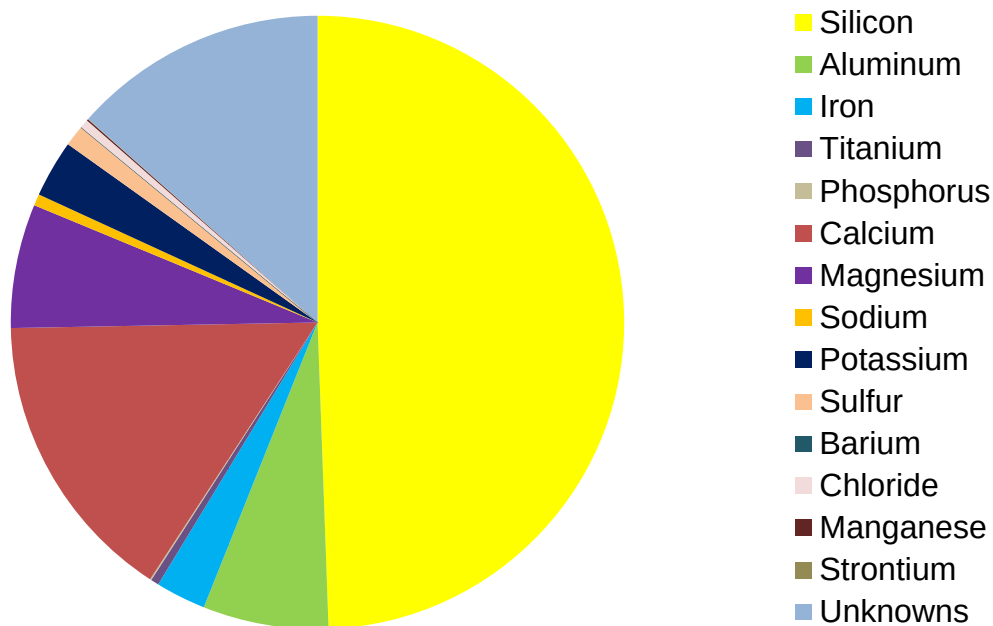
Transmission and Fluorescence Whole-Slide Images



The image collected from a depth of 10227.00 ft shows a laminated dolomitic siltstone. Effective porosity is reported at 7.73 vol%. Inter-particle-based micro-porosity mainly exists within quartz and euhedral dolomite-rich laminations. These laminations typically host larger and inconsistent grain sizes. Lesser amounts of porosity are noted within areas of small, mostly anhedral dolomite grains and clay concentrations. Pore sizes appear to be very small (under 30 μm) and moderately non-variable in size. No natural open fractures are observed. Induced continuous and discontinuous horizontal fractures are likely the product of the sampling process. Though unnatural, they may provide insight to structural stability within this interval.

	Applied Geology Laboratory		ID: 117023
	Well Name: NDIC No. 20844	Middle Bakken 5	Grenora Field
	API No.: 33-105-02204-00-02	Lithology: Argillaceous, dolomitic siltstone	Depth: 10227.0'

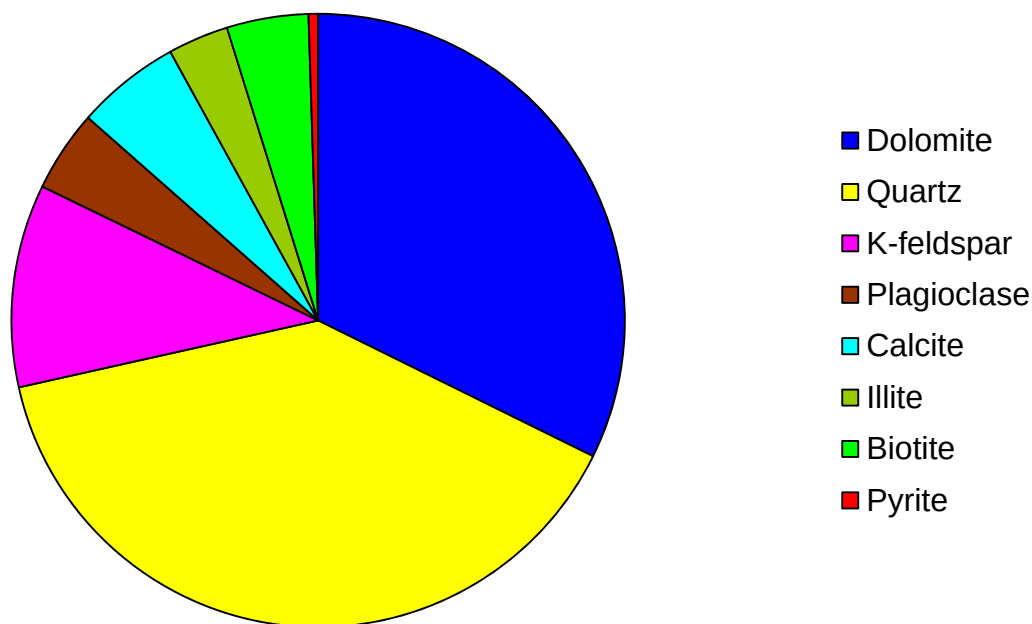
XRF BULK CHEMICAL COMPOSITION



Element	Reporting Convention (Oxide)	Weight %
Si (silicon)	SiO ₂	49.43
Al (aluminum)	Al ₂ O ₃	6.63
Fe (iron)	Fe ₂ O ₃	2.65
Ti (titanium)	TiO ₂	0.43
P (phosphorus)	P ₂ O ₅	0.07
Ca (calcium)	CaO	15.51
Mg (magnesium)	MgO	6.54
Na (sodium)	Na ₂ O	0.61
K (potassium)	K ₂ O	3.02
S (sulfur)	SO ₃	1.11
Ba (barium)	BaO	0.00
Cl (chloride)	Cl	0.47
Mn (manganese)	MnO	0.08
Sr (strontium)	SrO	0.02
Unknowns	Due to the presence of carbonates	13.45
Total		100.02

	Applied Geology Laboratory		ID: 117023
	Well Name: NDIC No. 20844	Middle Bakken 5	Grenora Field
	API No.: 33-105-02204-00-02	Lithology: Argillaceous, dolomitic siltstone	Depth: 10227.0'

XRD MINERAL PHASE DISTRIBUTION



Mineral Phase	Formula	Weight %
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	32.3
Quartz	SiO_2	39.2
K-feldspar	KAlSi_3O_8	10.7
Plagioclase	$\text{Na}_{0.5}\text{Ca}_{0.5}\text{Al}_{1.5}\text{Si}_{2.5}\text{O}_8$	4.3
Calcite	CaCO_3	5.5
Illite	$(\text{K},\text{H}_3\text{O})(\text{Al},\text{Mg},\text{Fe})_2(\text{Si},\text{Al})_4\text{O}_{10}[(\text{OH})_2,(\text{H}_2\text{O})]$	3.2
Biotite	$\text{K}(\text{Mg},\text{Fe})_3[(\text{OH})_2\text{AlSi}_3\text{O}_{10}]$	4.3
Pyrite	FeS_2	0.5

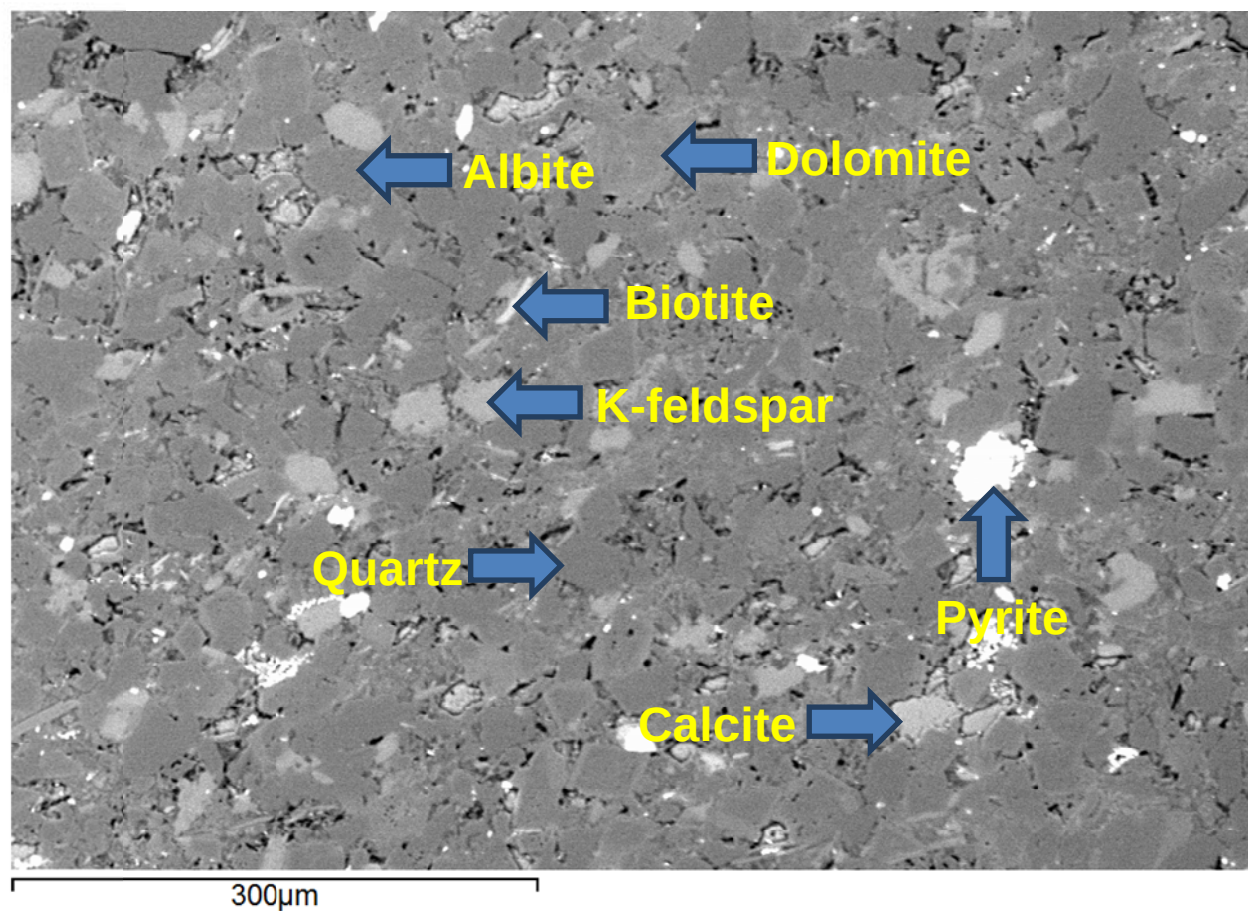
	Applied Geology Laboratory		ID: 117023
	Well Name: NDIC No. 20844	Middle Bakken 5	Grenora Field
	API No.: 33-105-02204-00-02	Lithology: Argillaceous, dolomitic siltstone	Depth: 10227.0'

SEM

Observed Minerals

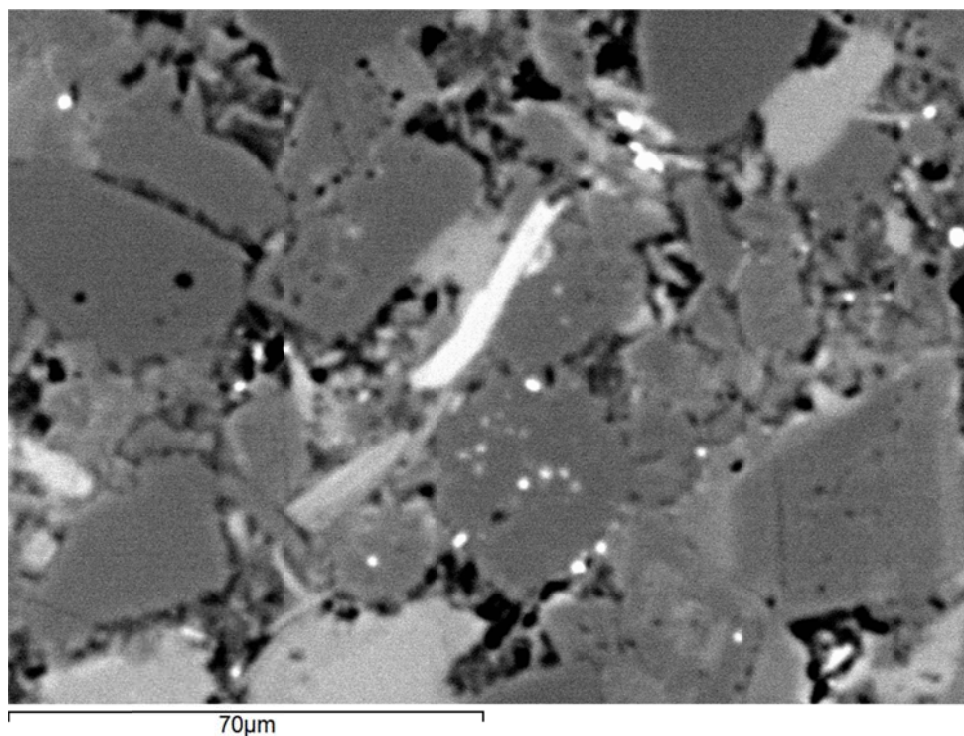
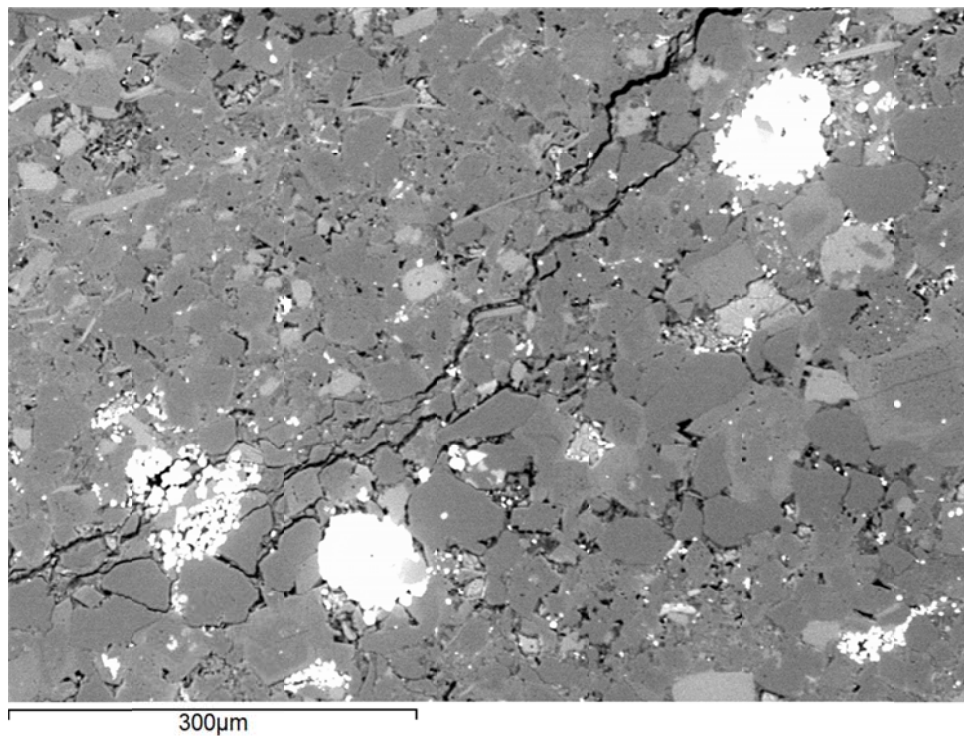
Mineral Phase	Mineral Phase
Calcite	Apatite
Quartz	Biotite
Dolomite	Zircon
Illite	Rutile
Pyrite	Chromite
K-feldspar	

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified

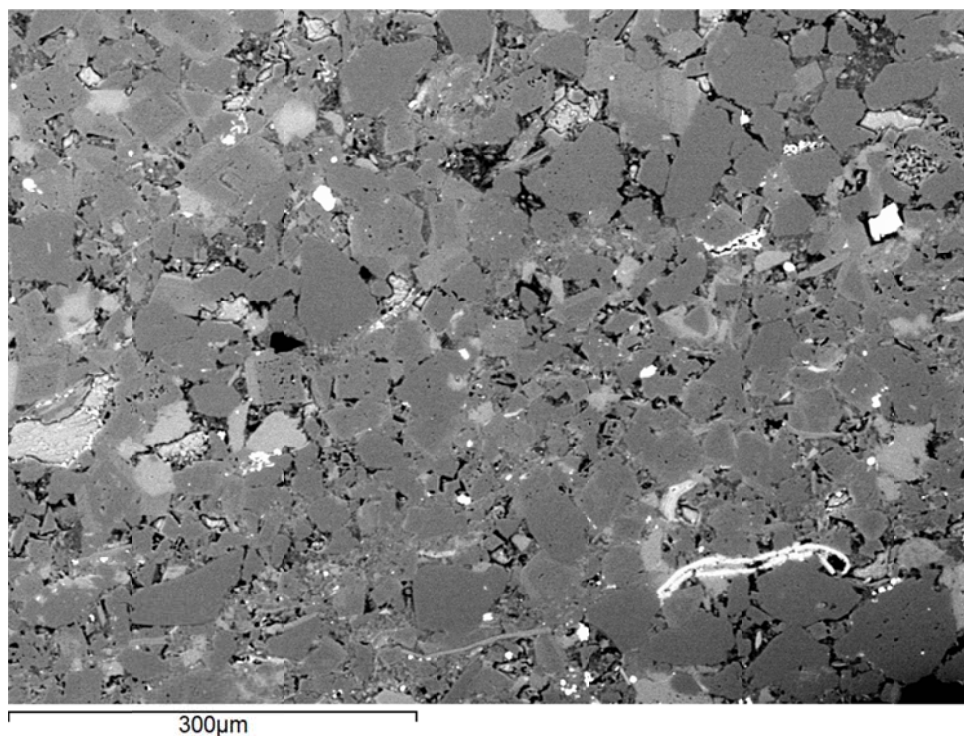
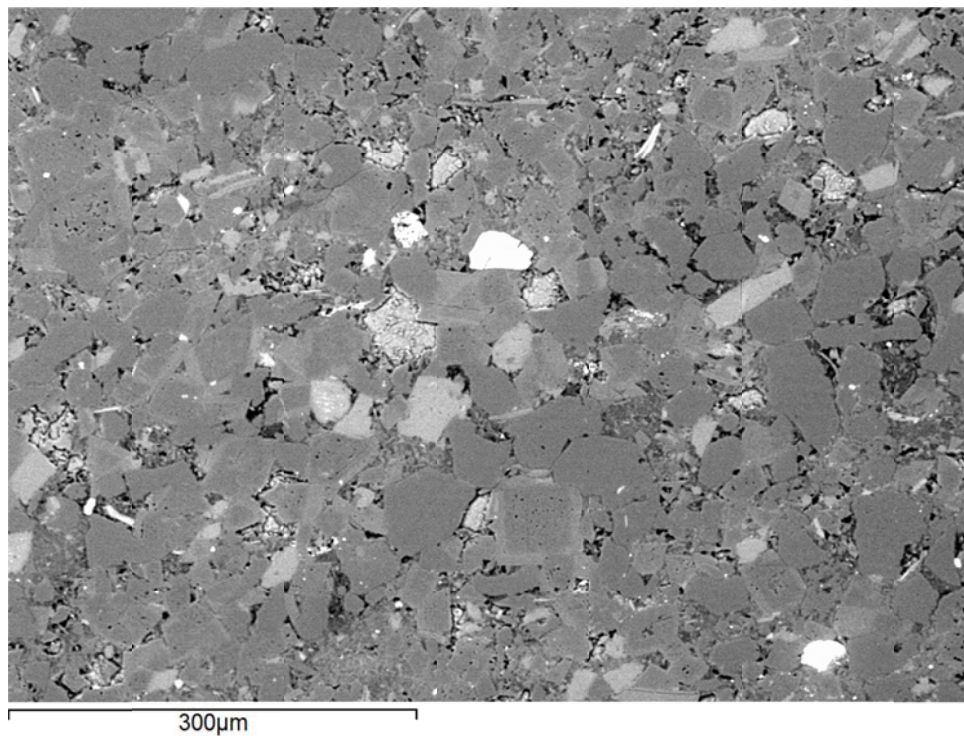


	Applied Geology Laboratory		ID: 117023
	Well Name: NDIC No. 20844	Middle Bakken 5	Grenora Field
	API No.: 33-105-02204-00-02	Lithology: Argillaceous, dolomitic siltstone	Depth: 10227.0'

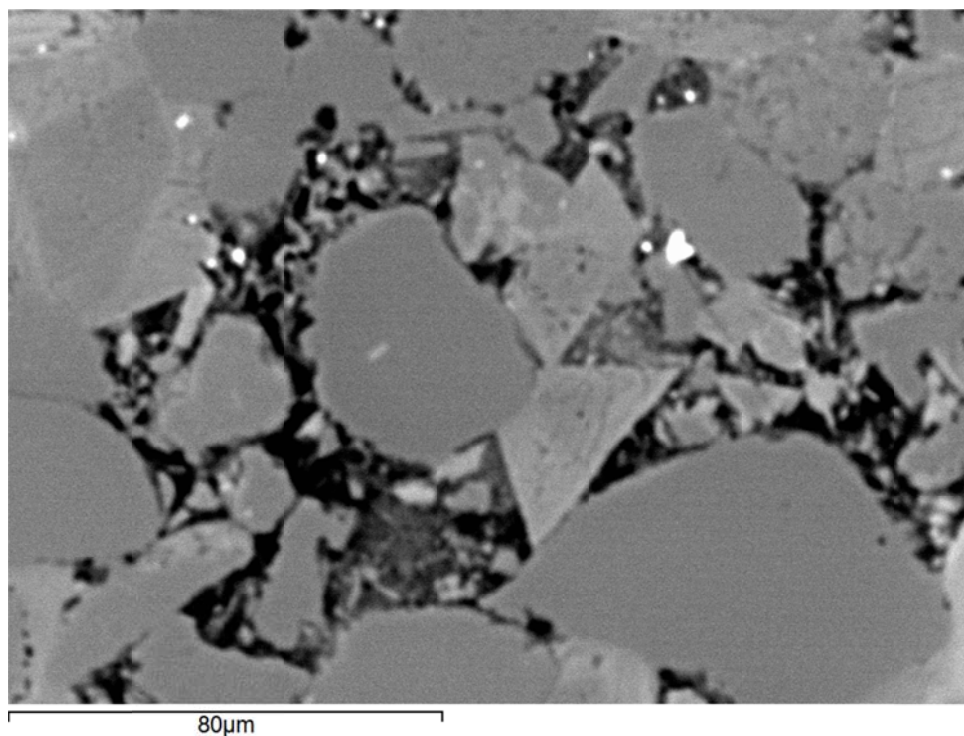
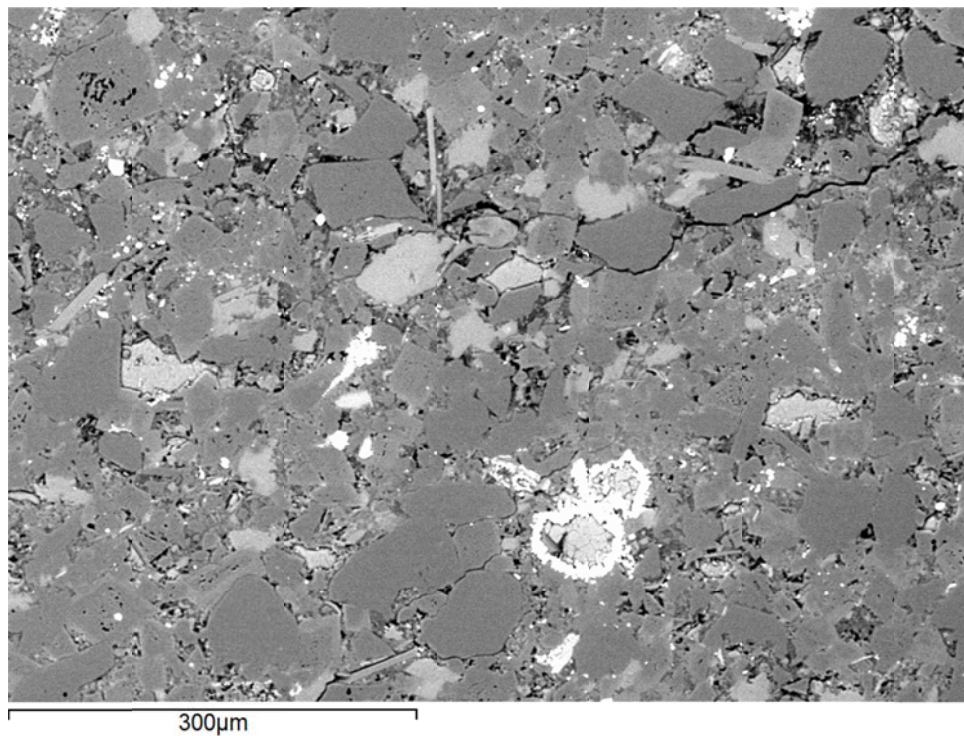
Additional High-Magnification BSE Images



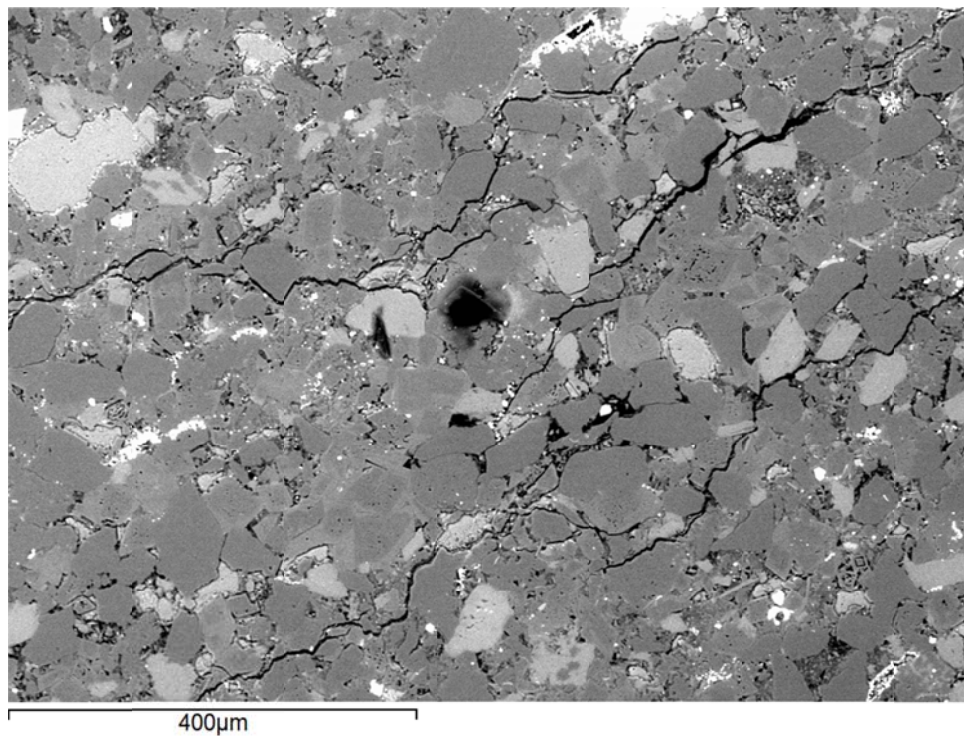
	Applied Geology Laboratory		ID: 117023
	Well Name: NDIC No. 20844	Middle Bakken 5	Grenora Field
	API No.: 33-105-02204-00-02	Lithology: Argillaceous, dolomitic siltstone	Depth: 10227.0'



	Applied Geology Laboratory		ID: 117023
	Well Name: NDIC No. 20844	Middle Bakken 5	Grenora Field
	API No.: 33-105-02204-00-02	Lithology: Argillaceous, dolomitic siltstone	Depth: 10227.0'

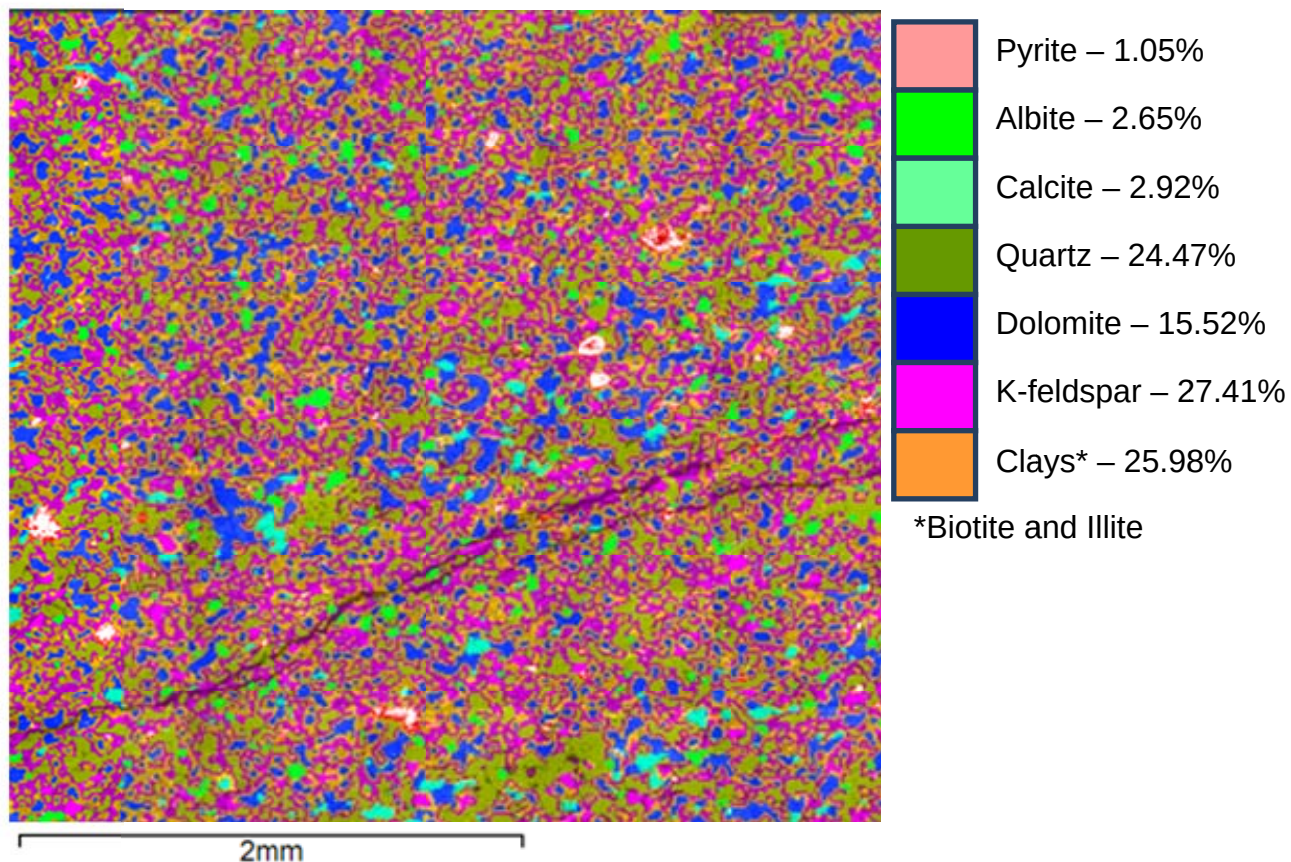


	Applied Geology Laboratory		ID: 117023
	Well Name: NDIC No. 20844	Middle Bakken 5	Grenora Field
	API No.: 33-105-02204-00-02	Lithology: Argillaceous, dolomitic siltstone	Depth: 10227.0'



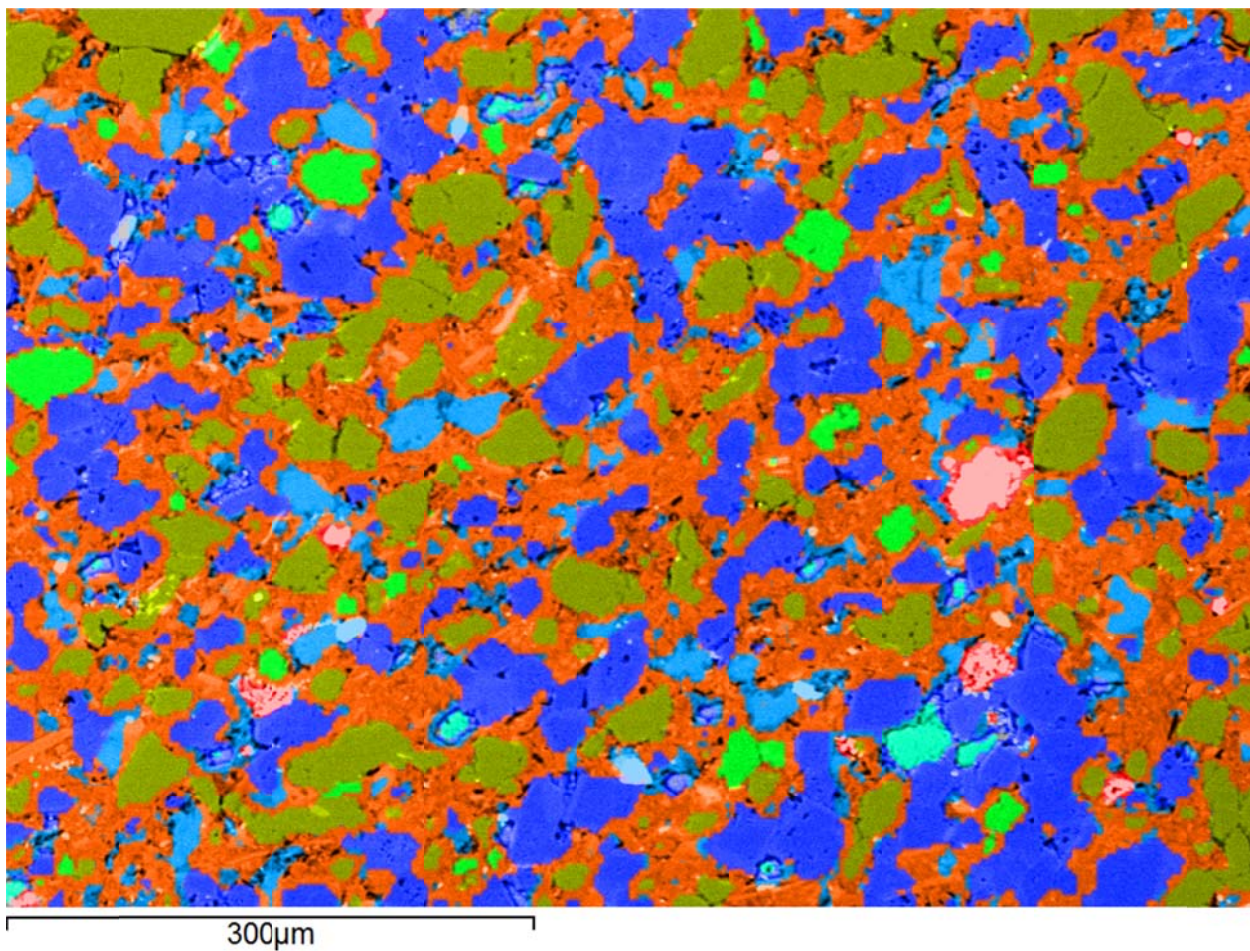
	Applied Geology Laboratory		ID: 117023
	Well Name: NDIC No. 20844	Middle Bakken 5	Grenora Field
	API No.: 33-105-02204-00-02	Lithology: Argillaceous, dolomitic siltstone	Depth: 10227.0'

SEM Digital Composite Mineral Map Image Overlaid on BSE Image with Mineral Phase 2D Area Percentages



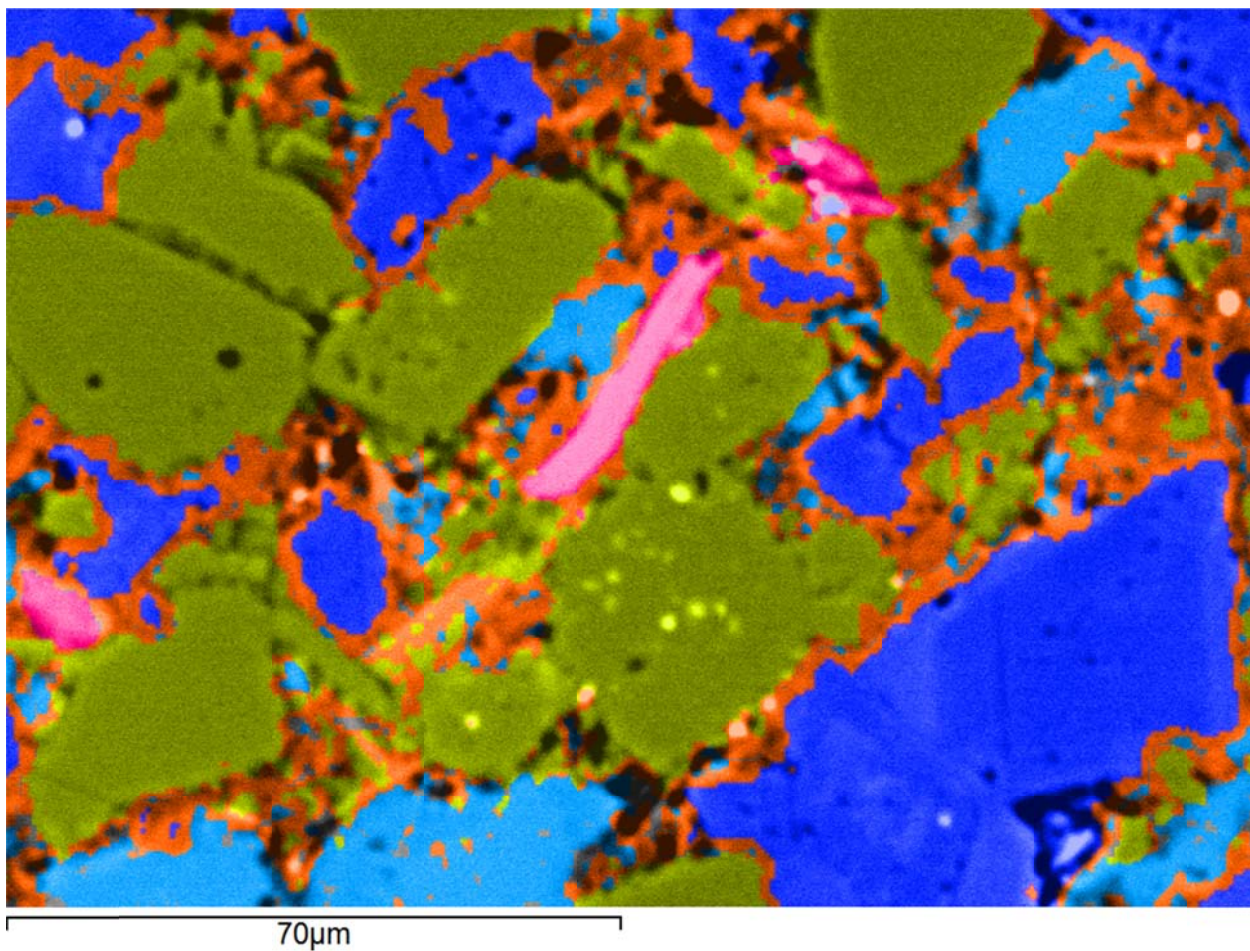
	Applied Geology Laboratory		ID: 117023
	Well Name: NDIC No. 20844	Middle Bakken 5	Grenora Field
	API No.: 33-105-02204-00-02	Lithology: Argillaceous, dolomitic siltstone	Depth: 10227.0'

SEM Mineral Map Image Overlaid on BSE Image **with Mineral Phase 2D Area Percentages**



	Applied Geology Laboratory		ID: 117023
	Well Name: NDIC No. 20844	Middle Bakken 5	Grenora Field
	API No.: 33-105-02204-00-02	Lithology: Argillaceous, dolomitic siltstone	Depth: 10227.0'

Additional SEM Mineral Map Image Overlaid on BSE Image with Mineral Phase 2D Area Percentages



	Applied Geology Laboratory		ID: 117026
	Well Name: NDIC No. 20844	Middle Bakken 3	Grenora Field
	API No.: 33-105-02204-00-05	Lithology: Calcareous siltstone	Depth: 10237.0'

SAMPLE PHOTOGRAPH



PHYSICAL PROPERTIES

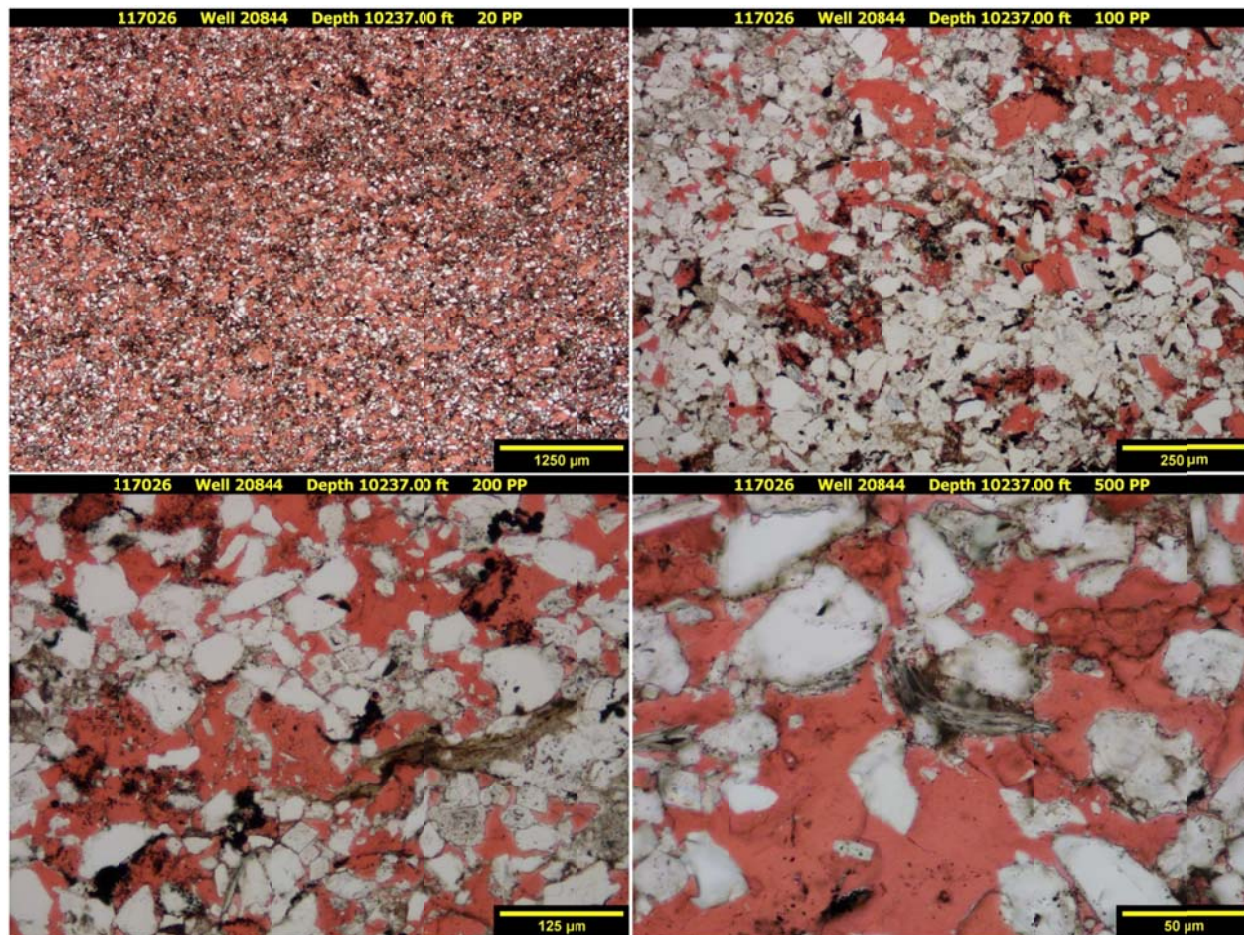
Porosity and Grain Density by Core Laboratories

Pycnometer Effective Porosity, vol%	Grain Density, g/cm ³
3.07	2.716

	Applied Geology Laboratory		ID: 117026
	Well Name: NDIC No. 20844	Middle Bakken 3	Grenora Field
	API No.: 33-105-02204-00-05	Lithology: Calcareous siltstone	Depth: 10237.0'

PHOTOMICROGRAPHS

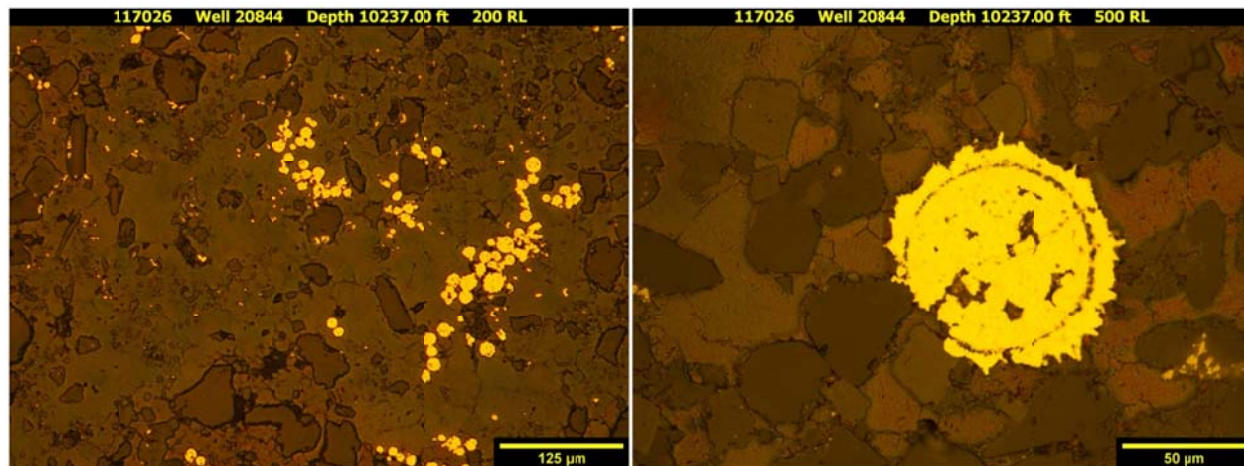
Transmission



The sample from a depth of 10237.00 ft is a predominately massive calcareous siltstone. Very fine grained, angular to subangular, monocrystalline quartz is speckled throughout the sample. Additional detrital minerals found at trace amounts are muscovite and feldspars. Calcareous skeletal and non-skeletal grains commonly occur throughout the sample. The matrix is composed predominantly of sparry calcite cement and lesser amounts of microcrystalline to cryptocrystalline dolomite and clays. Disseminated pore-filling and replacement pyrite is found at lesser amounts than in other well intervals. Small organics specs, typically associated with pyrite, are found sporadically throughout and occasionally congregate. Occasional small (organic/pyrite filled) fractures are observed. No particle-based porosity is detected.

	Applied Geology Laboratory		ID: 117026
	Well Name: NDIC No. 20844	Middle Bakken 3	Grenora Field
	API No.: 33-105-02204-00-05	Lithology: Calcareous siltstone	Depth: 10237.0'

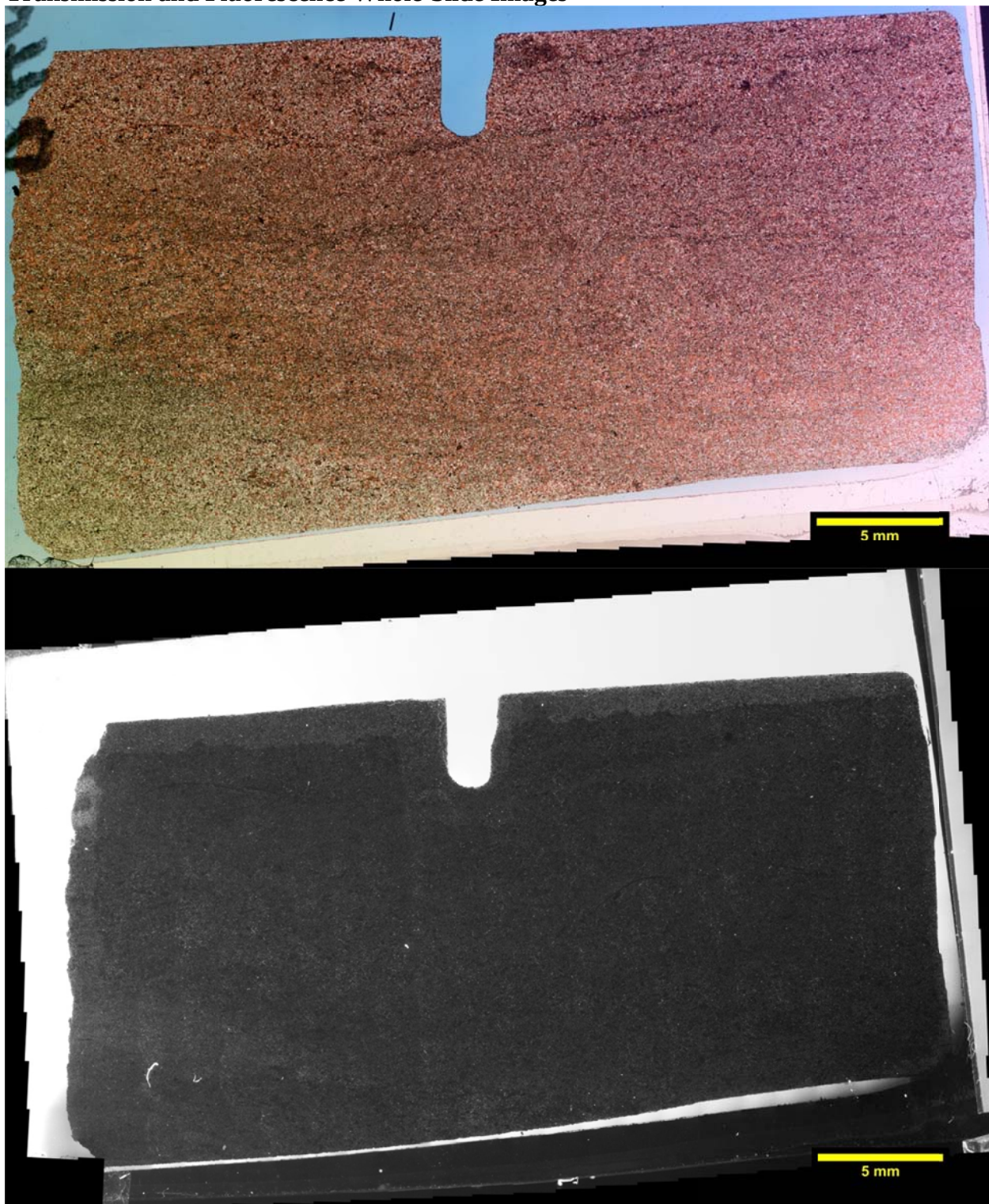
Reflection



The sample from a depth of 10237.00 ft displays both euhedral and framboidal pyrite mineralization speckled at moderate amounts. This diagenetic mineralization replaced and filled pores. Framboidal pyrite predominately is shown as individual spheres; no occurrences of larger sphere assemblages and are concentrated within clay-rich portions. Nearly complete pyritization of skeletal, non-skeletal, and organics have occurred. Organics observed are typically associated with both euhedral and framboidal pyrite.

	Applied Geology Laboratory		ID: 117026
	Well Name: NDIC No. 20844	Middle Bakken 3	Grenora Field
	API No.: 33-105-02204-00-05	Lithology: Calcareous siltstone	Depth: 10237.0'

Transmission and Fluorescence Whole-Slide Images

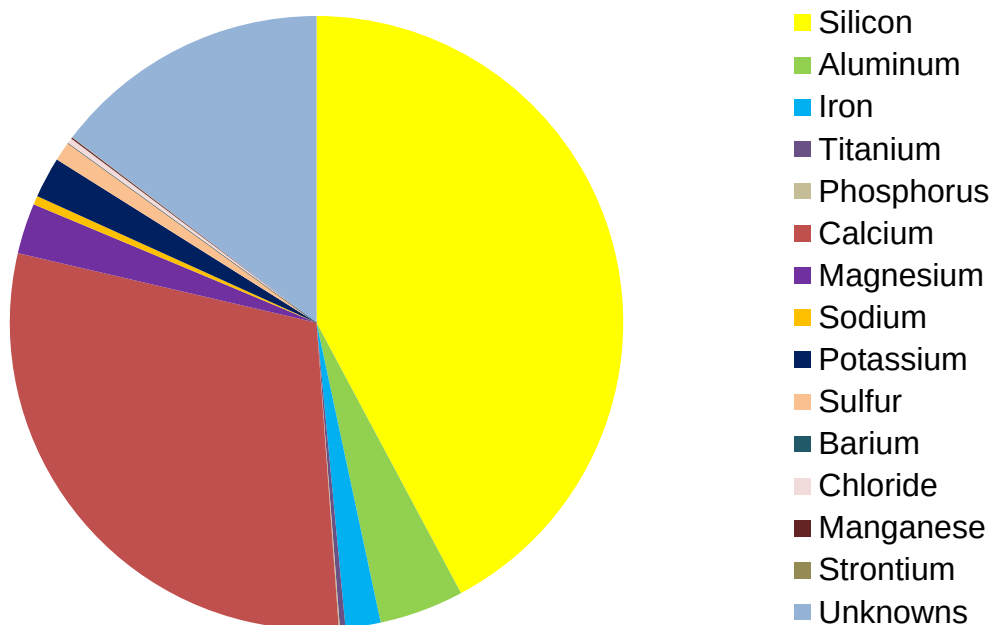


	Applied Geology Laboratory		ID: 117026
	Well Name: NDIC No. 20844	Middle Bakken 3	Grenora Field
	API No.: 33-105-02204-00-05	Lithology: Calcareous siltstone	Depth: 10237.0'

The image collected at a depth of 10237.00 ft displays a calcareous siltstone having few bedding features. Effective reported porosity is 3.07 vol%. The sample is well-cemented with calcite spar leaving trace levels of observable porosity. The observed micro-inter-particle porosity may be because of dolomitization (concentrated at the lower left of the sample), incomplete calcite cementation, and/or mineral dissolution (feldspar) or leaching (pyrite). No open natural or induced fractures are detected.

	Applied Geology Laboratory		ID: 117026
	Well Name: NDIC No. 20844	Middle Bakken 3	Grenora Field
	API No.: 33-105-02204-00-05	Lithology: Calcareous siltstone	Depth: 10237.0'

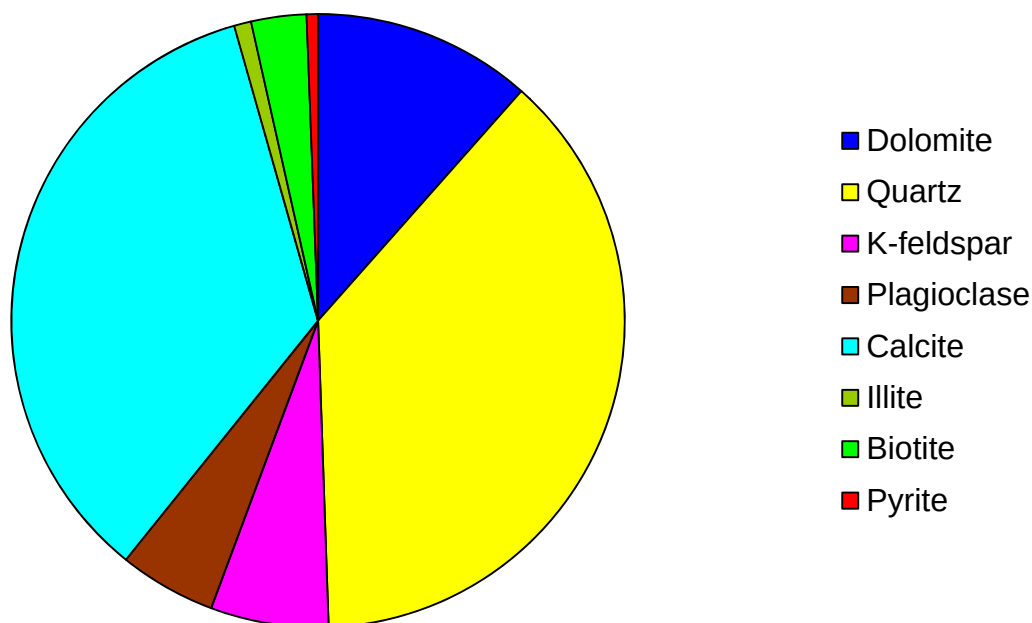
XRF BULK CHEMICAL COMPOSITION



Element	Reporting Convention (Oxide)	Weight %
Si (silicon)	SiO ₂	42.19
Al (aluminum)	Al ₂ O ₃	4.46
Fe (iron)	Fe ₂ O ₃	1.85
Ti (titanium)	TiO ₂	0.29
P (phosphorus)	P ₂ O ₅	0.06
Ca (calcium)	CaO	29.80
Mg (magnesium)	MgO	2.67
Na (sodium)	Na ₂ O	0.46
K (potassium)	K ₂ O	2.16
S (sulfur)	SO ₃	1.03
Ba (barium)	BaO	0.00
Cl (chloride)	Cl	0.29
Mn (manganese)	MnO	0.07
Sr (strontium)	SrO	0.02
Unknowns	Due to the presence of carbonates	14.66
Total		100.01

	Applied Geology Laboratory		ID: 117026
	Well Name: NDIC No. 20844	Middle Bakken 3	Grenora Field
	API No.: 33-105-02204-00-05	Lithology: Calcareous siltstone	Depth: 10237.0'

XRD MINERAL PHASE DISTRIBUTION



Mineral Phase	Formula	Weight %
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	11.5
Quartz	SiO_2	37.8
K-feldspar	KAlSi_3O_8	6.2
Plagioclase	$\text{Na}_{0.5}\text{Ca}_{0.5}\text{Al}_{1.5}\text{Si}_{2.5}\text{O}_8$	5.1
Calcite	CaCO_3	34.7
Illite	$(\text{K},\text{H}_3\text{O})(\text{Al},\text{Mg},\text{Fe})_2(\text{Si},\text{Al})_4\text{O}_{10}[(\text{OH})_2,(\text{H}_2\text{O})]$	0.9
Biotite	$\text{K}(\text{Mg},\text{Fe})_3[(\text{OH})_2\text{AlSi}_3\text{O}_{10}]$	2.9
Pyrite	FeS_2	0.6

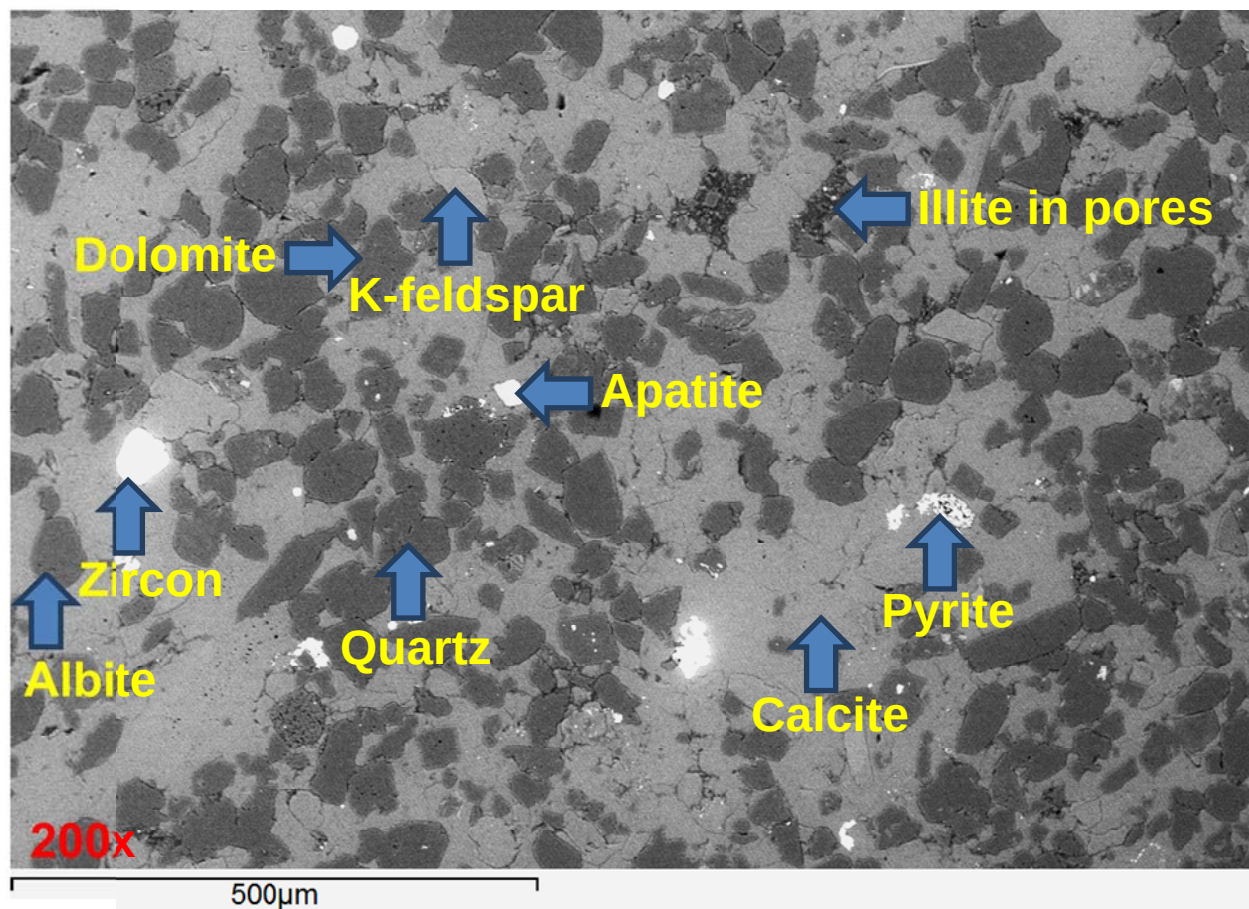
	Applied Geology Laboratory		ID: 117026
	Well Name: NDIC No. 20844	Middle Bakken 3	Grenora Field
	API No.: 33-105-02204-00-05	Lithology: Calcareous siltstone	Depth: 10237.0'

SEM

Observed Minerals

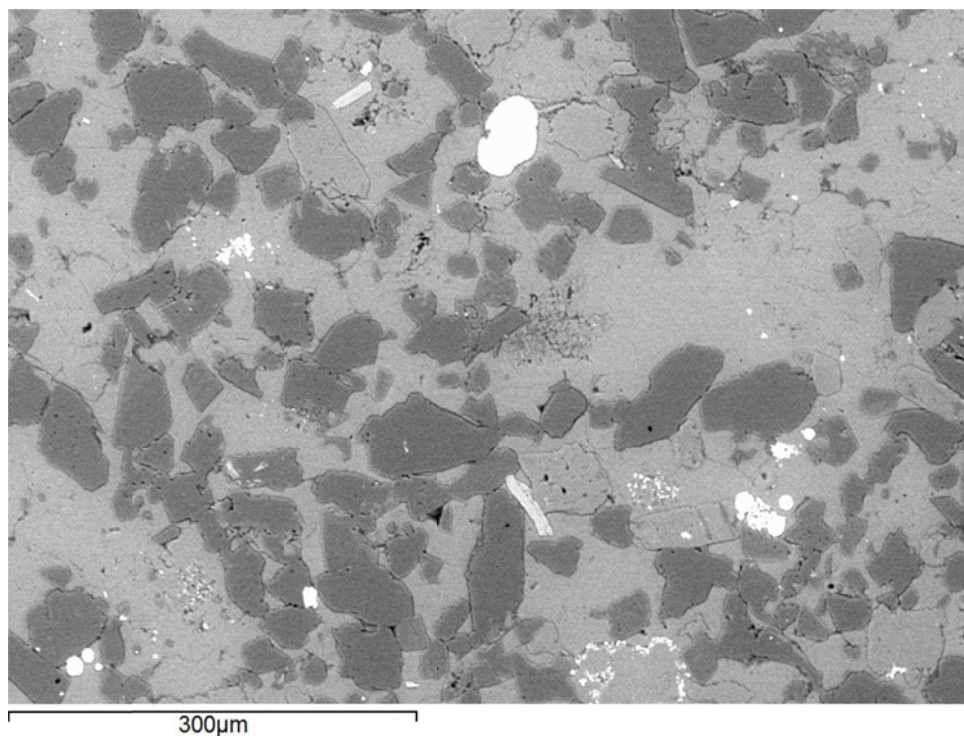
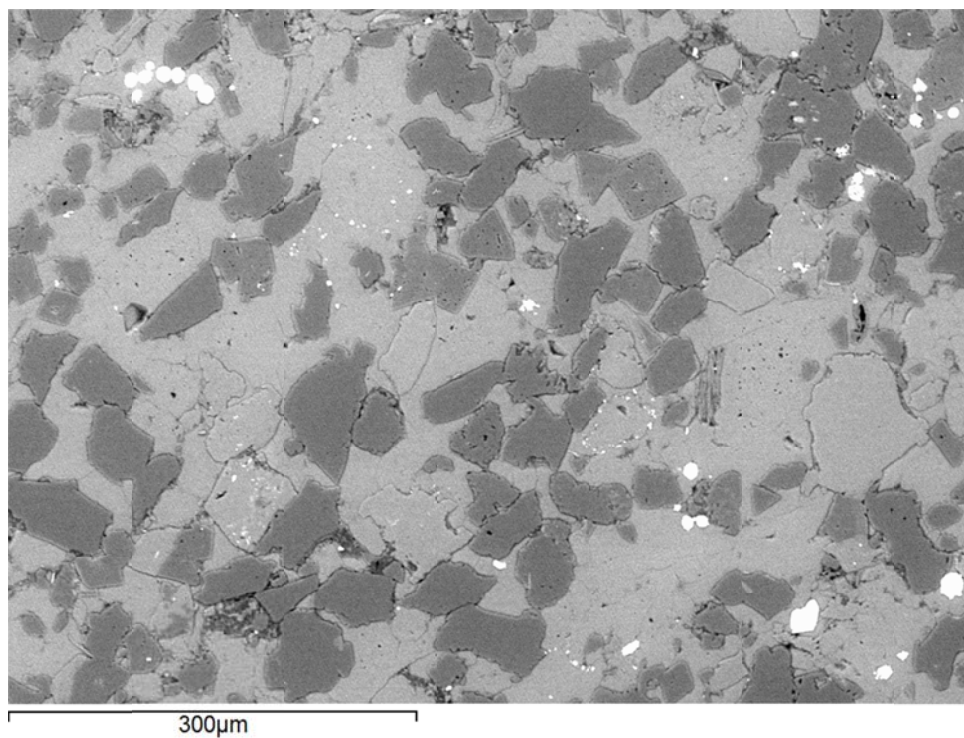
Mineral Phase	Mineral Phase
Calcite	Albite
Quartz	Rutile
Dolomite	Illite
Apatite	K-feldspar
Pyrite	Chromite
Zircon	Monazite

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified

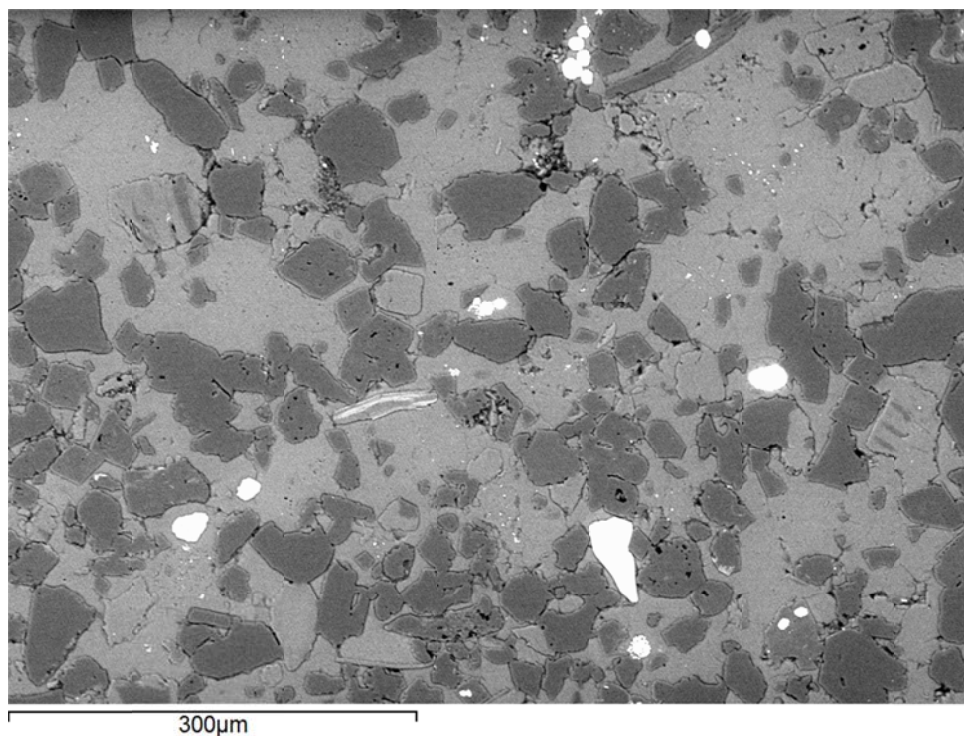
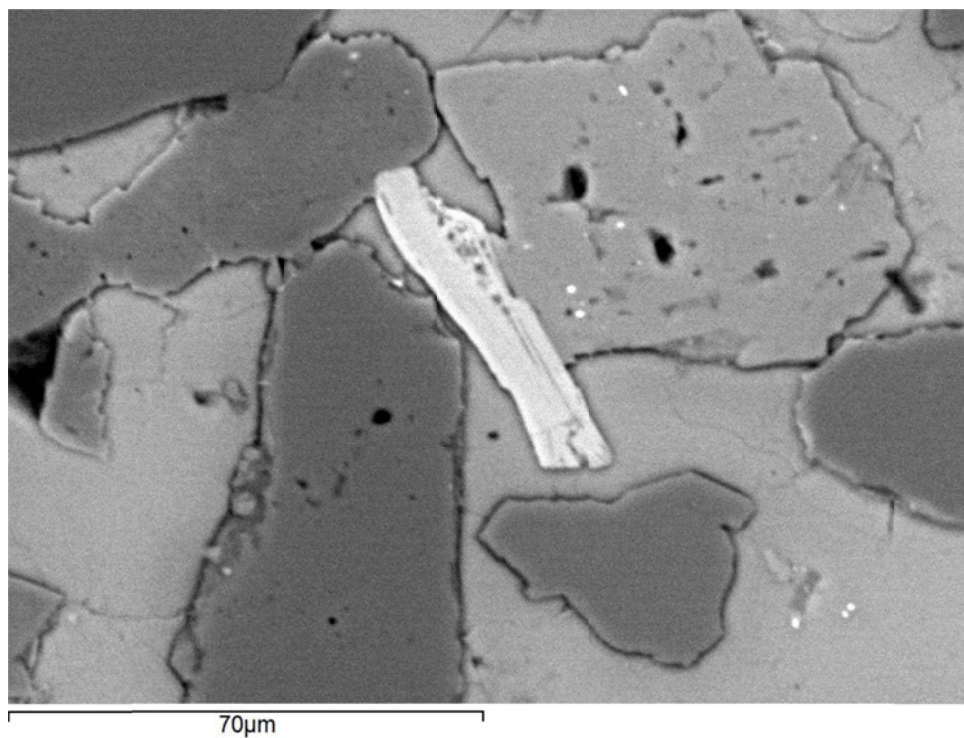


	Applied Geology Laboratory		ID: 117026
	Well Name: NDIC No. 20844	Middle Bakken 3	Grenora Field
	API No.: 33-105-02204-00-05	Lithology: Calcareous siltstone	Depth: 10237.0'

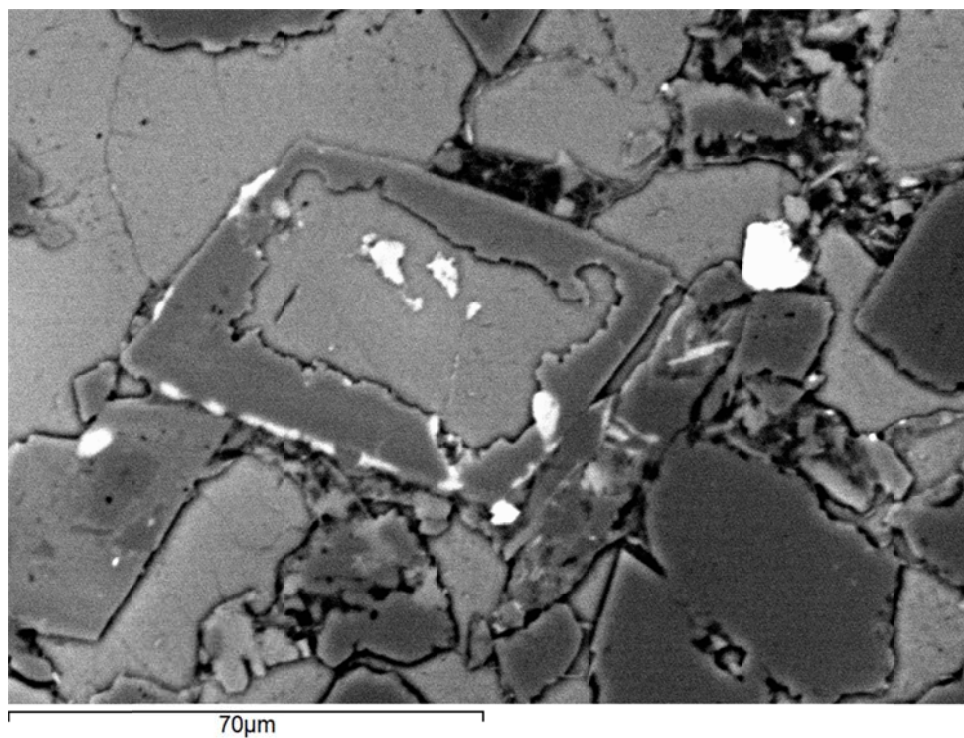
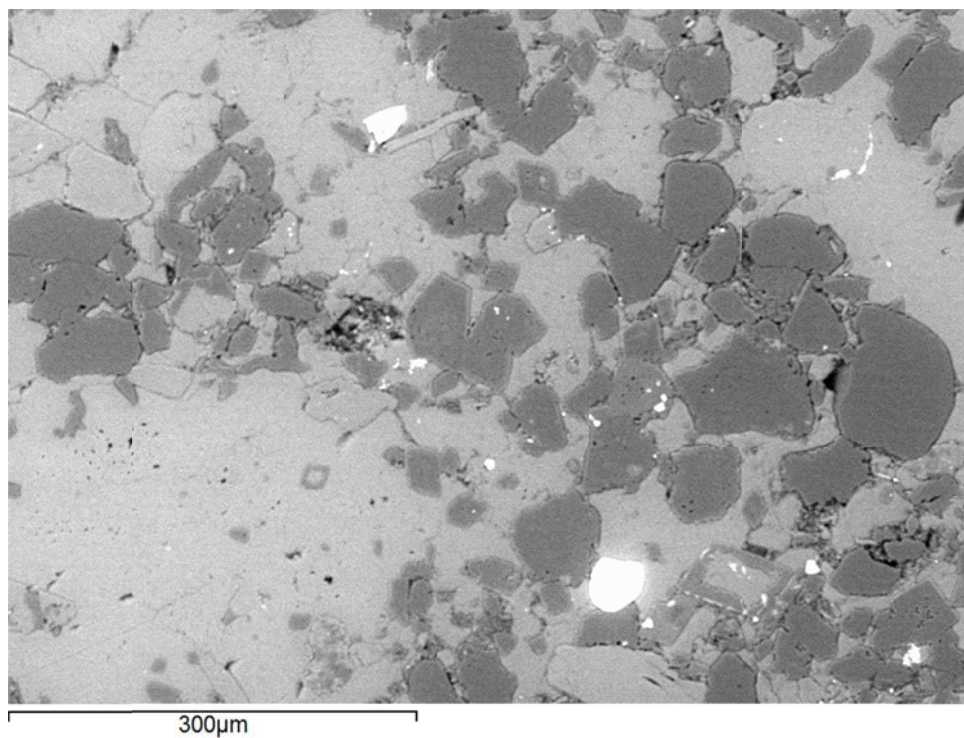
Additional High-Magnification BSE Images



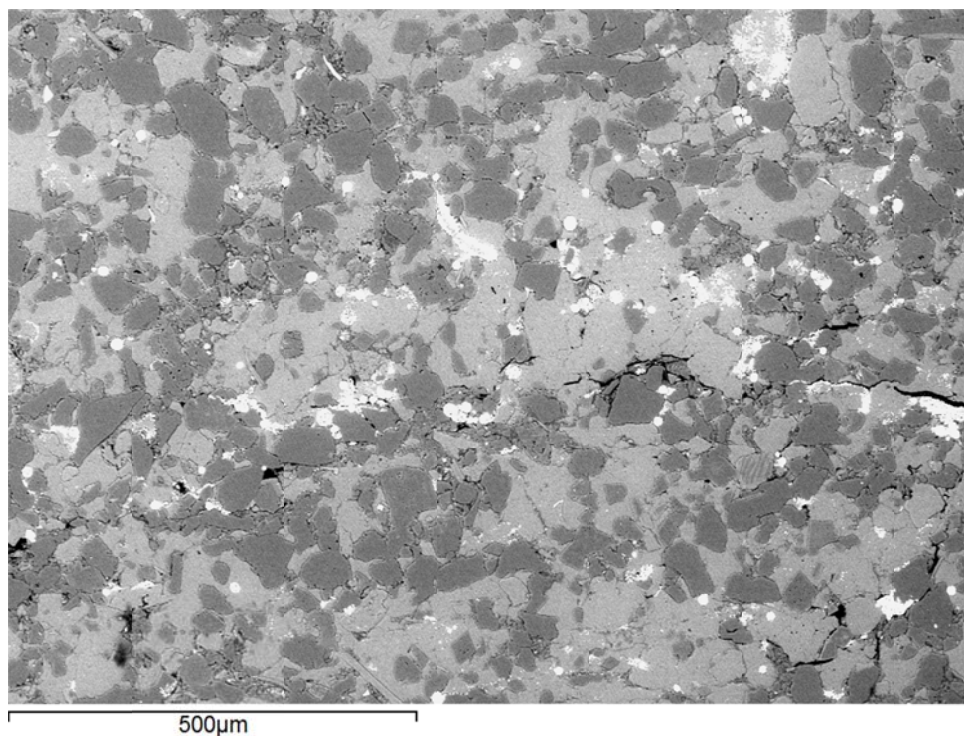
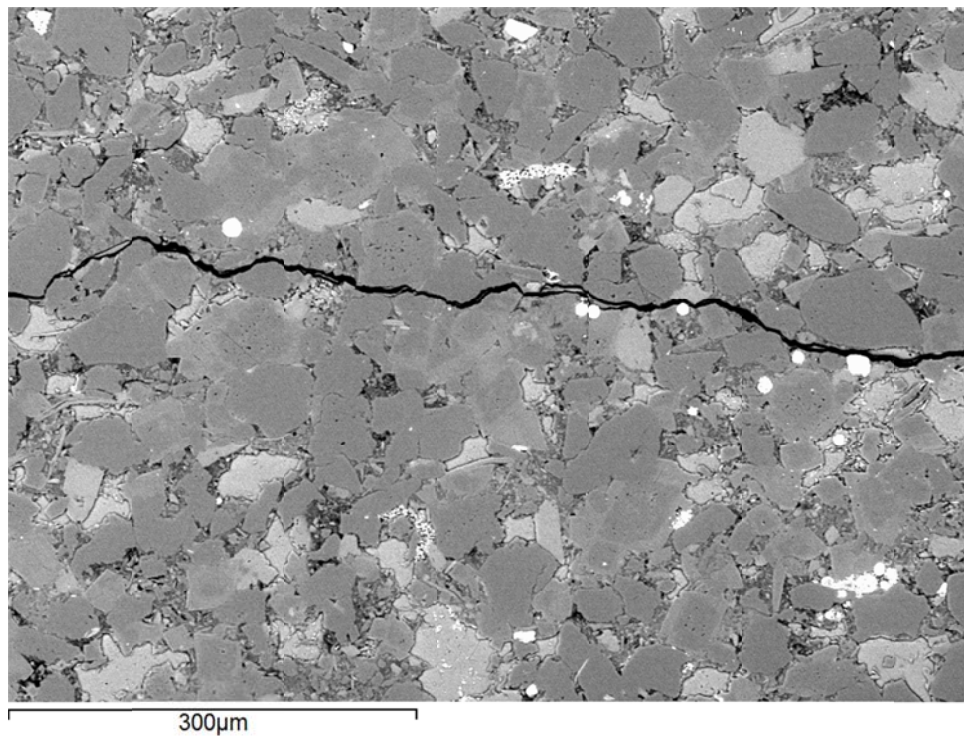
	Applied Geology Laboratory		ID: 117026
	Well Name: NDIC No. 20844	Middle Bakken 3	Grenora Field
	API No.: 33-105-02204-00-05	Lithology: Calcareous siltstone	Depth: 10237.0'



	Applied Geology Laboratory		ID: 117026
	Well Name: NDIC No. 20844	Middle Bakken 3	Grenora Field
	API No.: 33-105-02204-00-05	Lithology: Calcareous siltstone	Depth: 10237.0'

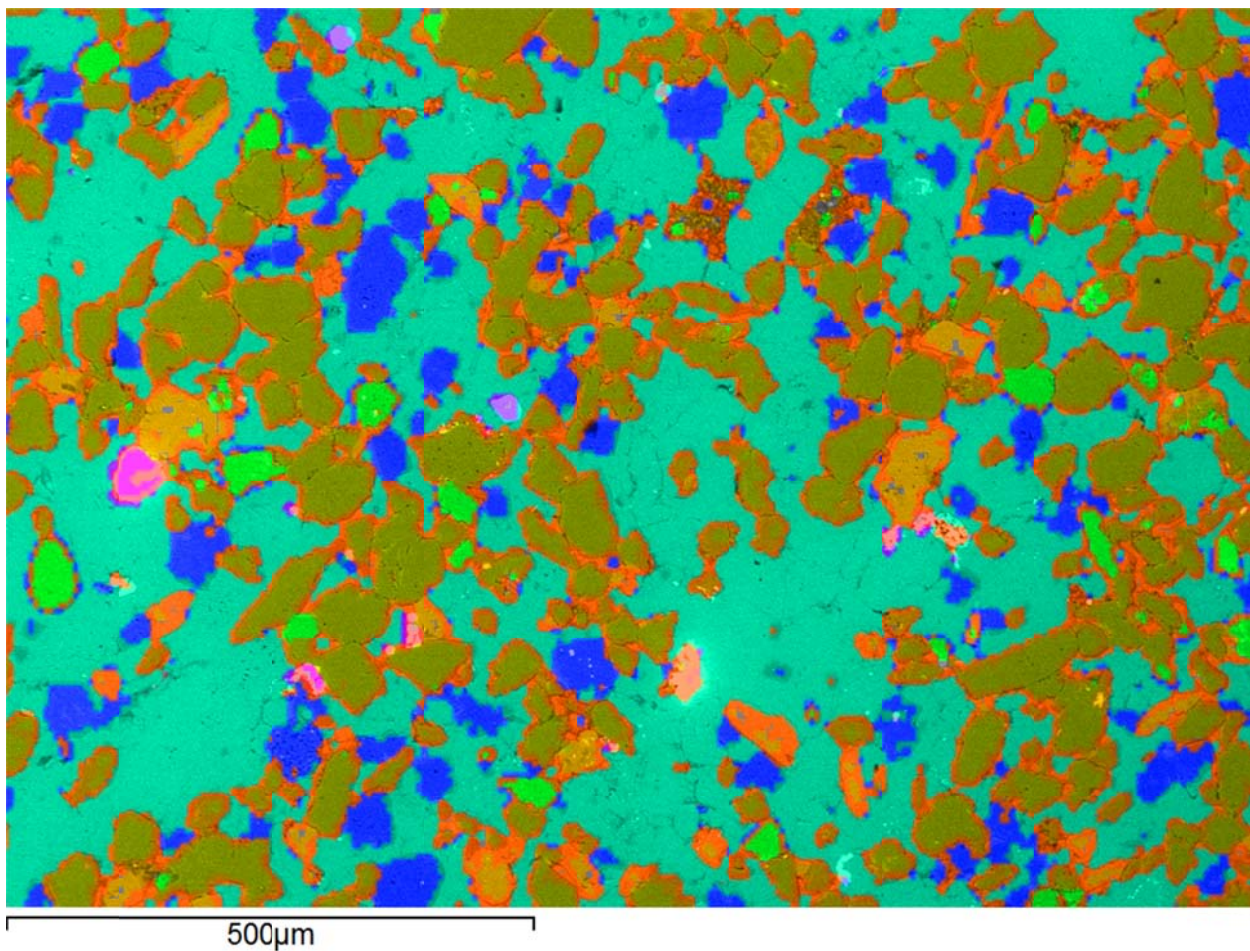


	Applied Geology Laboratory		ID: 117026
	Well Name: NDIC No. 20844	Middle Bakken 3	Grenora Field
	API No.: 33-105-02204-00-05	Lithology: Calcareous siltstone	Depth: 10237.0'



	Applied Geology Laboratory		ID: 117026
	Well Name: NDIC No. 20844	Middle Bakken 3	Grenora Field
	API No.: 33-105-02204-00-05	Lithology: Calcareous siltstone	Depth: 10237.0'

SEM Mineral Map Image Overlaid on BSE Image with Mineral Phase 2D Area Percentages

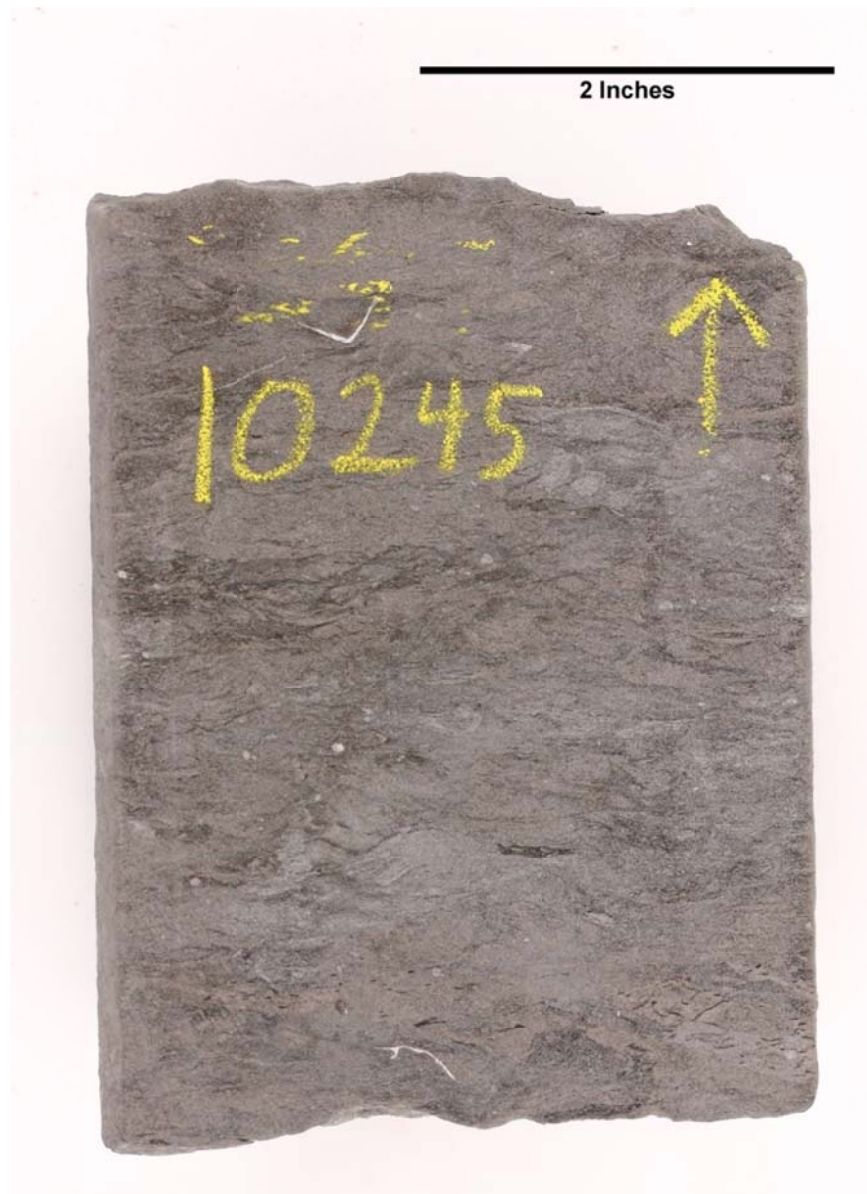


	Applied Geology Laboratory		ID: 117026
	Well Name: NDIC No. 20844	Middle Bakken 3	Grenora Field
	API No.: 33-105-02204-00-05	Lithology: Calcareous siltstone	Depth: 10237.0'

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	Applied Geology Laboratory		ID: 117027
	Well Name: NDIC No. 20844	Middle Bakken 2	Grenora Field
	API No.: 33-105-02204-00-06	Lithology: Slightly calcareous, dolomitic siltstone	Depth: 10245.0'

SAMPLE PHOTOGRAPH



PHYSICAL PROPERTIES

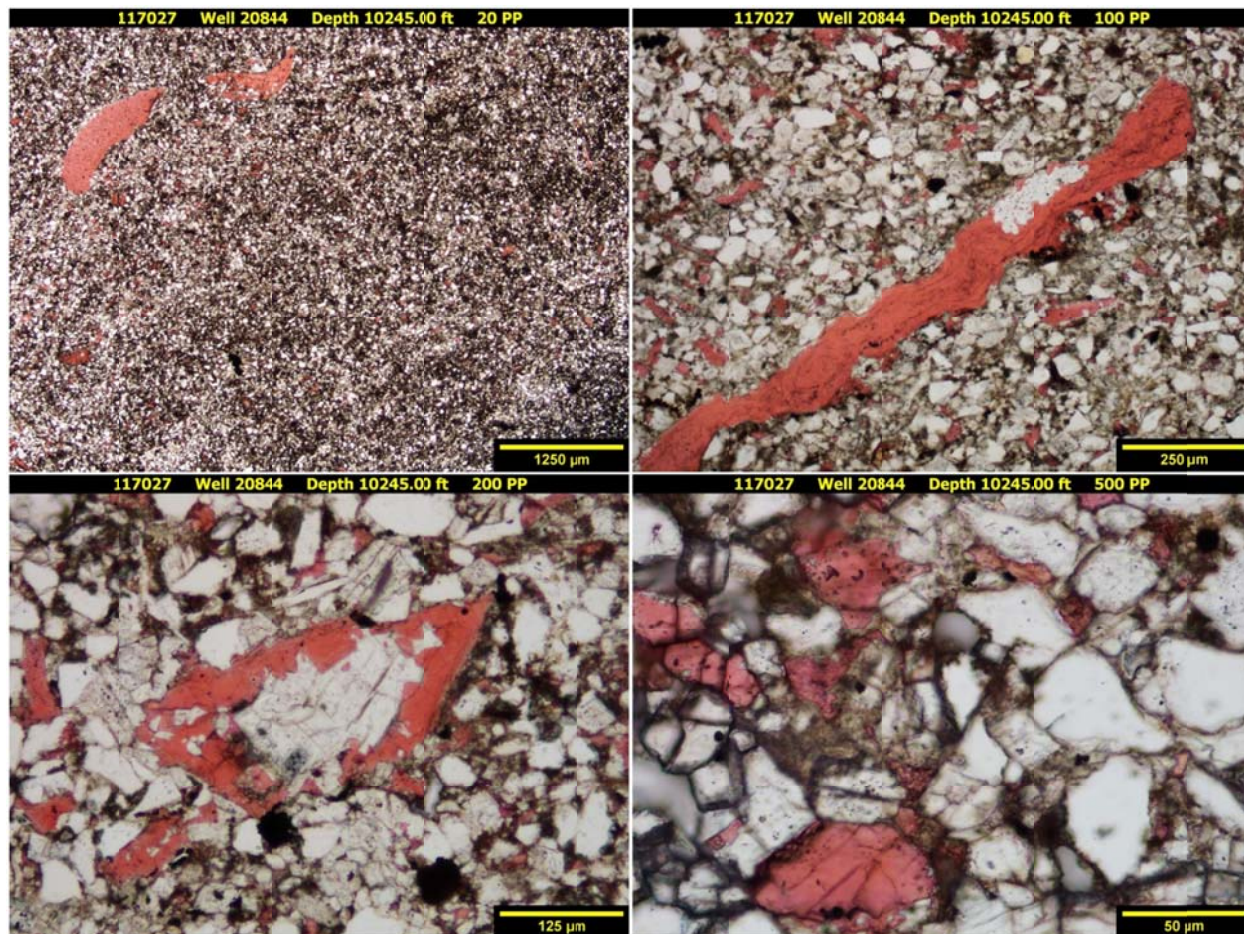
Porosity and Grain Density by Core Laboratories

Pycnometer Effective Porosity, vol%	Grain Density, g/cm ³
3.38	2.733

	Applied Geology Laboratory		ID: 117027
	Well Name: NDIC No. 20844	Middle Bakken 2	Grenora Field
	API No.: 33-105-02204-00-06	Lithology: Slightly calcareous, dolomitic siltstone	Depth: 10245.0'

PHOTOMICROGRAPHS

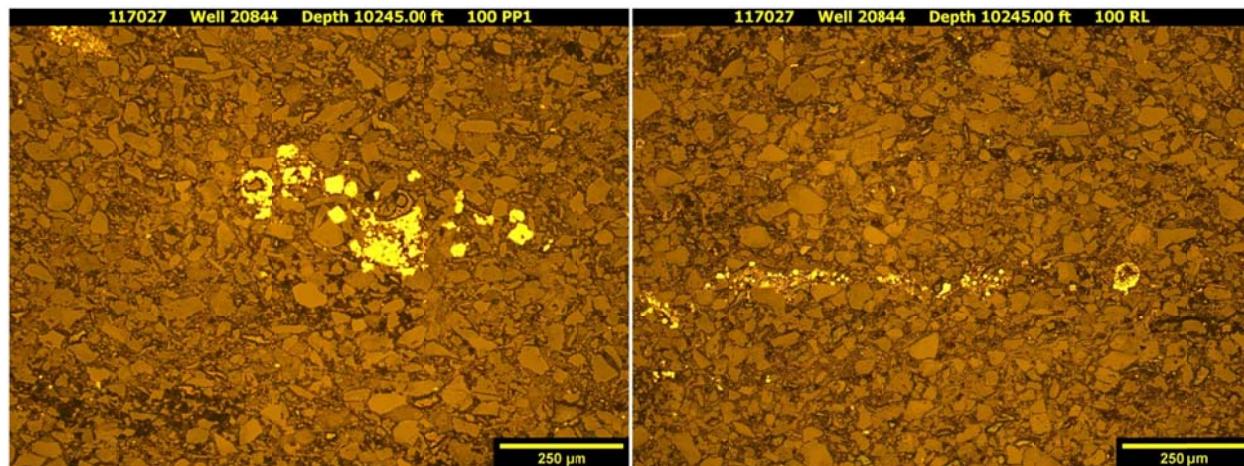
Transmission



The sample from a depth of 10245.00 ft shows a slightly calcareous, dolomitic siltstone. Some burrowing and wavy laminations are observed but the sample is largely massive. Very fine grained, angular to subangular, monocrystalline quartz grains and trace amounts of muscovite and feldspars are disseminated throughout. Extensive anhedral to euhedral dolomitization has occurred throughout the sample. Abundant, fine-grained, crystalline dolomite occurs as replacement of precursor carbonate grains and mud. Moderate quantities of skeletal and non-skeletal grains remain. Disseminated pore-filling and replacement pyrite grains are observed throughout at small quantities. The matrix composes a combination of clays and micro- to cryptocrystalline dolomite and rarely calcite cement. Rare gypsum replacement is detected. Open fractures are detected and are likely because of the sampling process. Additional organics are observed as globular and lensing features typically associated with pyrite. Other than potential open fractures, no porosity is observed using standard petrographic techniques.

	Applied Geology Laboratory		ID: 117027
	Well Name: NDIC No. 20844	Middle Bakken 2	Grenora Field
	API No.: 33-105-02204-00-06	Lithology: Slightly calcareous, dolomitic siltstone	Depth: 10245.0'

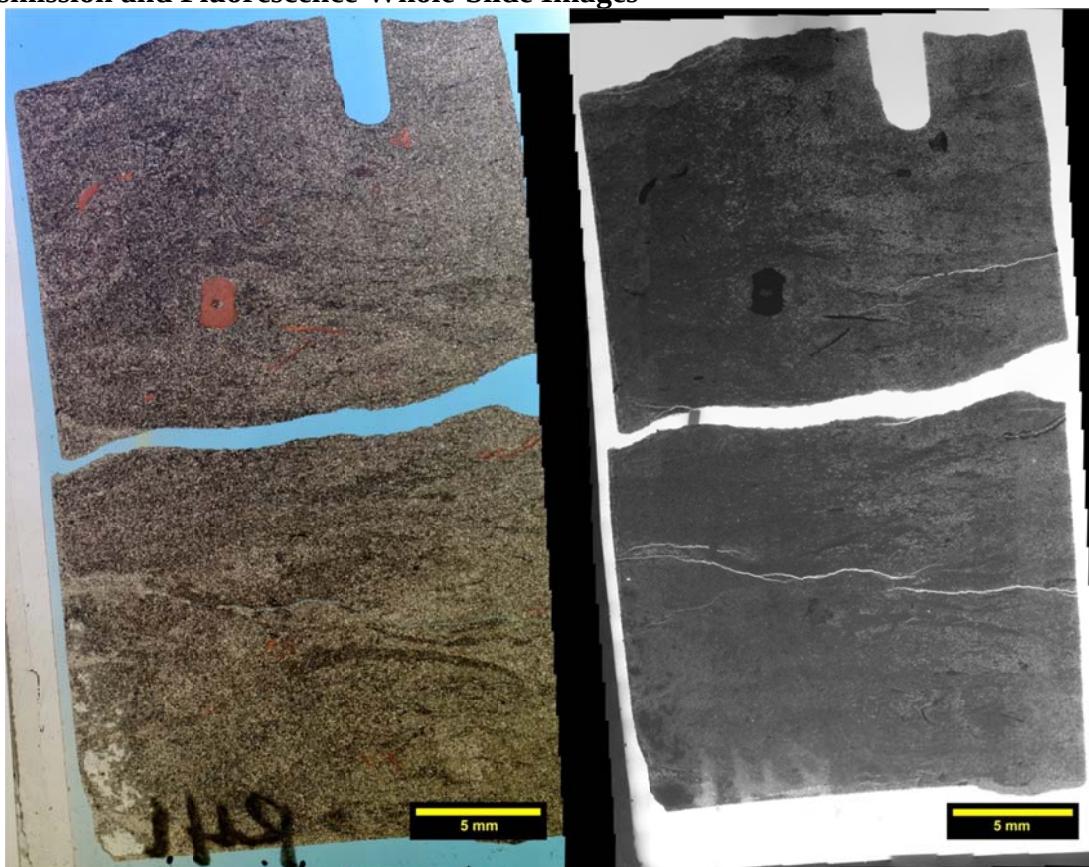
Reflection



The sample from a depth of 10245.00 ft displays both euhedral and framboidal pyrite mineralization speckled at lesser amounts. This diagenetic mineralization replaced grains (calcareous skeletal and non-skeletal appear non-pyritized) and filled pores. Framboidal pyrite predominately is shown as individual spheres, with no occurrences of larger sphere assemblages. Organics observed are typically associated with both euhedral and framboidal pyrite.

	Applied Geology Laboratory		ID: 117027
	Well Name: NDIC No. 20844	Middle Bakken 2	Grenora Field
	API No.: 33-105-02204-00-06	Lithology: Slightly calcareous, dolomitic siltstone	Depth: 10245.0'

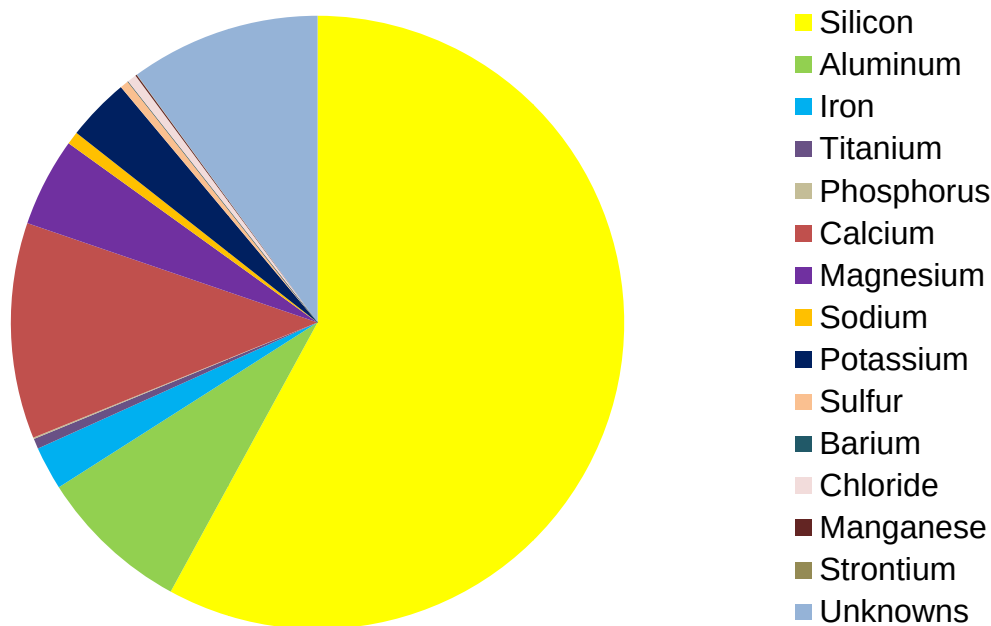
Transmission and Fluorescence Whole-Slide Images



The image collected from a depth of 10245.00 ft is a moderately burrowed dolomitic siltstone. Effective porosity is reported at 3.38 vol%. Extensive interlocking anhedral to euhedral dolomitization and rare pyritization has occurred. These diagenetic events along consistent, very fine grain sizes (except for skeletal and skeletal calcite grains and pyrite) and zonal concentrations of clay are limiting factors of pore size and distribution. No open naturally-occurring fractures are observed. Induced horizontal fractures are likely the product of the sampling process. Though unnatural, they may provide insight to structural stability within this interval.

	Applied Geology Laboratory		ID: 117027
	Well Name: NDIC No. 20844	Middle Bakken 2	Grenora Field
	API No.: 33-105-02204-00-06	Lithology: Slightly calcareous, dolomitic siltstone	Depth: 10245.0'

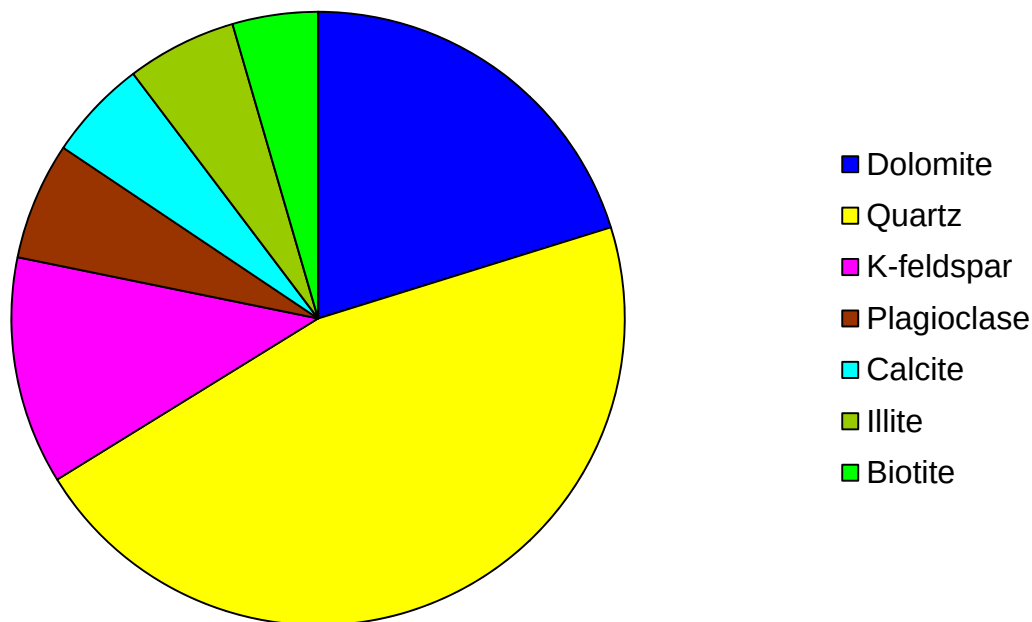
XRF BULK CHEMICAL COMPOSITION



Element	Reporting Convention (Oxide)	Weight %
Si (silicon)	SiO ₂	57.95
Al (aluminum)	Al ₂ O ₃	8.02
Fe (iron)	Fe ₂ O ₃	2.29
Ti (titanium)	TiO ₂	0.54
P (phosphorus)	P ₂ O ₅	0.07
Ca (calcium)	CaO	11.38
Mg (magnesium)	MgO	4.68
Na (sodium)	Na ₂ O	0.68
K (potassium)	K ₂ O	3.31
S (sulfur)	SO ₃	0.48
Ba (barium)	BaO	0.00
Cl (chloride)	Cl	0.49
Mn (manganese)	MnO	0.07
Sr (strontium)	SrO	0.02
Unknowns	Due to the presence of carbonates	10.02
Total		100.00

	Applied Geology Laboratory		ID: 117027
	Well Name: NDIC No. 20844	Middle Bakken 2	Grenora Field
	API No.: 33-105-02204-00-06	Lithology: Slightly calcareous, dolomitic siltstone	Depth: 10245.0'

XRD MINERAL PHASE DISTRIBUTION



Mineral Phase	Formula	Weight %
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	20.2
Quartz	SiO_2	46.0
K-feldspar	KAlSi_3O_8	12.0
Plagioclase	$\text{Na}_{0.5}\text{Ca}_{0.5}\text{Al}_{1.5}\text{Si}_{2.5}\text{O}_8$	6.2
Calcite	CaCO_3	5.3
Illite	$(\text{K},\text{H}_3\text{O})(\text{Al},\text{Mg},\text{Fe})_2(\text{Si},\text{Al})_4\text{O}_{10}[(\text{OH})_2,(\text{H}_2\text{O})]$	5.8
Biotite	$\text{K}(\text{Mg},\text{Fe})_3[(\text{OH})_2\text{AlSi}_3\text{O}_{10}]$	4.5

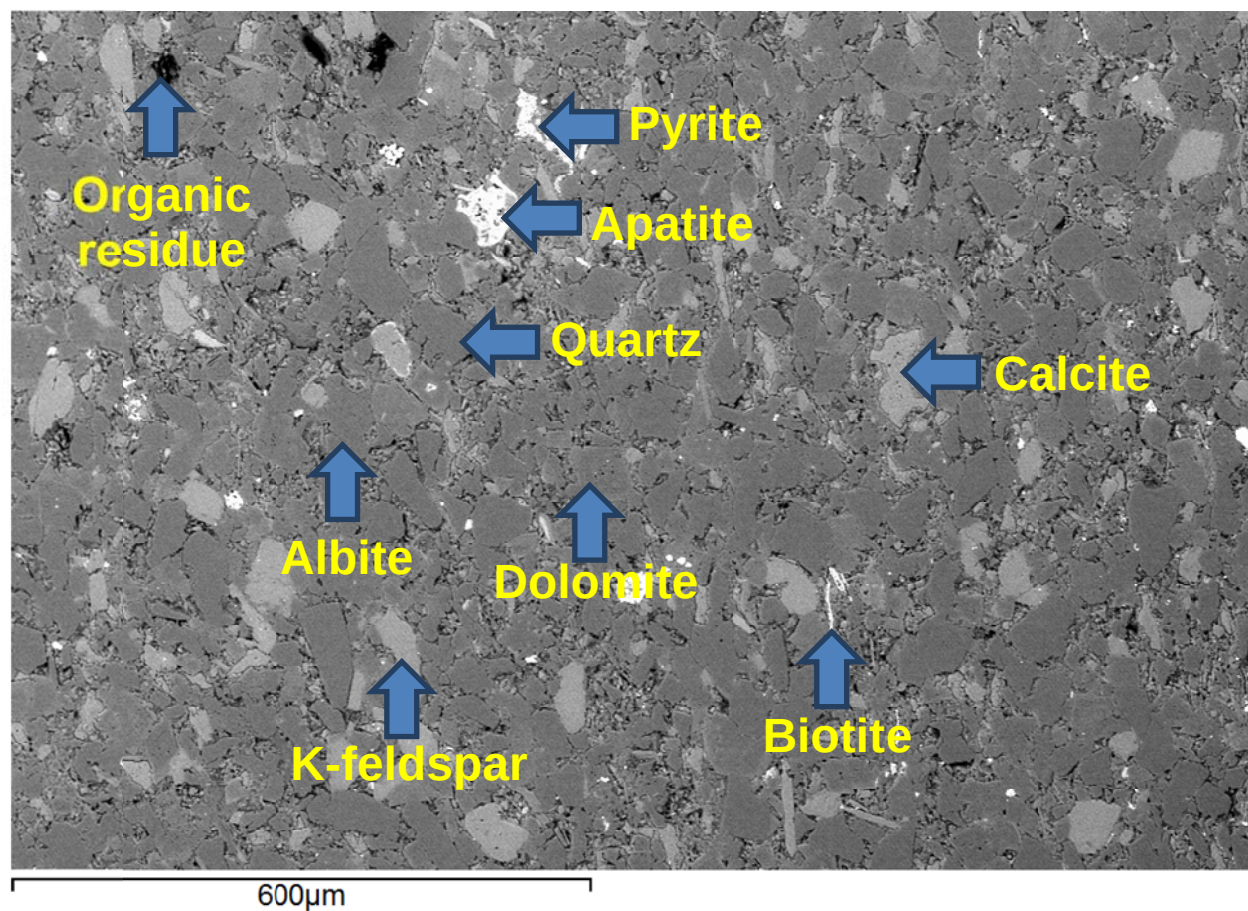
	Applied Geology Laboratory		ID: 117027
	Well Name: NDIC No. 20844	Middle Bakken 2	Grenora Field
	API No.: 33-105-02204-00-06	Lithology: Slightly calcareous, dolomitic siltstone	Depth: 10245.0'

SEM

Observed Minerals

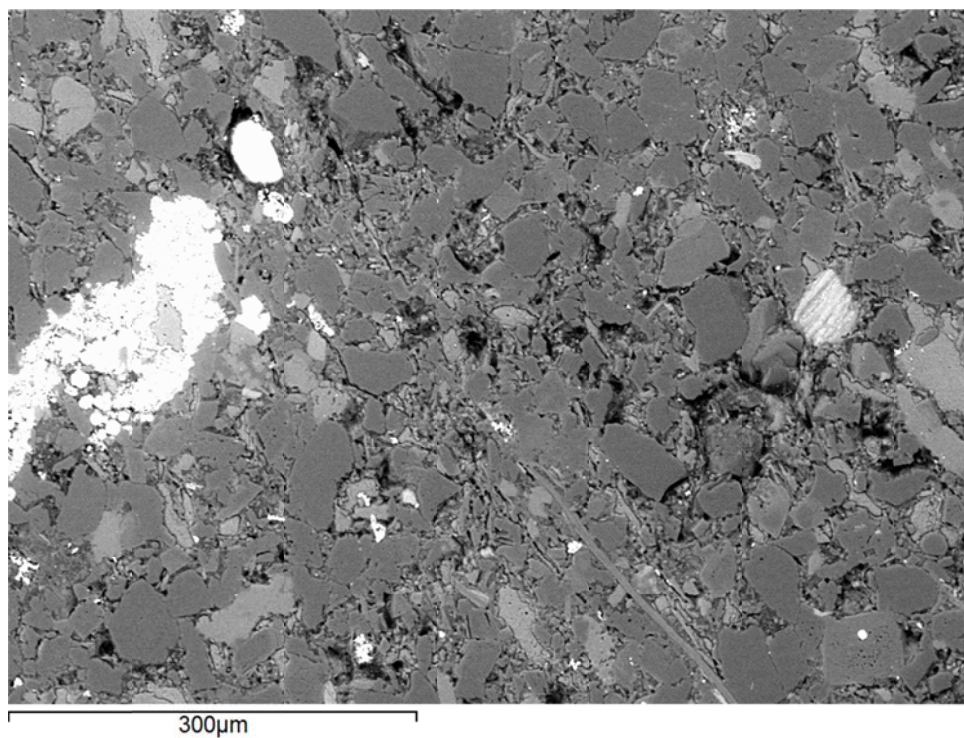
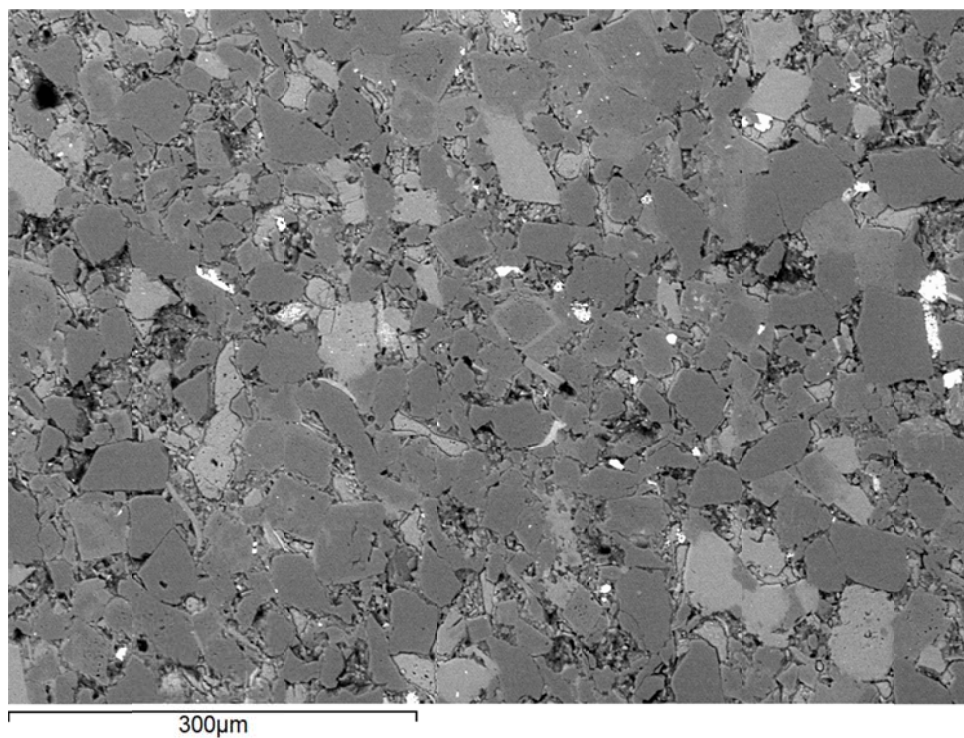
Mineral Phase	Mineral Phase
Calcite	Zircon
Dolomite	Albite
Quartz	Rutile
Pyrite	Apatite
Illite	Monazite
K-feldspar	

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified

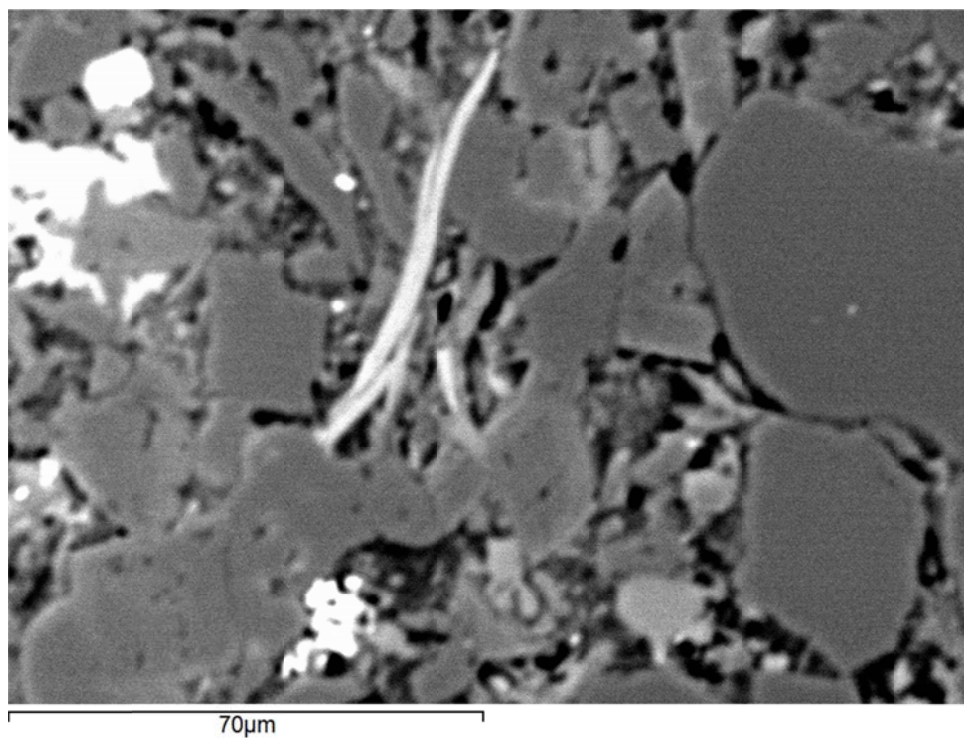
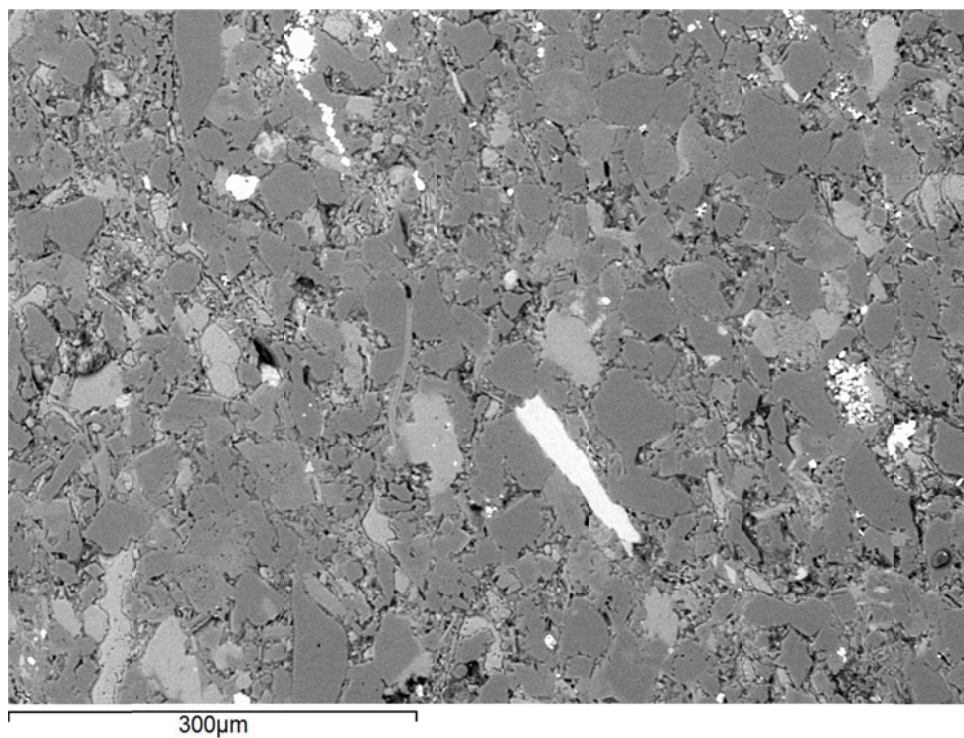


	Applied Geology Laboratory		ID: 117027
	Well Name: NDIC No. 20844	Middle Bakken 2	Grenora Field
	API No.: 33-105-02204-00-06	Lithology: Slightly calcareous, dolomitic siltstone	Depth: 10245.0'

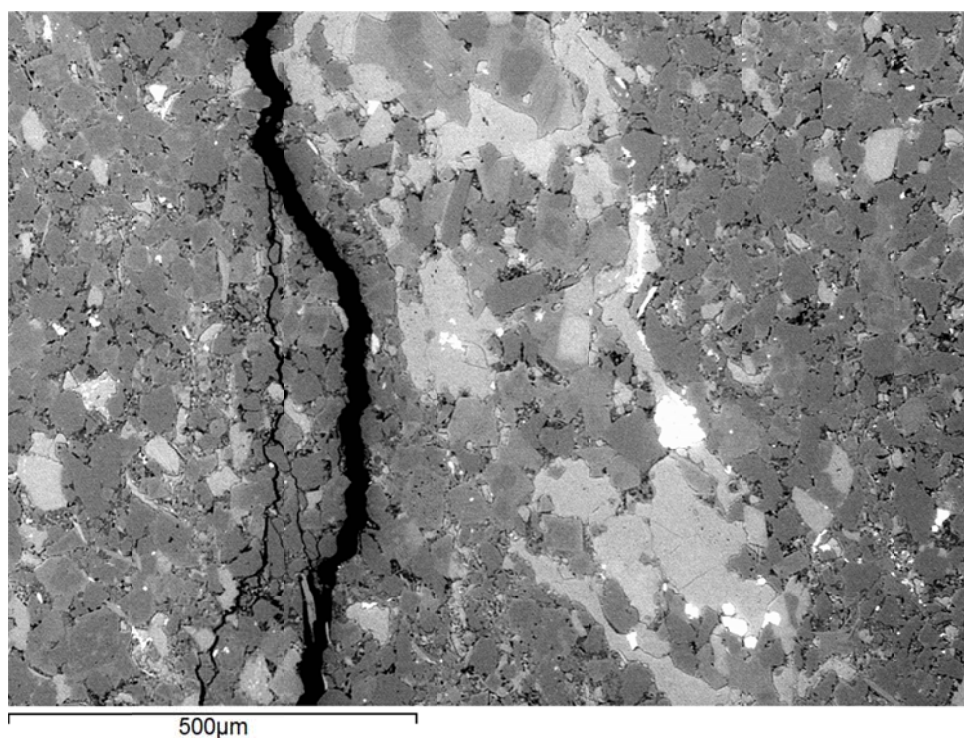
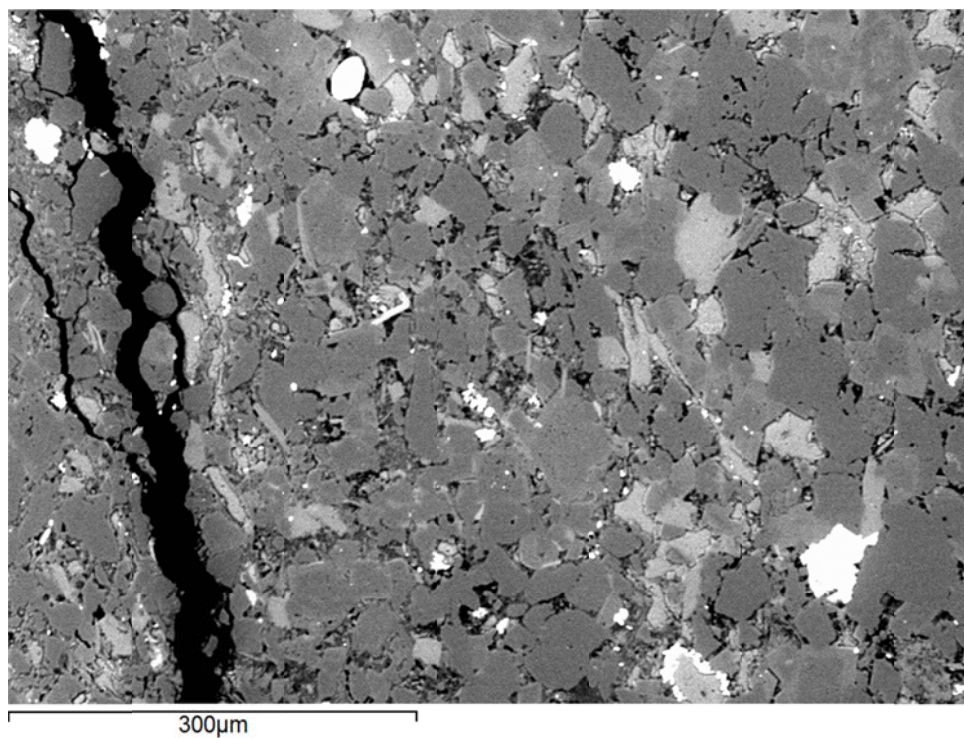
Additional High-Magnification BSE Images



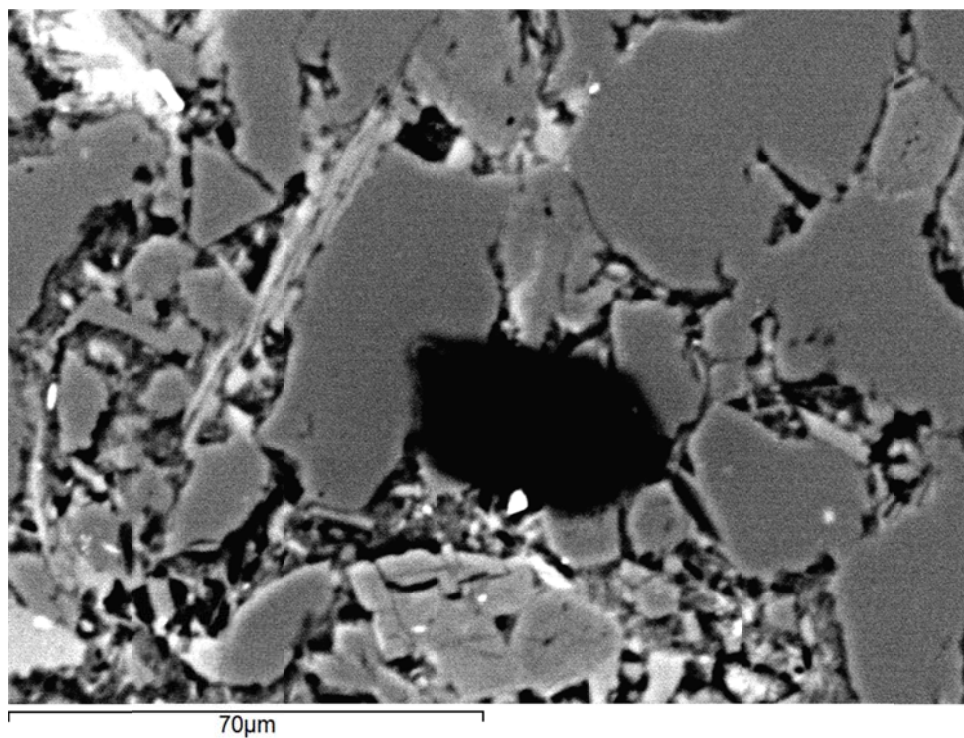
	Applied Geology Laboratory		ID: 117027
	Well Name: NDIC No. 20844	Middle Bakken 2	Grenora Field
	API No.: 33-105-02204-00-06	Lithology: Slightly calcareous, dolomitic siltstone	Depth: 10245.0'



	Applied Geology Laboratory		ID: 117027
	Well Name: NDIC No. 20844	Middle Bakken 2	Grenora Field
	API No.: 33-105-02204-00-06	Lithology: Slightly calcareous, dolomitic siltstone	Depth: 10245.0'

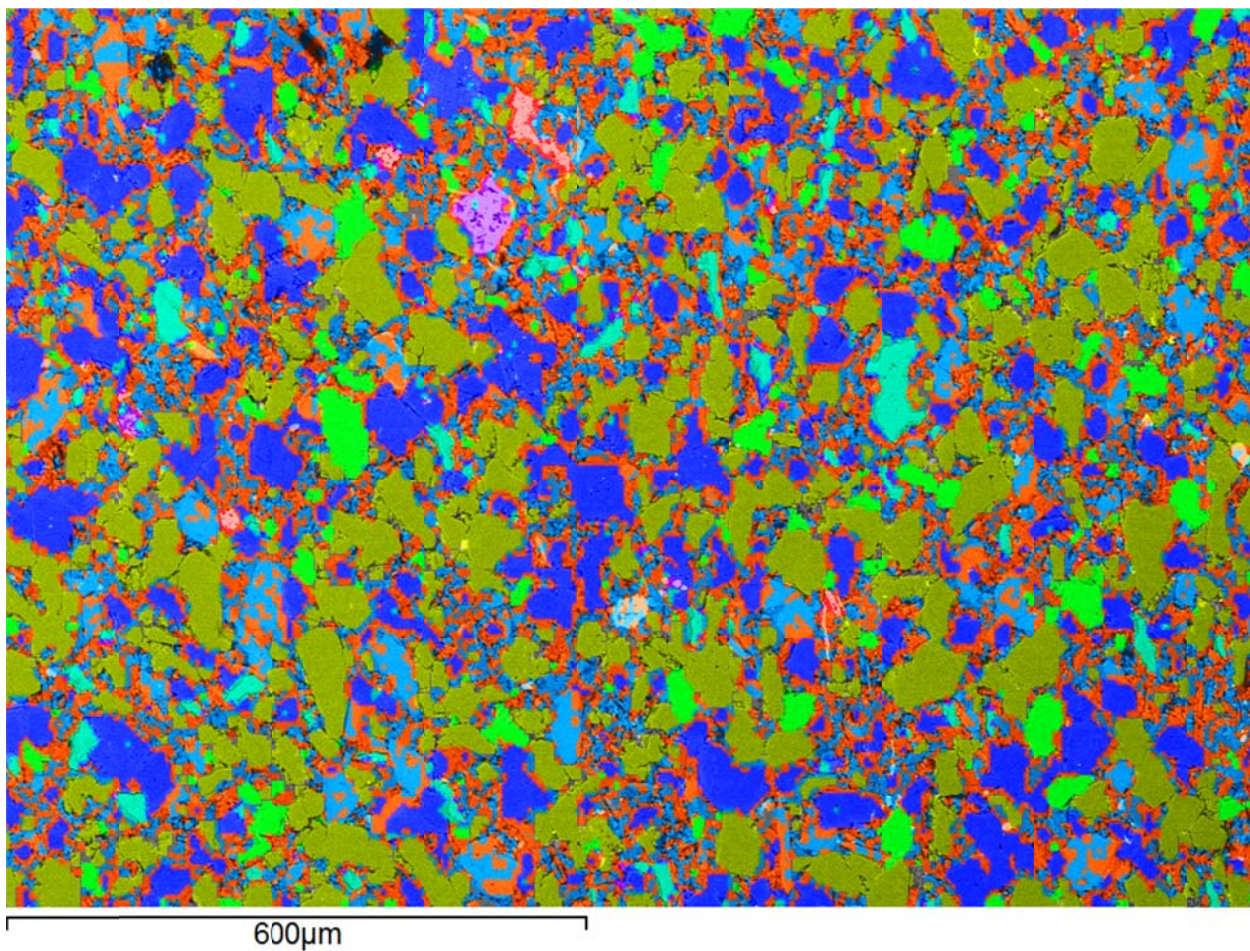


	Applied Geology Laboratory		ID: 117027
	Well Name: NDIC No. 20844	Middle Bakken 2	Grenora Field
	API No.: 33-105-02204-00-06	Lithology: Slightly calcareous, dolomitic siltstone	Depth: 10245.0'



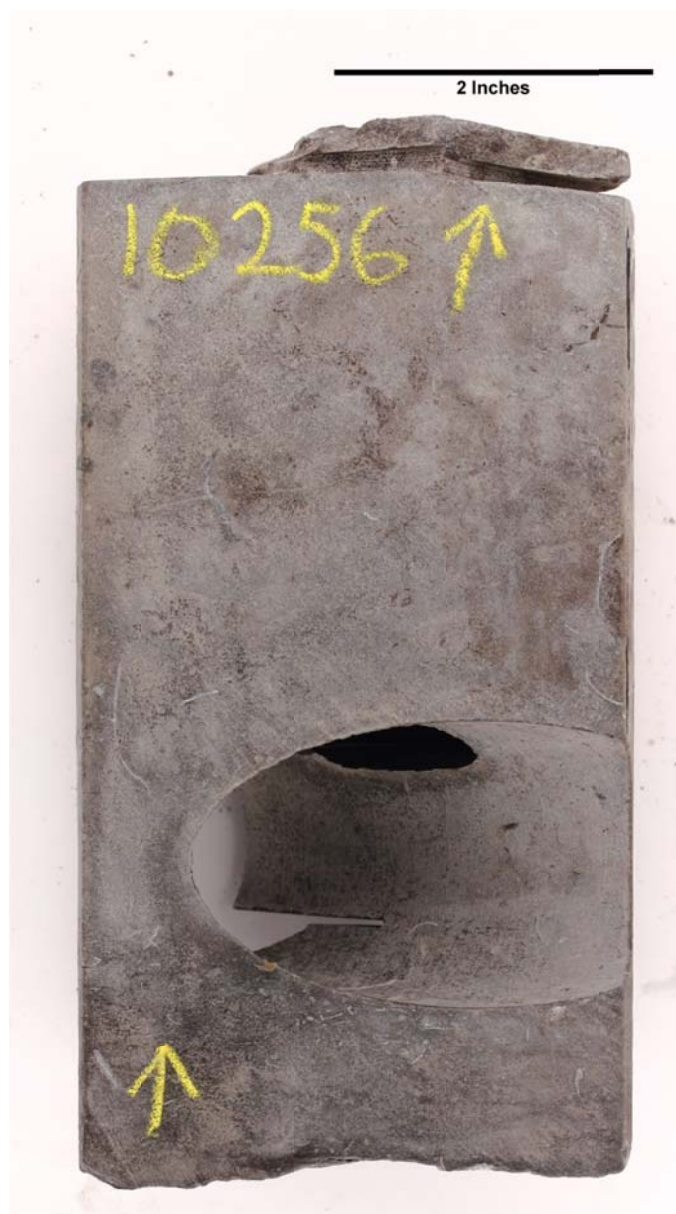
	Applied Geology Laboratory		ID: 117027
	Well Name: NDIC No. 20844	Middle Bakken 2	Grenora Field
	API No.: 33-105-02204-00-06	Lithology: Slightly calcareous, dolomitic siltstone	Depth: 10245.0'

SEM Mineral Map Image Overlaid on BSE Image with Mineral Phase 2D Area Percentages



	Applied Geology Laboratory		ID: 117030
	Well Name: NDIC No. 20844	Middle Bakken 1	Grenora Field
	API No.: 33-105-02204-00-09	Lithology: Silty, calcareous mudstone	Depth: 10256.0'

SAMPLE PHOTOGRAPH



PHYSICAL PROPERTIES

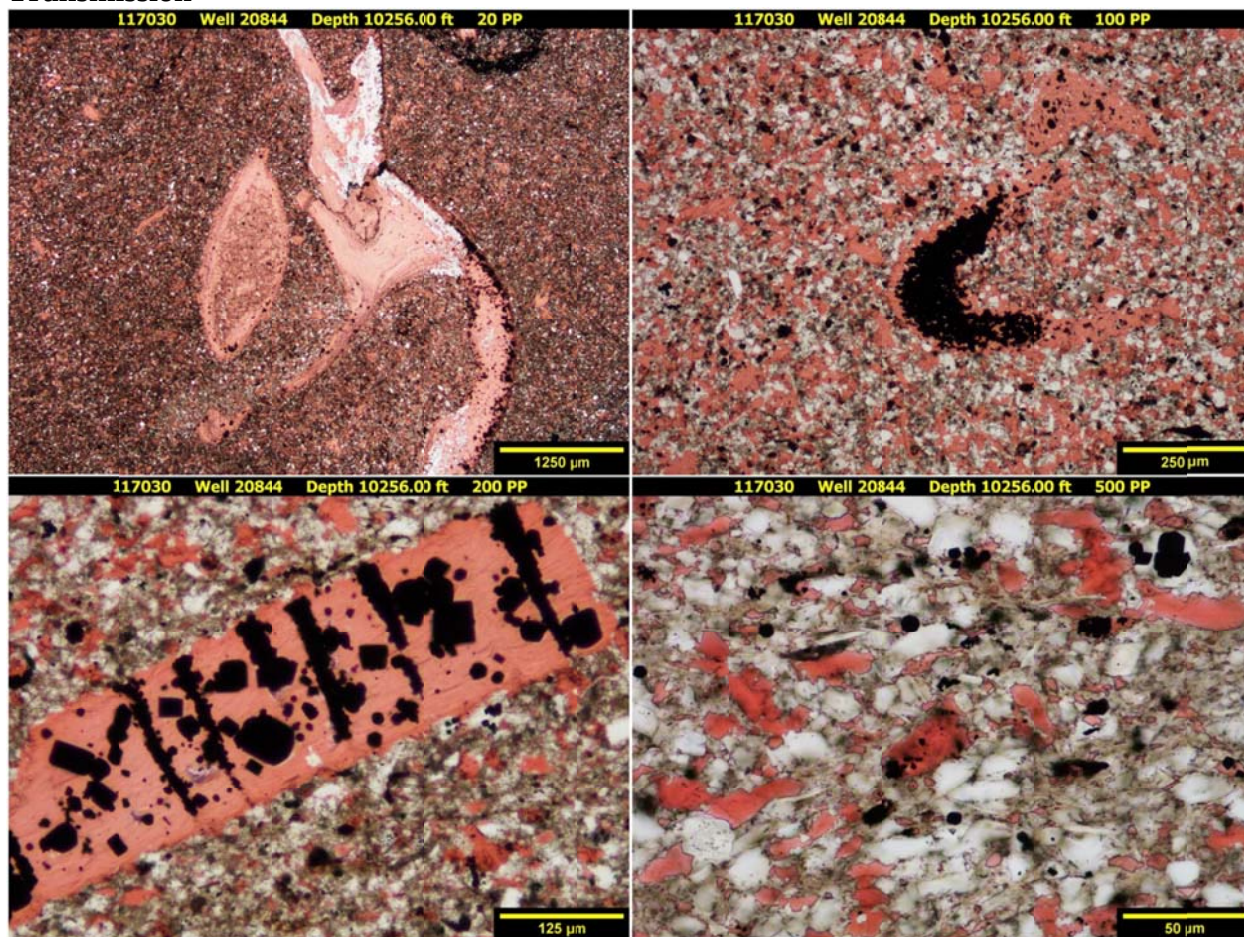
Porosity and Grain Density by Core Laboratories

Pycnometer Effective Porosity, vol%	Grain Density, g/cm ³
7.18	2.726

	Applied Geology Laboratory		ID: 117030
	Well Name: NDIC No. 20844	Middle Bakken 1	Grenora Field
	API No.: 33-105-02204-00-09	Lithology: Silty, calcareous mudstone	Depth: 10256.0'

PHOTOMICROGRAPHS

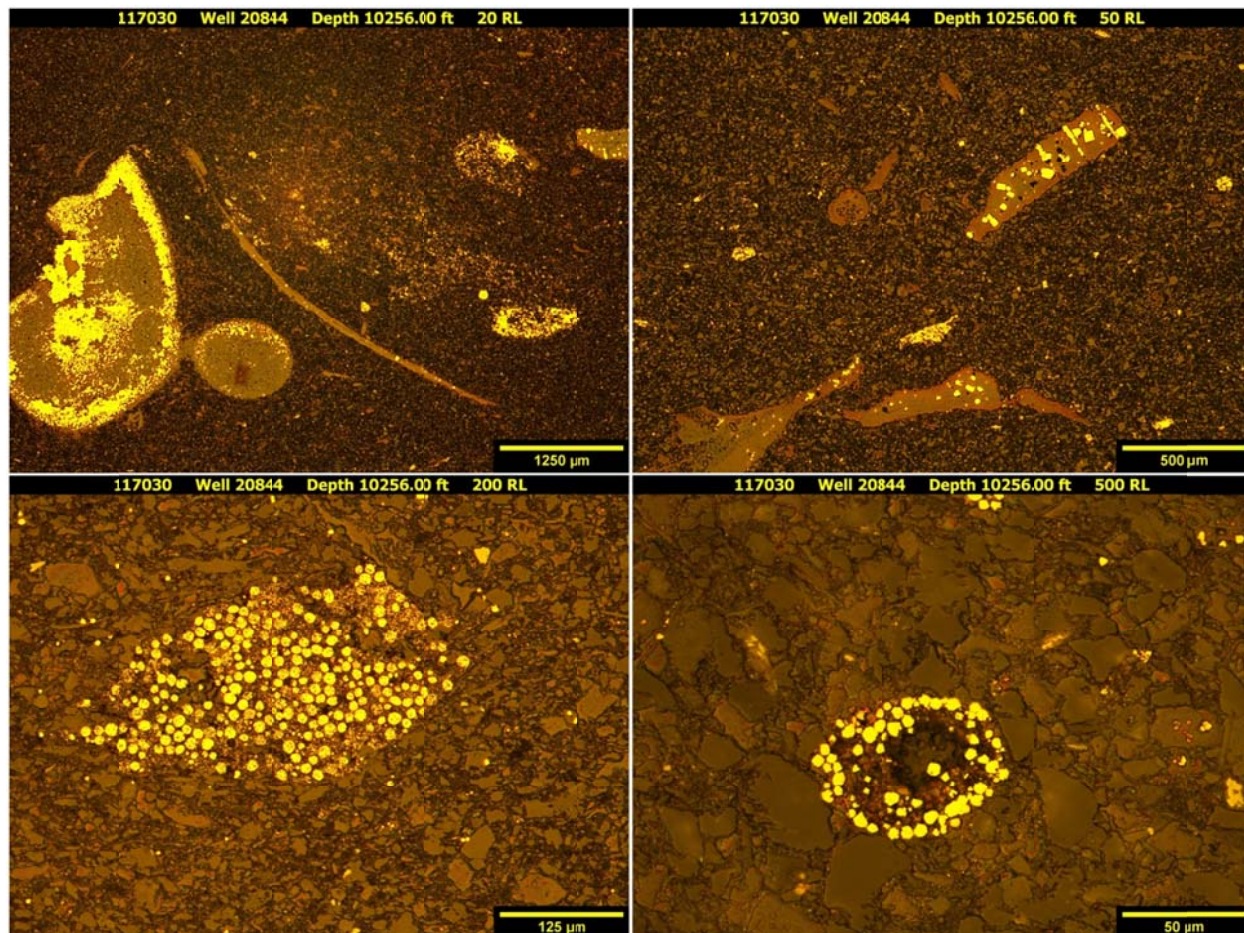
Transmission



The sample from a depth of 10256.00 ft shows a silty, calcareous mudstone. Rare burrowing and no laminations are observed, leaving a largely massive sample. Very fine grained, angular to subangular, monocrystalline quartz grains and trace amounts of muscovite and feldspars are disseminated throughout. Some anhedral to euhedral dolomitization has occurred throughout the sample. Fine-grained, crystalline dolomite occurs as replacement of precursor carbonate grains and mud. Abundant quantities of skeletal and non-skeletal grains remain. Disseminated pyrite provides pore filling and extensive selected allochem replacement. The matrix is composed of a combination of clays and micro to cryptocrystalline dolomite and calcite cement. Gypsum replacement is detected at the highest quantities of any sample within the set. Open fractures are detected and are likely because of the sampling process. Additional organics are observed as globular and lensing features typically associated with pyrite. Other than potential open fractures, no porosity is observed using standard petrographic techniques.

	Applied Geology Laboratory		ID: 117030
	Well Name: NDIC No. 20844	Middle Bakken 1	Grenora Field
	API No.: 33-105-02204-00-09	Lithology: Silty, calcareous mudstone	Depth: 10256.0'

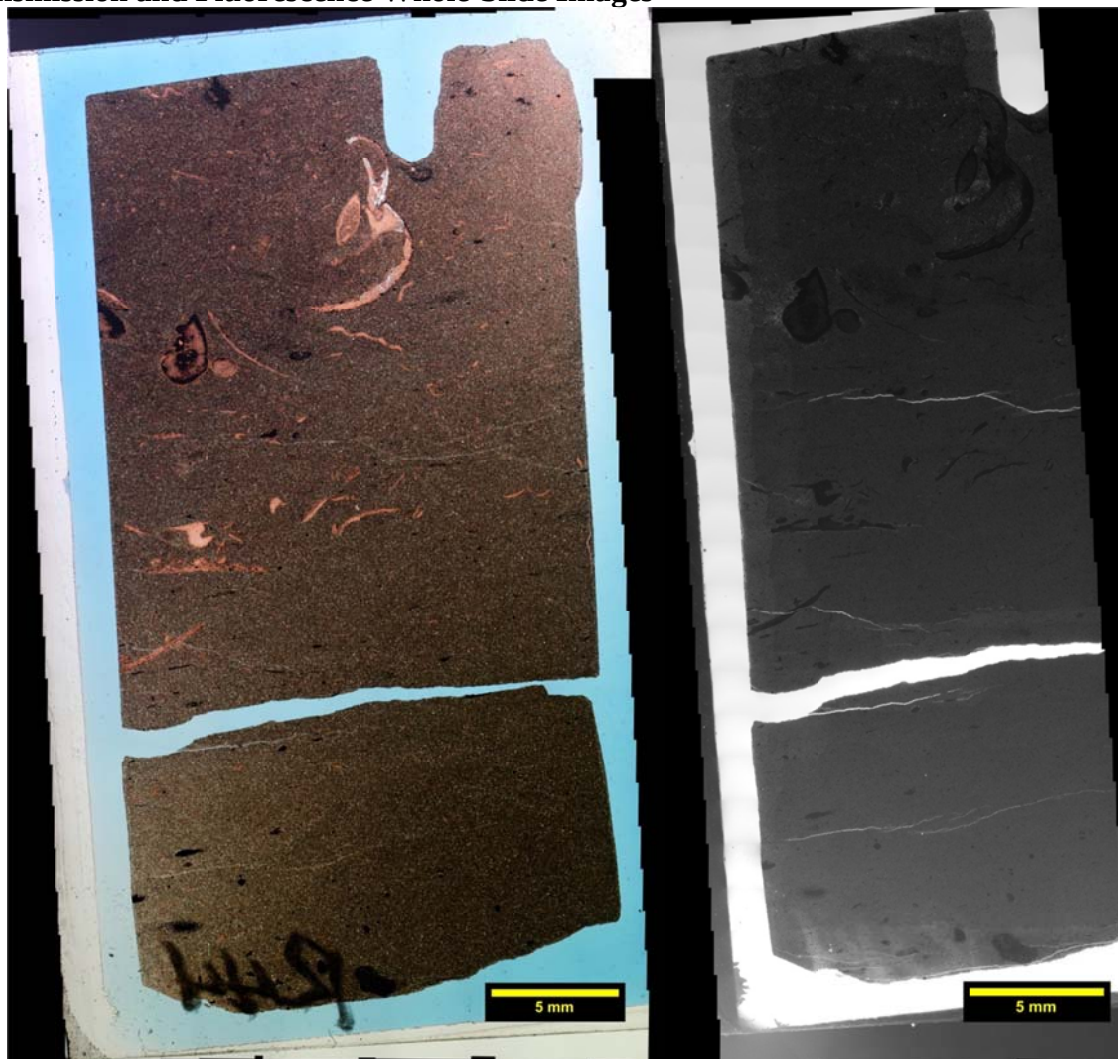
Reflection



The sample from a depth of 10256.00 ft displays both euhedral and framboidal pyrite grains. Within this sample, euhedral grains are typically replacing calcareous skeletal grains. Framboidal grains normally reside within precursor pore and organic spaces. Occasional aggregates of semi-mature framboidal pyrite spheres are observed. Partial to nearly complete pyritization of precursor grains and organics have occurred. Organics observed are typically associated with framboidal pyrite.

	Applied Geology Laboratory		ID: 117030
	Well Name: NDIC No. 20844	Middle Bakken 1	Grenora Field
	API No.: 33-105-02204-00-09	Lithology: Silty, calcareous mudstone	Depth: 10256.0'

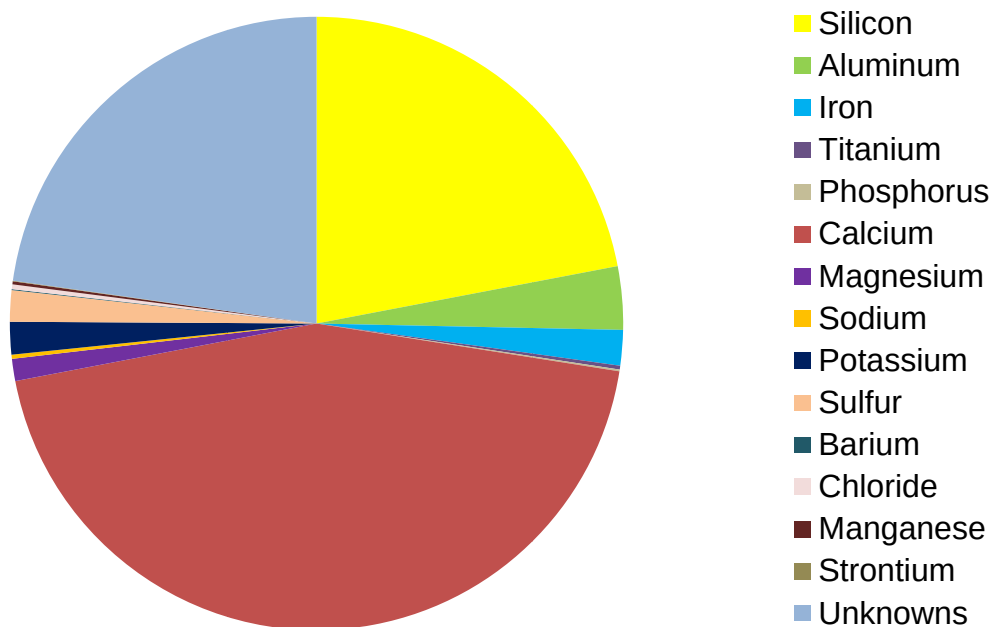
Transmission and Fluorescence Whole-Slide Images



The image collected from a depth of 10256.00 ft is a calcareous mudstone. It is a primarily massive sample containing fossils and displaying some burrowing structures. Effective porosity is reported at 7.18 vol%. A moderate amount of interlocking anhedral to rare euhedral dolomitization and rare pyritization has occurred. These diagenetic events along consistent, extremely fine grain sizes (except for skeletal and skeletal calcite grains and pyrite) and dispersed clay are limiting factors of pore size (under 30 μm) and distribution. The reported effective porosity of 7.18 vol% appears high based on the inverted epifluorescent image. No open natural fractures are observed. The fractures observed are likely the result of the sampling process. The noted fractures may depict areas of structural weakness as stress is applied.

	Applied Geology Laboratory		ID: 117030
	Well Name: NDIC No. 20844	Middle Bakken 1	Grenora Field
	API No.: 33-105-02204-00-09	Lithology: Silty, calcareous mudstone	Depth: 10256.0'

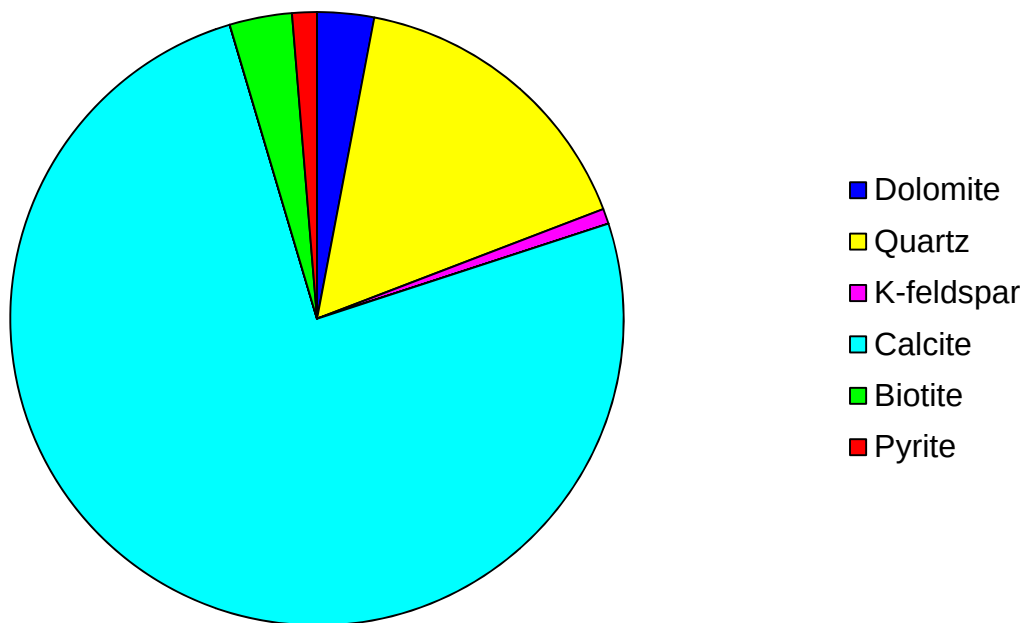
XRF BULK CHEMICAL COMPOSITION



Element	Reporting Convention (Oxide)	Weight %
Si (silicon)	SiO ₂	22.00
Al (aluminum)	Al ₂ O ₃	3.33
Fe (iron)	Fe ₂ O ₃	1.87
Ti (titanium)	TiO ₂	0.20
P (phosphorus)	P ₂ O ₅	0.09
Ca (calcium)	CaO	44.50
Mg (magnesium)	MgO	1.17
Na (sodium)	Na ₂ O	0.22
K (potassium)	K ₂ O	1.71
S (sulfur)	SO ₃	1.65
Ba (barium)	BaO	0.05
Cl (chloride)	Cl	0.25
Mn (manganese)	MnO	0.16
Sr (strontium)	SrO	0.03
Unknowns	Due to the presence of carbonates	22.77
Total		100.00

	Applied Geology Laboratory		ID: 117030
	Well Name: NDIC No. 20844	Middle Bakken 1	Grenora Field
	API No.: 33-105-02204-00-09	Lithology: Silty, calcareous mudstone	Depth: 10256.0'

XRD MINERAL PHASE DISTRIBUTION



Mineral Phase	Formula	Weight %
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	3.0
Quartz	SiO_2	16.2
K-feldspar	KAlSi_3O_8	0.8
Calcite	CaCO_3	75.5
Biotite	$\text{K}(\text{Mg,Fe})_3[(\text{OH})_2\text{AlSi}_3\text{O}_{10}]$	3.3
Pyrite	FeS_2	1.3

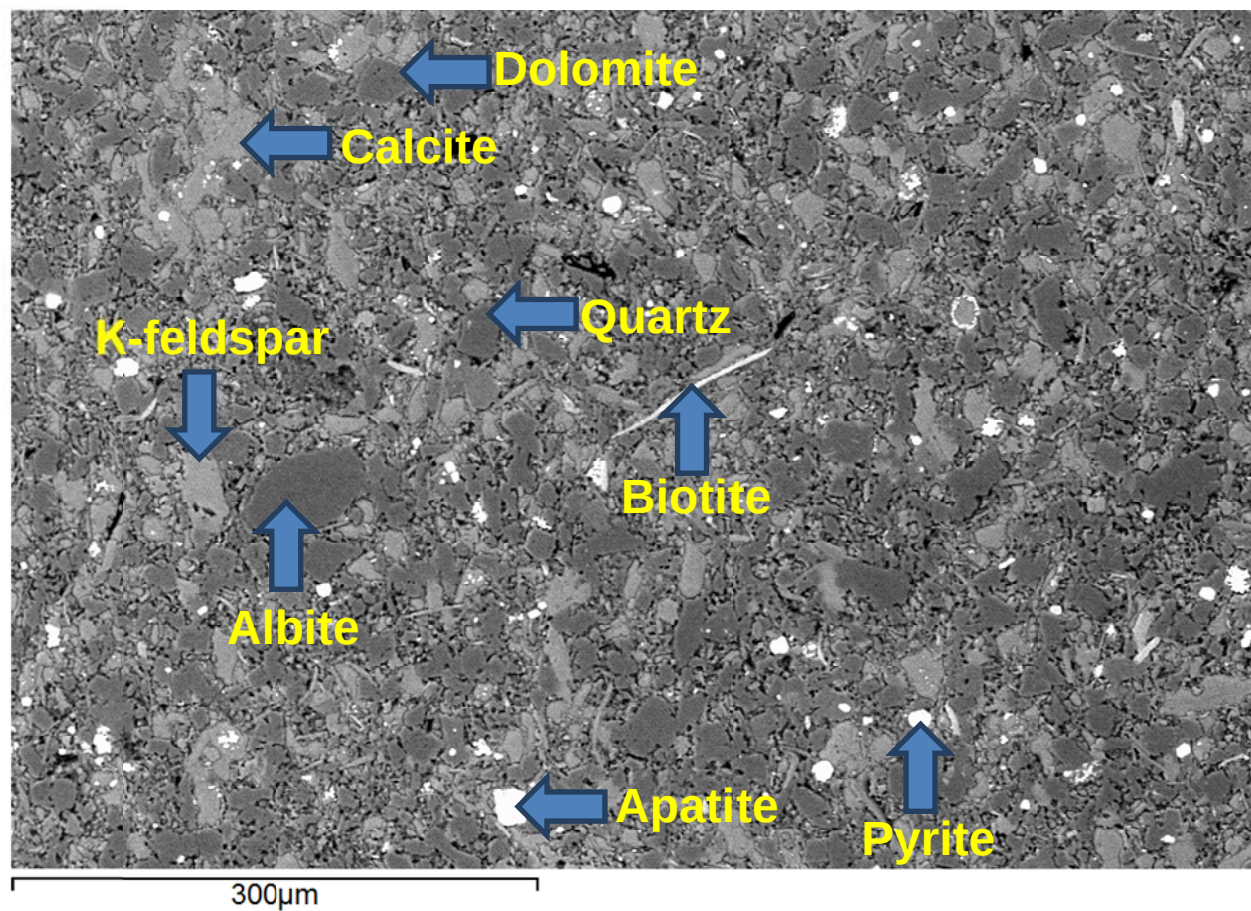
	Applied Geology Laboratory		ID: 117030
	Well Name: NDIC No. 20844	Middle Bakken 1	Grenora Field
	API No.: 33-105-02204-00-09	Lithology: Silty, calcareous mudstone	Depth: 10256.0'

SEM

Observed Minerals

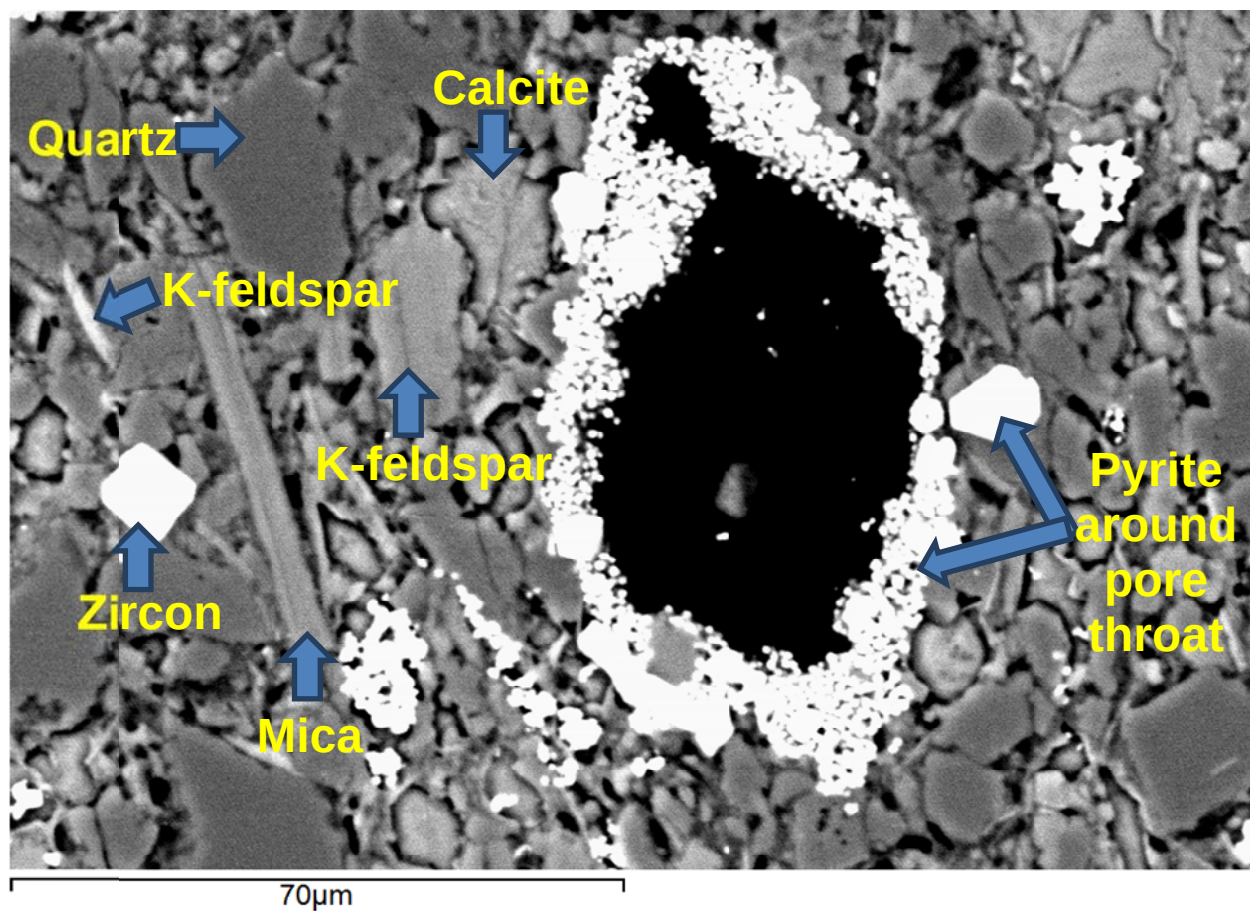
Mineral Phase	Mineral Phase
Calcite	K-feldspar
Dolomite	Rutile
Quartz	Albite
Pyrite	Zircon
Apatite	Biotite
Illite	Mica

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified



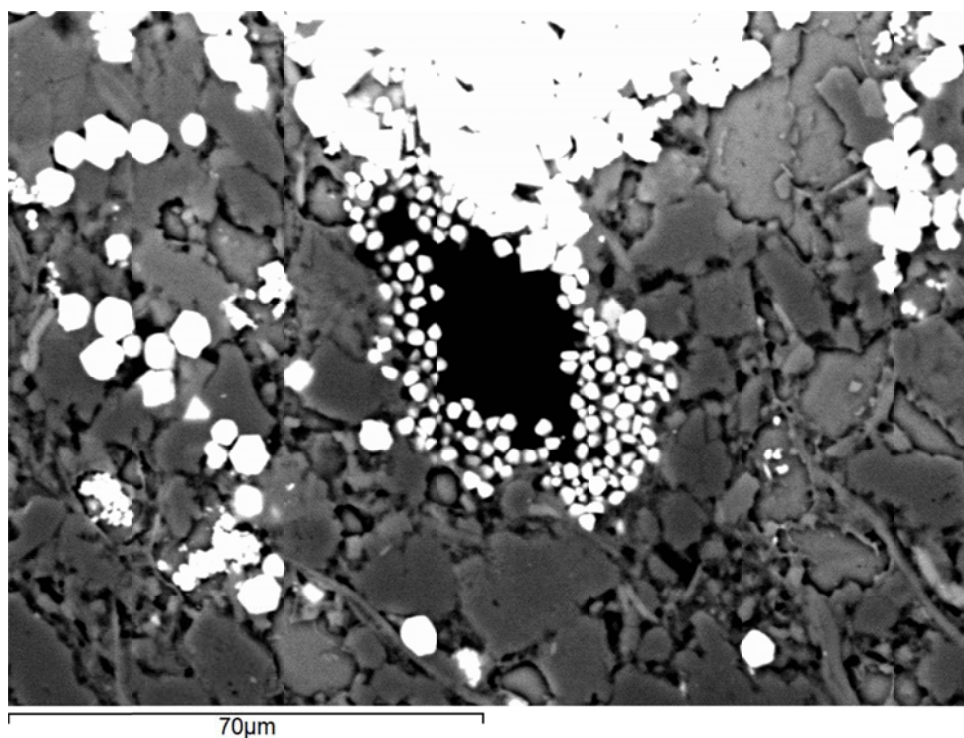
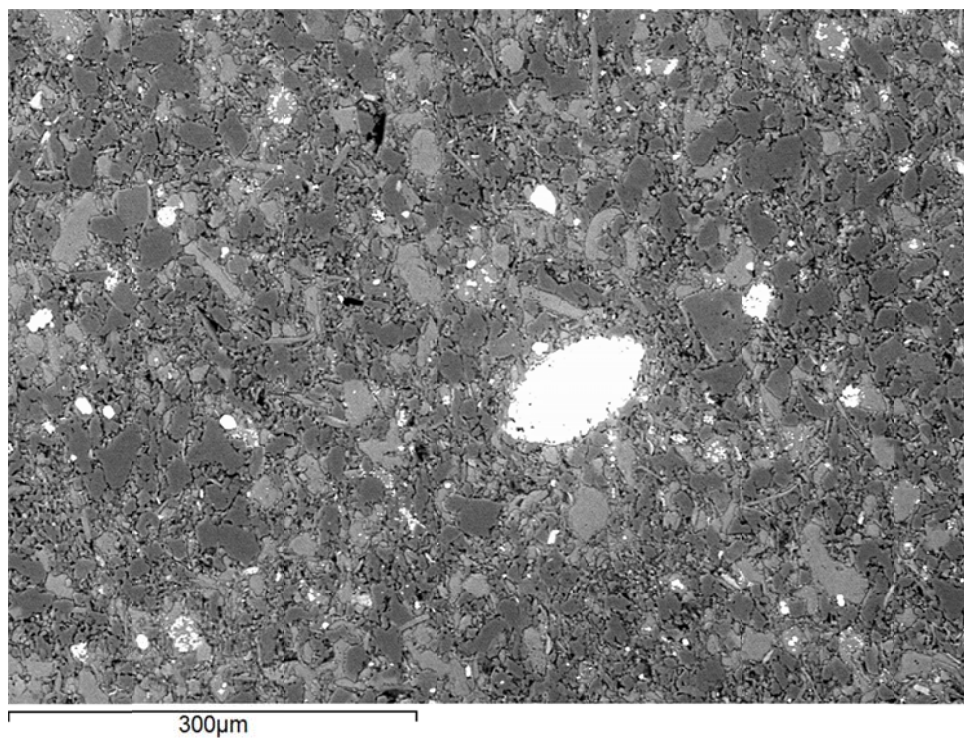
	Applied Geology Laboratory		ID: 117030
	Well Name: NDIC No. 20844	Middle Bakken 1	Grenora Field
	API No.: 33-105-02204-00-09	Lithology: Silty, calcareous mudstone	Depth: 10256.0'

Additional High-Magnification BSE Image of Interest Annotated with Examples of Mineral Phases Identified

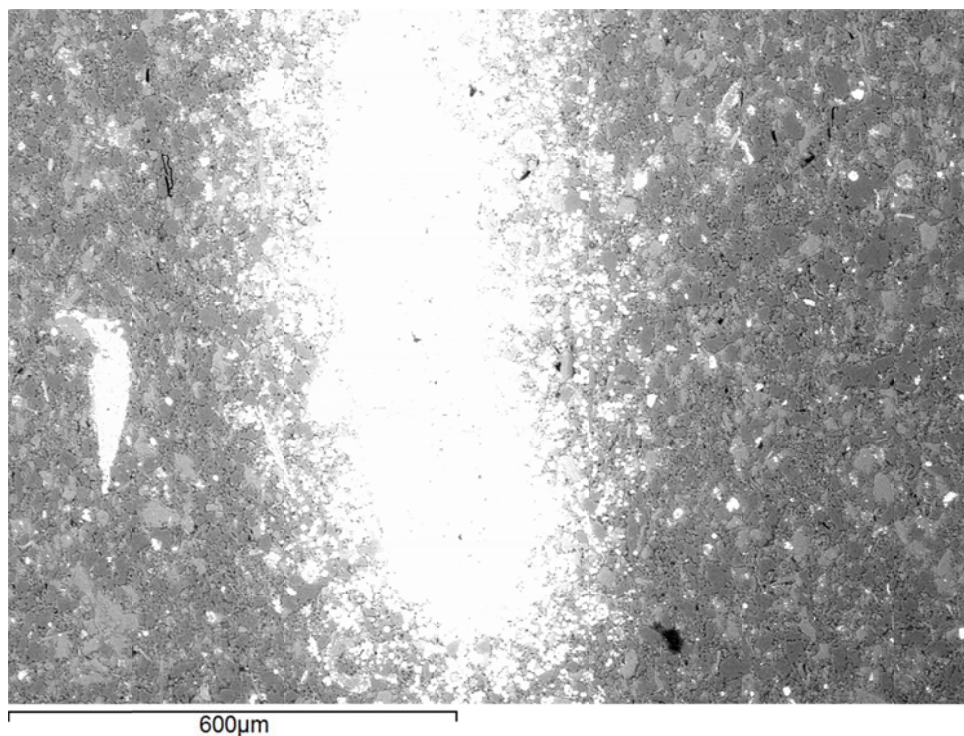
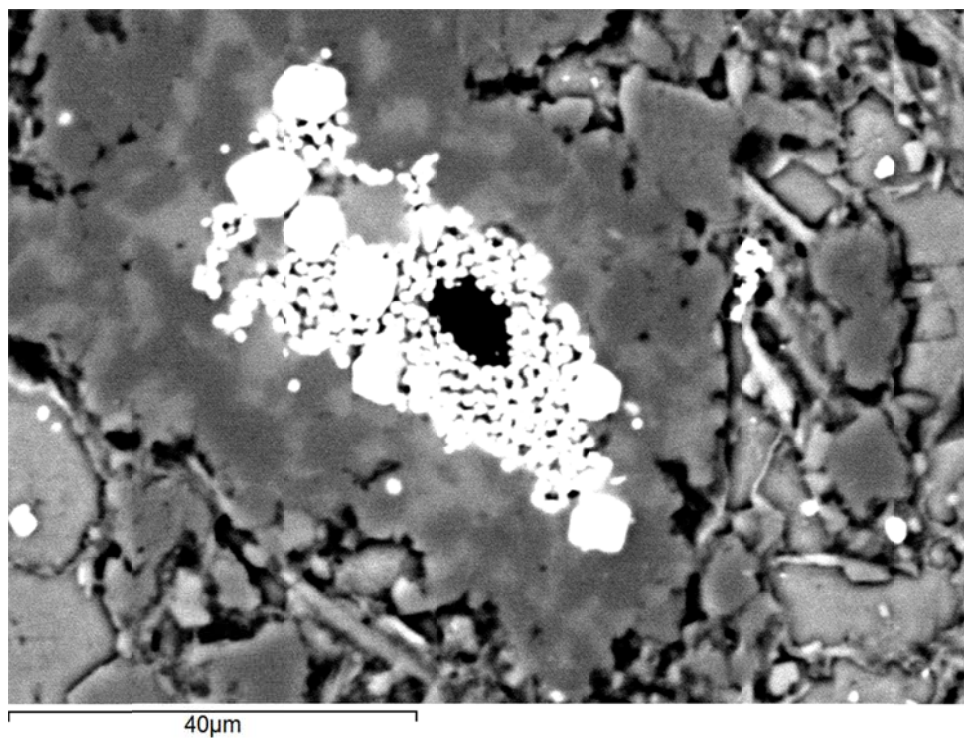


	Applied Geology Laboratory		ID: 117030
	Well Name: NDIC No. 20844	Middle Bakken 1	Grenora Field
	API No.: 33-105-02204-00-09	Lithology: Silty, calcareous mudstone	Depth: 10256.0'

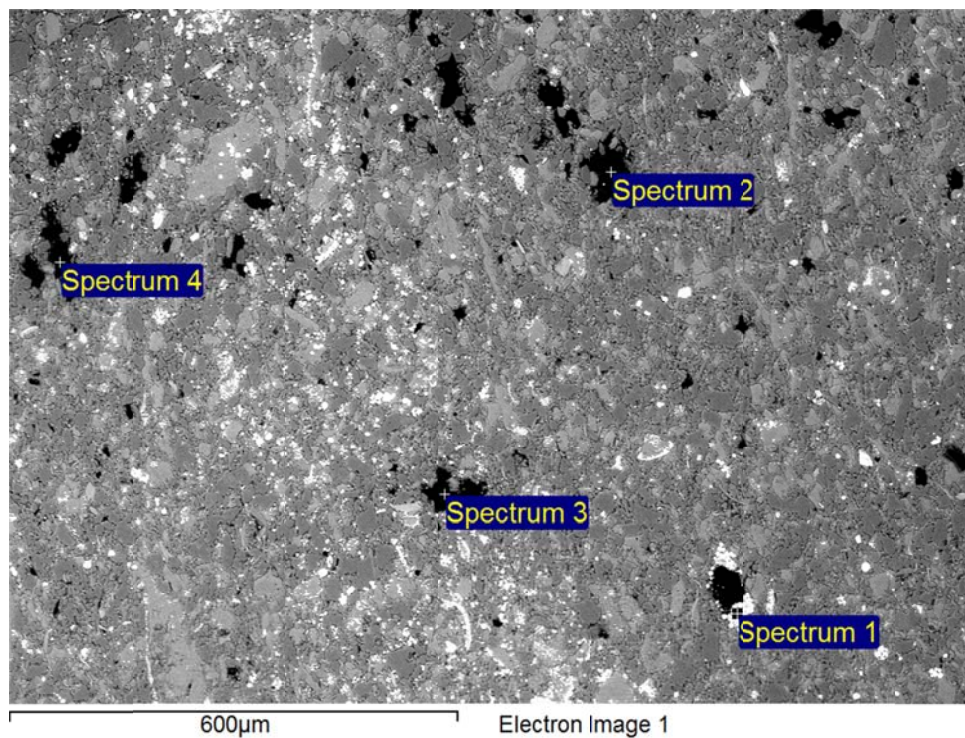
Additional High-Magnification BSE Images



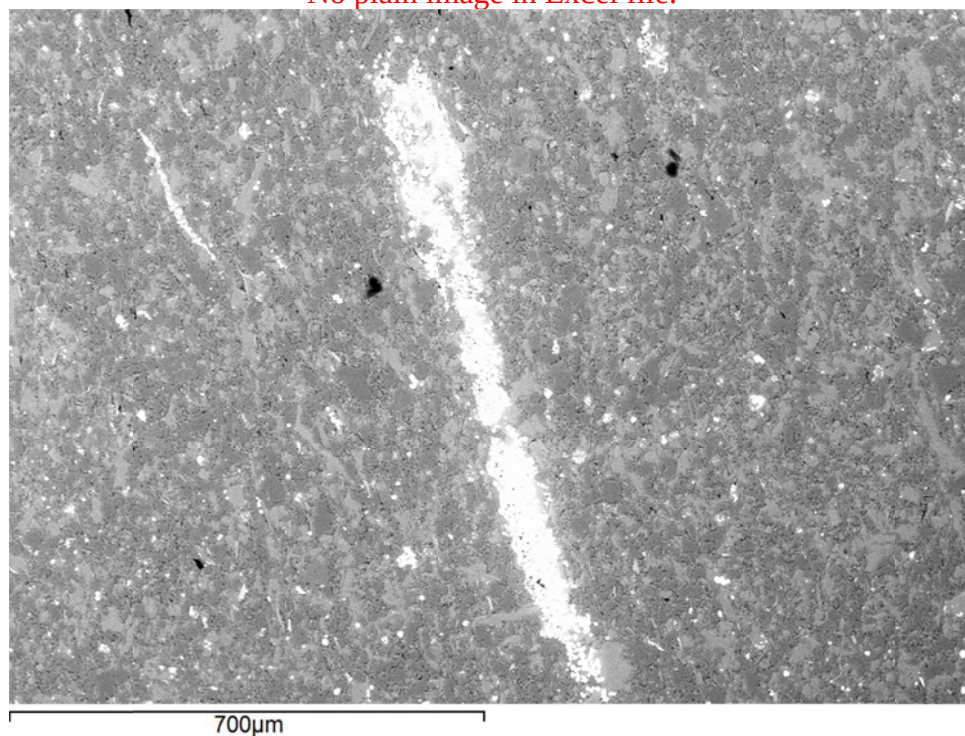
	Applied Geology Laboratory		ID: 117030
	Well Name: NDIC No. 20844	Middle Bakken 1	Grenora Field
	API No.: 33-105-02204-00-09	Lithology: Silty, calcareous mudstone	Depth: 10256.0'



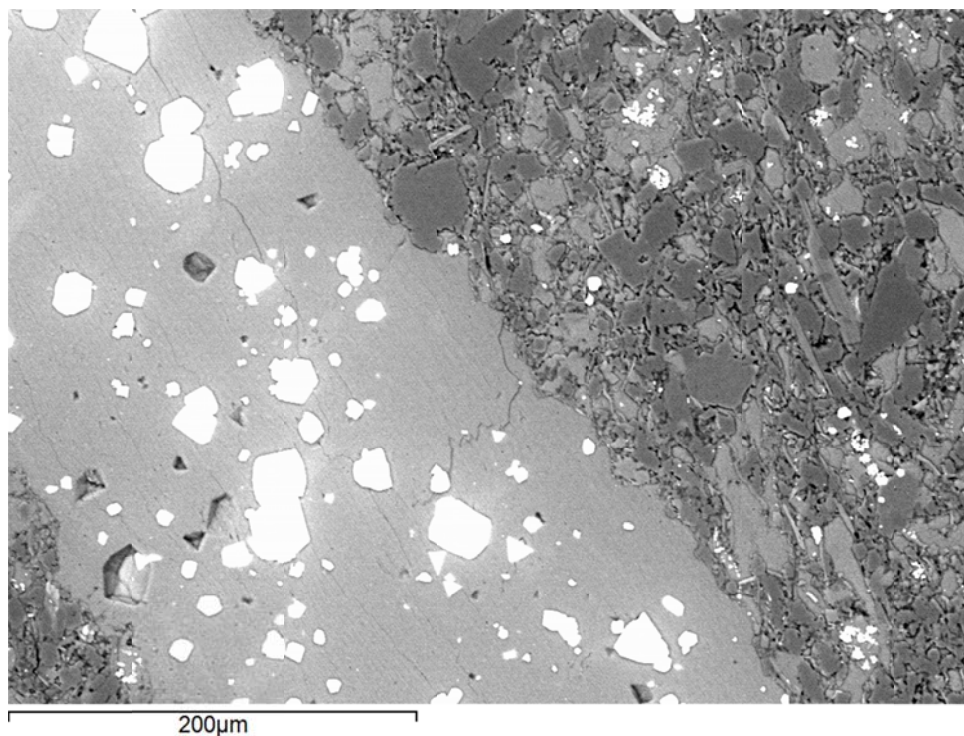
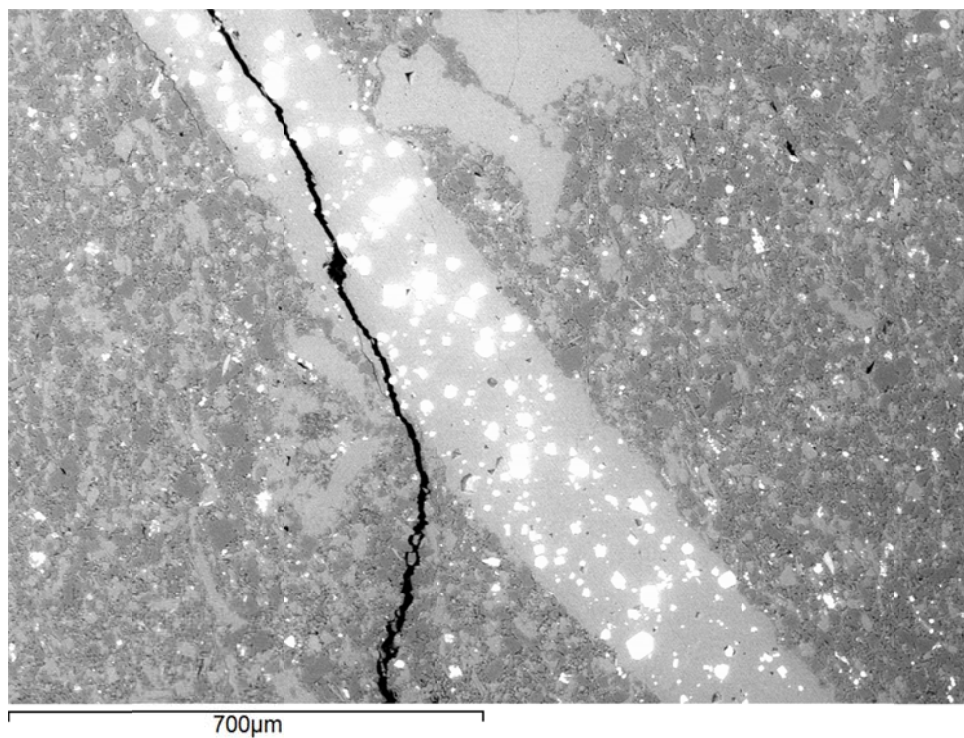
	Applied Geology Laboratory		ID: 117030
	Well Name: NDIC No. 20844	Middle Bakken 1	Grenora Field
	API No.: 33-105-02204-00-09	Lithology: Silty, calcareous mudstone	Depth: 10256.0'



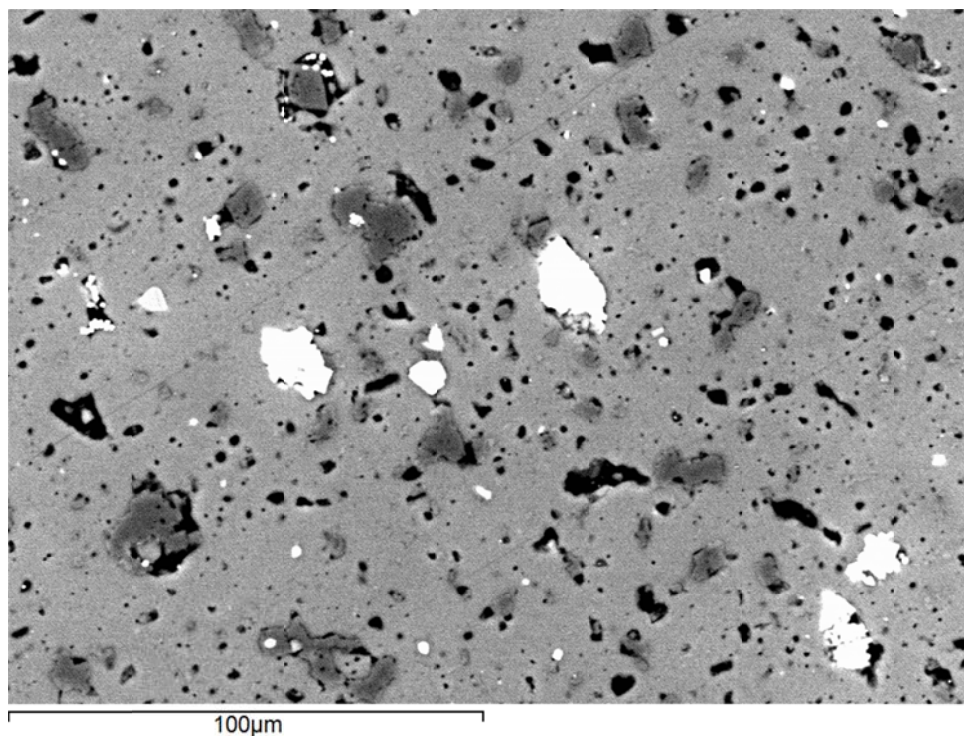
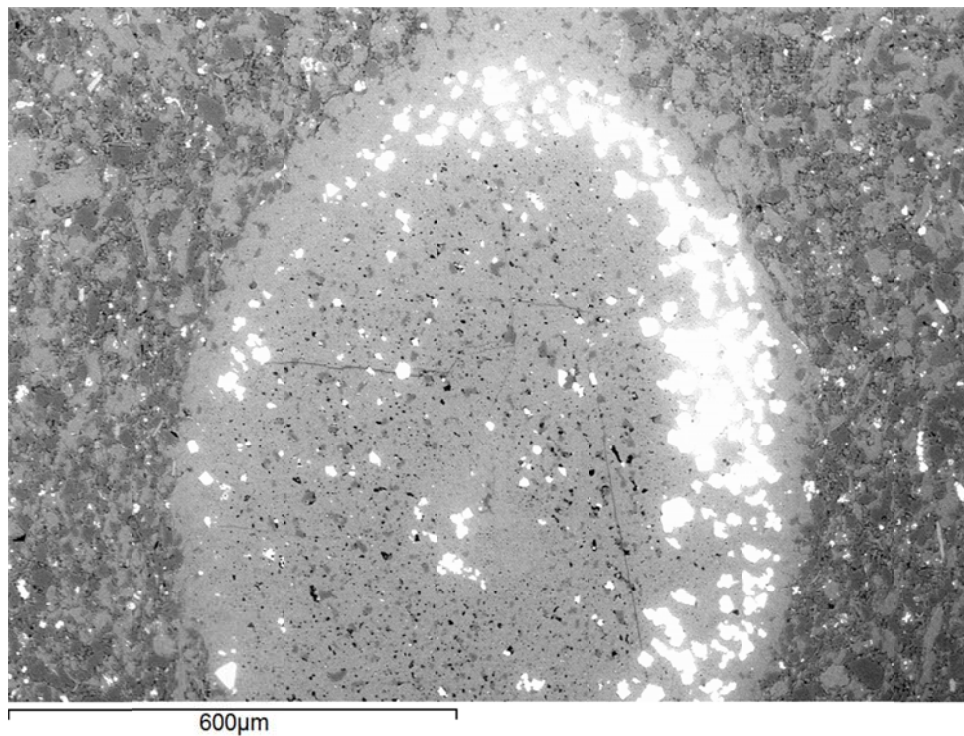
No plain image in Excel file.



	Applied Geology Laboratory		ID: 117030
	Well Name: NDIC No. 20844	Middle Bakken 1	Grenora Field
	API No.: 33-105-02204-00-09	Lithology: Silty, calcareous mudstone	Depth: 10256.0'

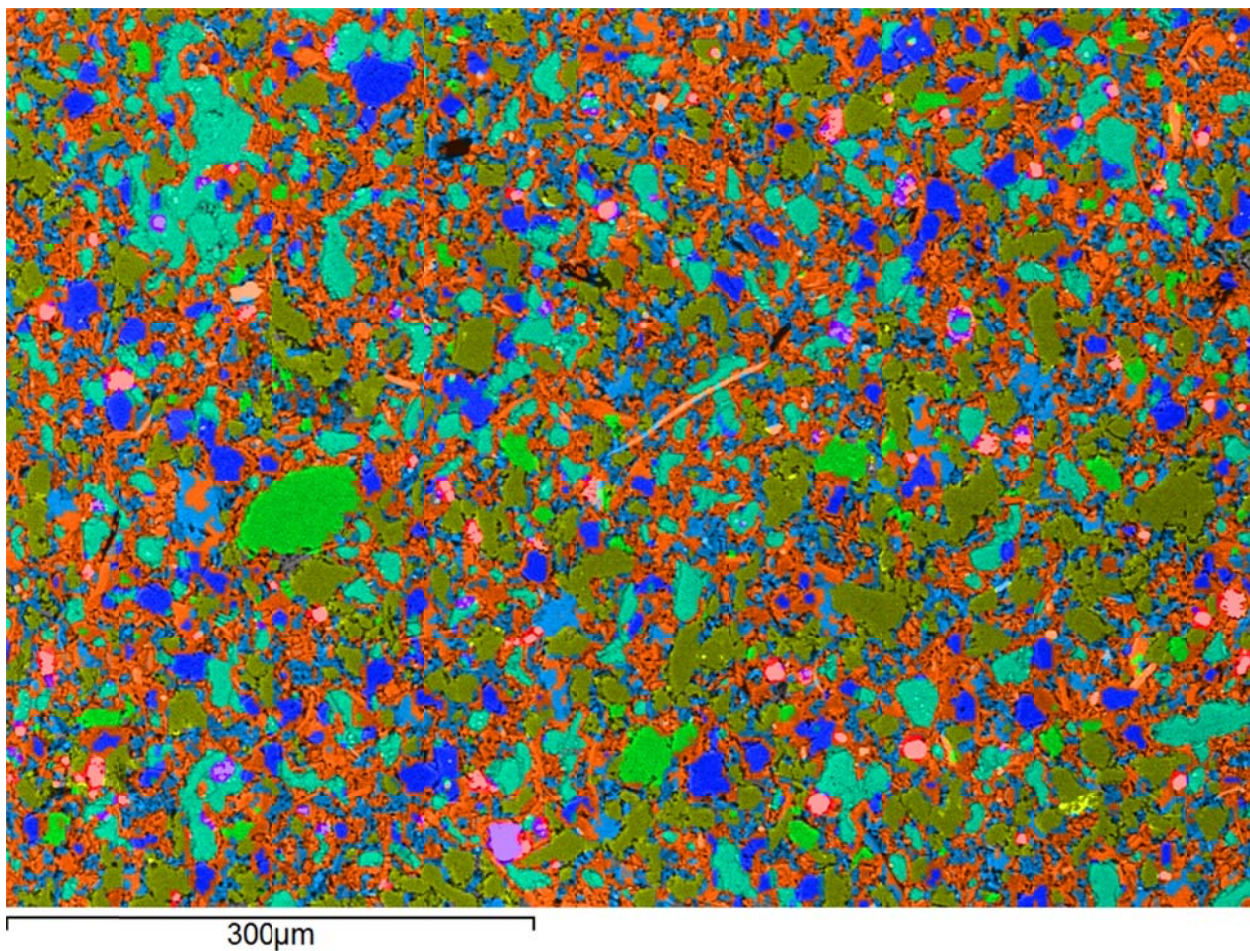


	Applied Geology Laboratory		ID: 117030
	Well Name: NDIC No. 20844	Middle Bakken 1	Grenora Field
	API No.: 33-105-02204-00-09	Lithology: Silty, calcareous mudstone	Depth: 10256.0'



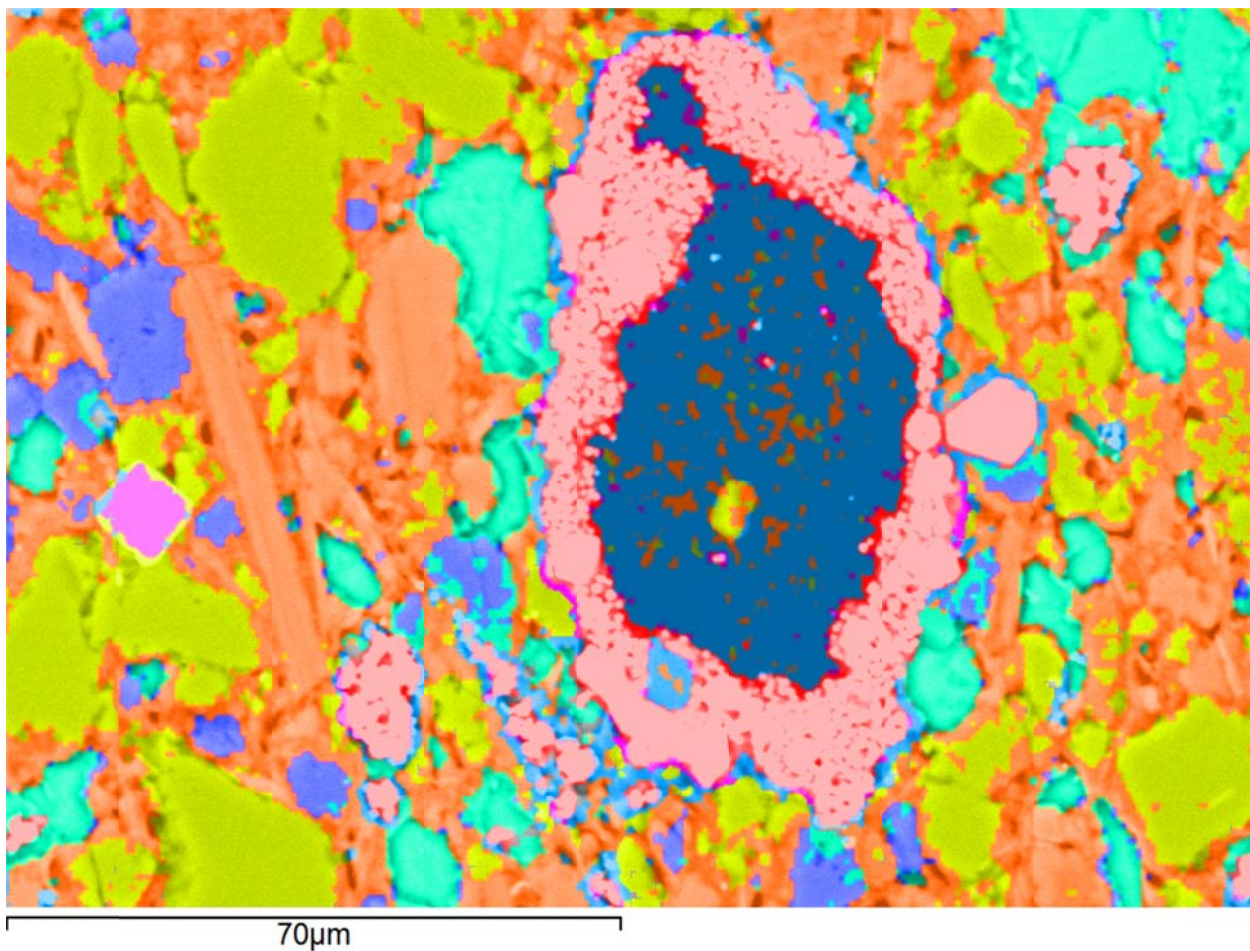
	Applied Geology Laboratory		ID: 117030
	Well Name: NDIC No. 20844	Middle Bakken 1	Grenora Field
	API No.: 33-105-02204-00-09	Lithology: Silty, calcareous mudstone	Depth: 10256.0'

SEM Mineral Map Image Overlaid on BSE Image with Mineral Phase 2D Area Percentages



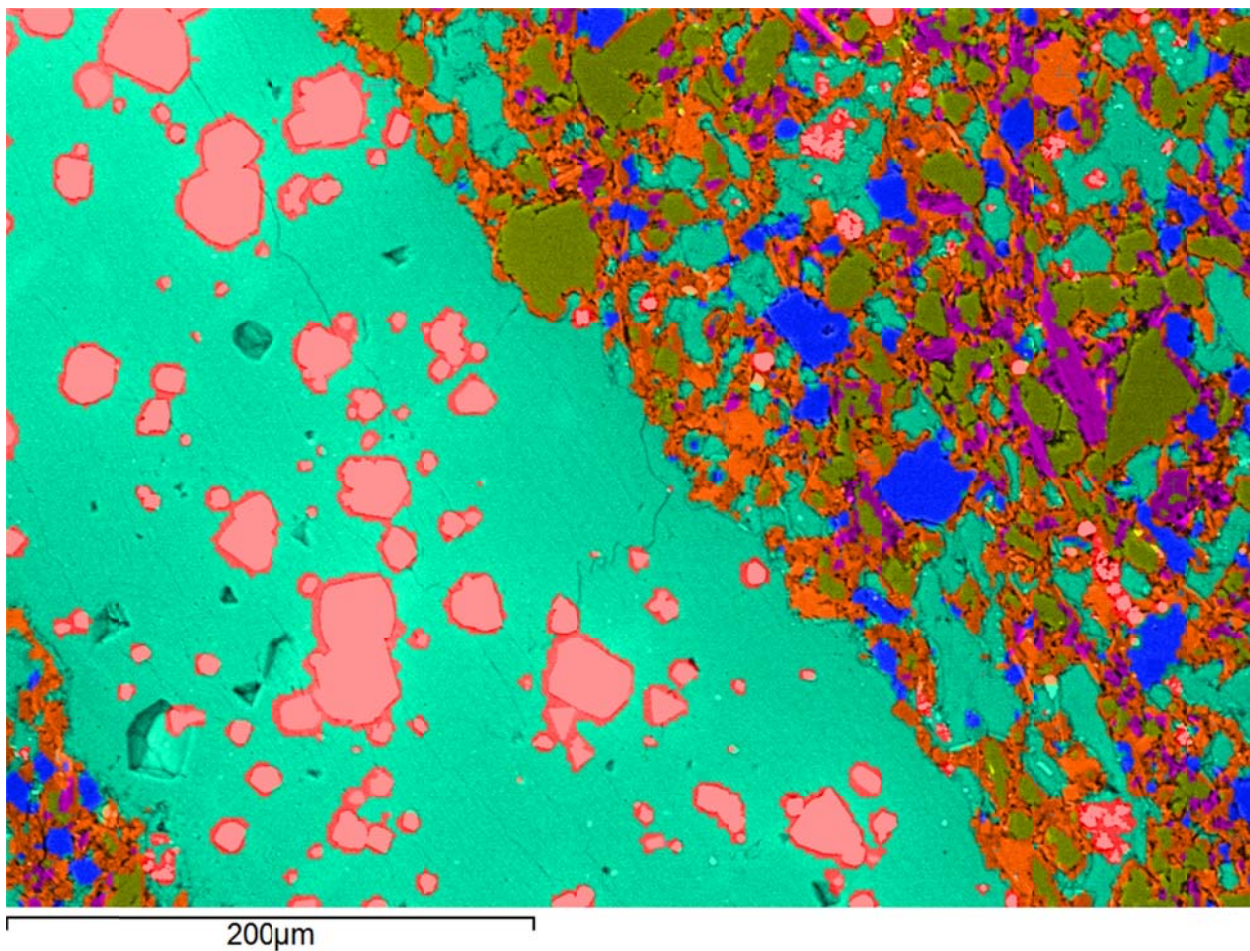
	Applied Geology Laboratory		ID: 117030
	Well Name: NDIC No. 20844	Middle Bakken 1	Grenora Field
	API No.: 33-105-02204-00-09	Lithology: Silty, calcareous mudstone	Depth: 10256.0'

Additional SEM Mineral Map Image Overlaid on BSE Image with Mineral Phase 2D Area Percentages



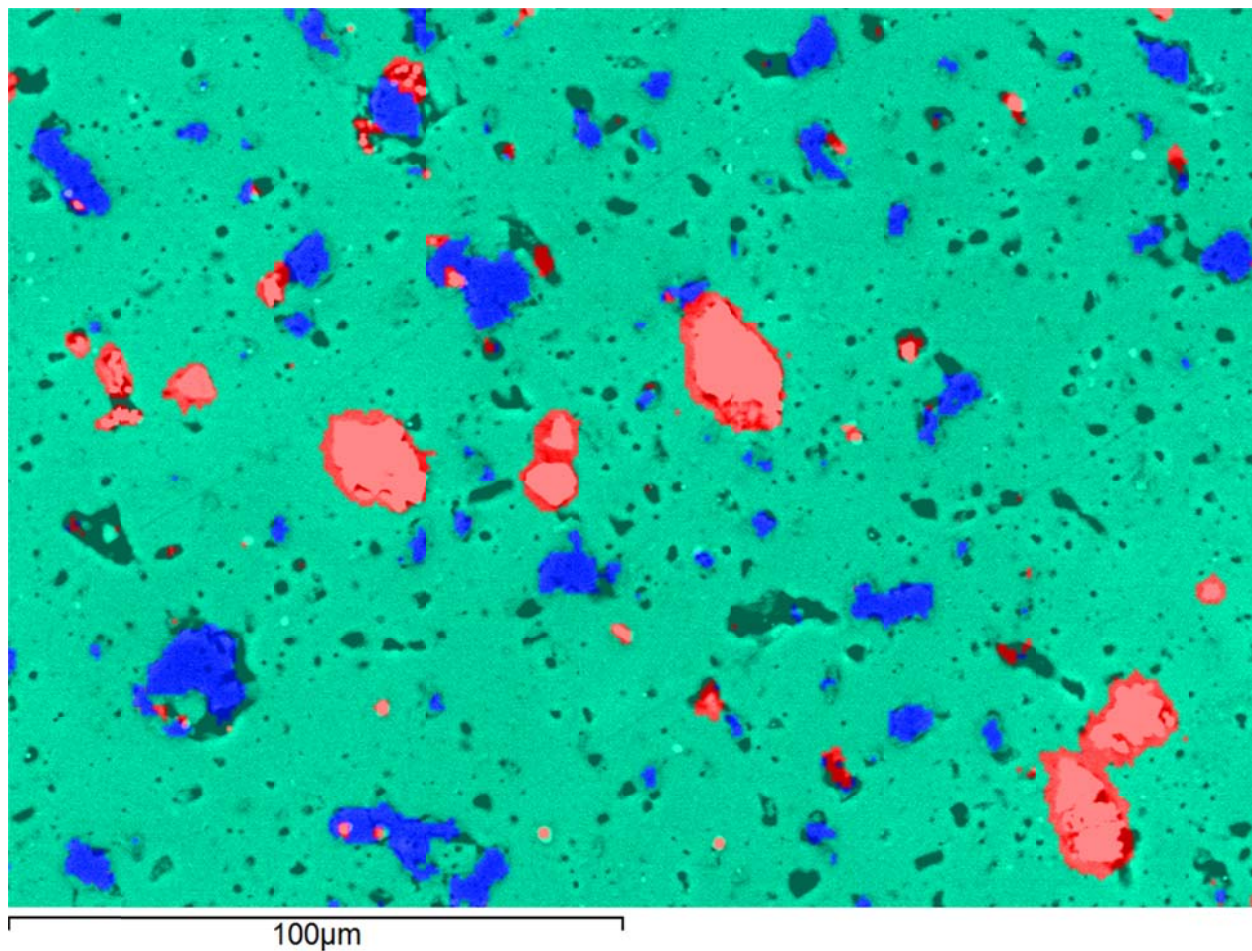
	Applied Geology Laboratory		ID: 117030
	Well Name: NDIC No. 20844	Middle Bakken 1	Grenora Field
	API No.: 33-105-02204-00-09	Lithology: Silty, calcareous mudstone	Depth: 10256.0'

Additional SEM Mineral Map Image Overlaid on BSE Image with Mineral Phase 2D Area Percentages



	Applied Geology Laboratory		ID: 117030
	Well Name: NDIC No. 20844	Middle Bakken 1	Grenora Field
	API No.: 33-105-02204-00-09	Lithology: Silty, calcareous mudstone	Depth: 10256.0'

Additional SEM Mineral Map Image Overlaid on BSE Image with Mineral Phase 2D Area Percentages



APPENDIX B

DUNN COUNTY DATA SHEETS

	Applied Geology Laboratory		ID: 116218
	Middle Bakken 5	NDIC Well 8709, Burbank BIA 23-8	Depth: 10545.0'
	American Petroleum Institute (API) No.: 33025002320000	Lithology: Argillaceous to dolomitic siltstone	

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION



Depth 10545.0': Displays interbeds of undulatory medium to dark grey shale and siltstone expressing areas of concentrated bioturbation.

PHYSICAL PROPERTIES

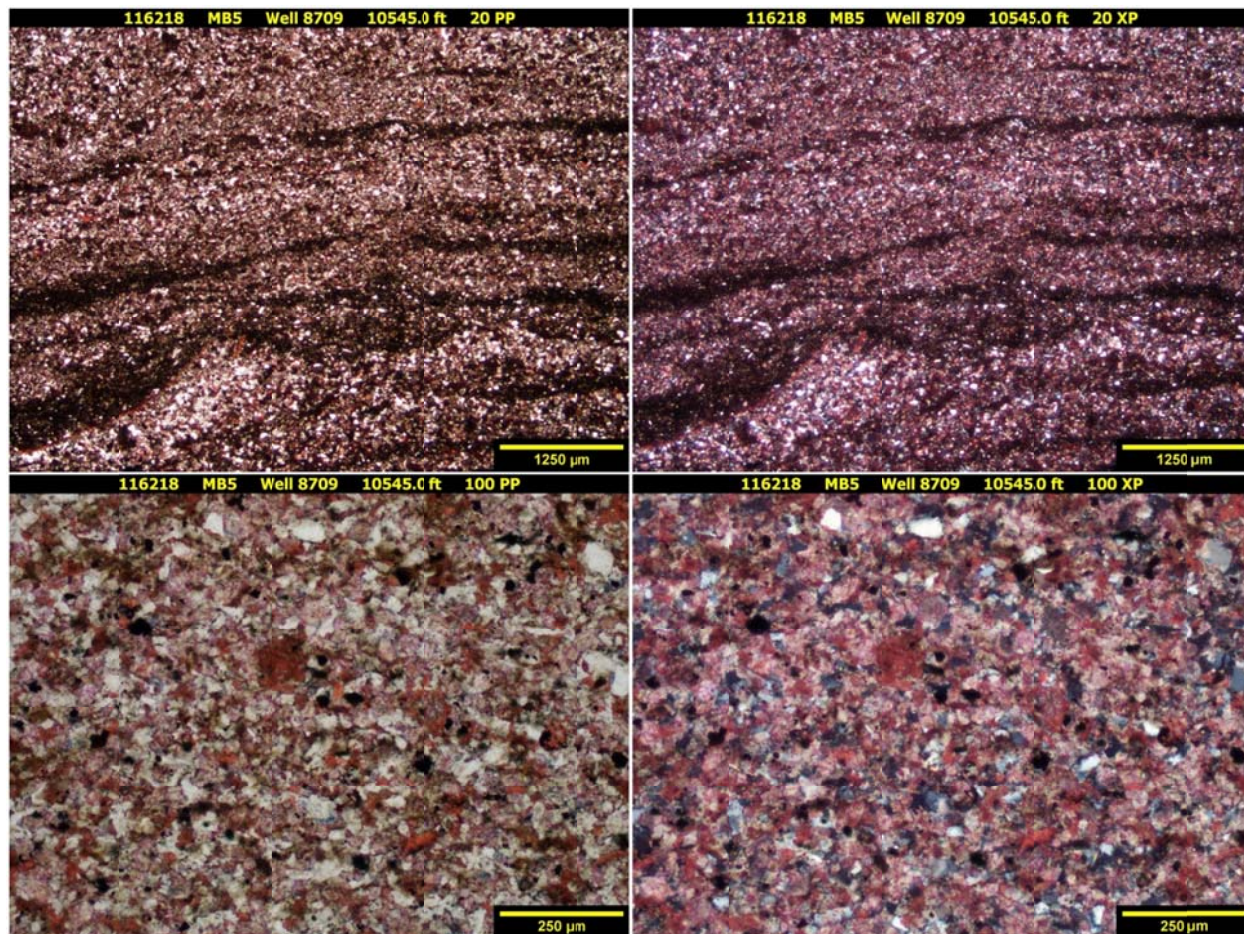
Porosity and Related Measurements Performed by MetaRock Laboratories

Pycnometer Effective Porosity, vol%	Bulk Volume, cm ³	Bulk Density, g/cm ³	Grain Volume, cm ³	Grain Density, g/cm ³
3.64	35.56	2.61	34.50	2.71

	Applied Geology Laboratory		ID: 116218
	Middle Bakken 5	NDIC Well 8709, Burbank BIA 23-8	Depth: 10545.0'
	American Petroleum Institute (API) No.: 33025002320000		Lithology: Argillaceous to dolomitic siltstone

PHOTOMICROGRAPHS

Transmission



This sample represents argillaceous to dolomitic siltstone. Angular to subangular, monocrystalline quartz is the predominant detrital mineral. Common occurrences of calcareous (sparry and micritic) clasts and bioclasts are observed throughout the sample. A combination of clays and cryptocrystalline dolomite is displayed throughout the sample. Irregular, wavy clay laminations are present perhaps because of bioturbation or other reworking events. Zonally-concentrated and erratically-placed subhedral to euhedral fine dolomite crystals are noted. Pyrite and micrite replacement of allochems are common. Trace levels of muscovite are detected. Open, horizontal, nonconnected fractures represent the only observed porosity. Other fractures are observed to have calcareous or opaque infill (organics, clay, and pyrite).

	Applied Geology Laboratory		ID: 116218
	Middle Bakken 5	NDIC Well 8709, Burbank BIA 23-8	Depth: 10545.0'
	American Petroleum Institute (API) No.: 33025002320000	Lithology: Argillaceous to dolomitic siltstone	

PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	40	Very fine grained
Calcite	15	Fossils, fractures, clasts
Dolomite	20	Few rhombs
Clay	20	
Metals	Trace	Pyrite
Muscovite	Trace	Largely horizontal orientation
Organics	Trace	Microfractures

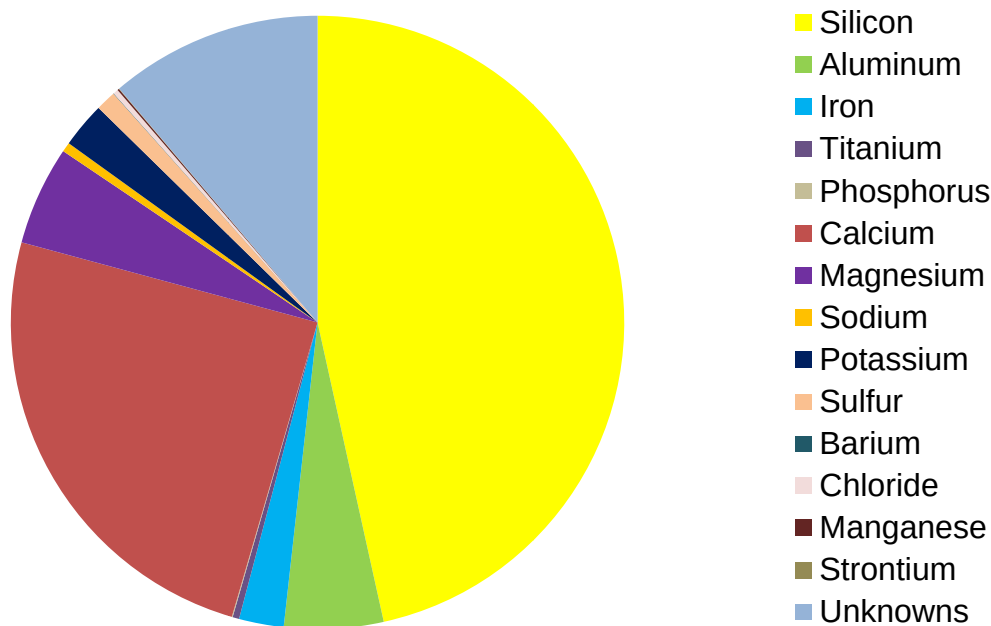
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through x-ray fluorescence (XRF) and x-ray diffraction (XRD) data sets.

Detrital Texture

Category	Classification
Grain Size	Very fine
Sorting	Moderately well
Roundness	Subangular to subrounded

	Applied Geology Laboratory		ID: 116218
	Middle Bakken 5	NDIC Well 8709, Burbank BIA 23-8	Depth: 10545.0'
	American Petroleum Institute (API) No.: 33025002320000		Lithology: Argillaceous to dolomitic siltstone

X-RAY FLUORESCENCE (XRF) BULK CHEMICAL COMPOSITION

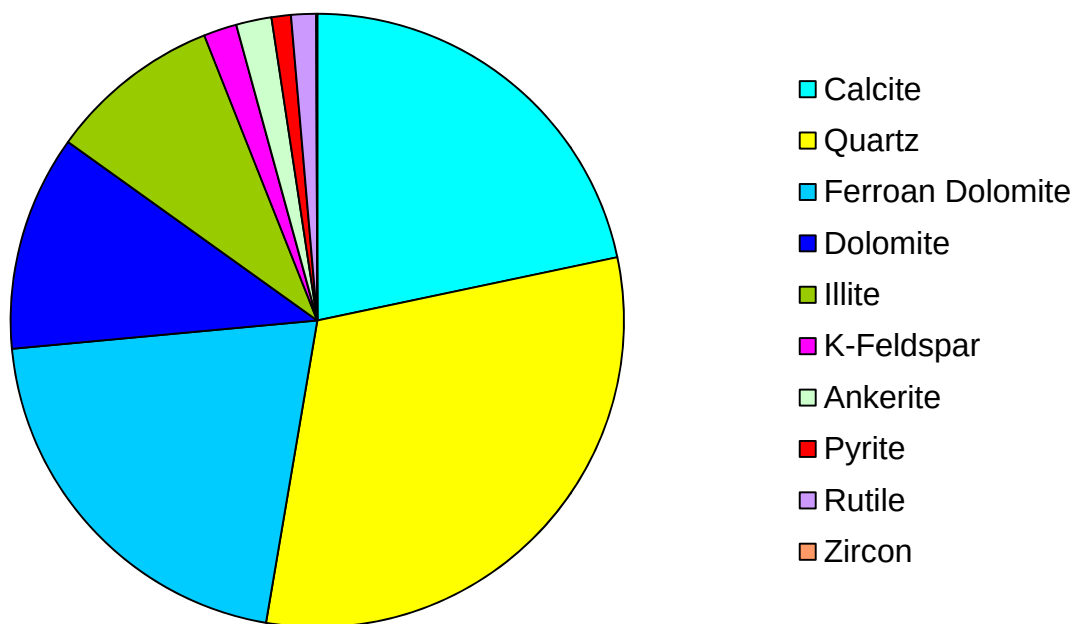


Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	46.52
Al (aluminum)	Al ₂ O ₃	5.23
Fe (iron)	Fe ₂ O ₃	2.36
Ti (titanium)	TiO ₂	0.34
P (phosphorus)	P ₂ O ₅	0.05
Ca (calcium)	CaO	24.69
Mg (magnesium)	MgO	5.23
Na (sodium)	Na ₂ O	0.50
K (potassium)	K ₂ O	2.40
S (sulfur)	SO ₃	1.07
Ba (barium)	BaO	0.02
Cl (chloride)	Cl	0.27
Mn (manganese)	MnO	0.09
Sr (strontium)	SrO	0.02
Unknowns	Due to the presence of carbonates*	11.19
Total		99.98

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

	Applied Geology Laboratory		ID: 116218
	Middle Bakken 5	NDIC Well 8709, Burbank BIA 23-8	Depth: 10545.0'
	American Petroleum Institute (API) No.: 33025002320000		Lithology: Argillaceous to dolomitic siltstone

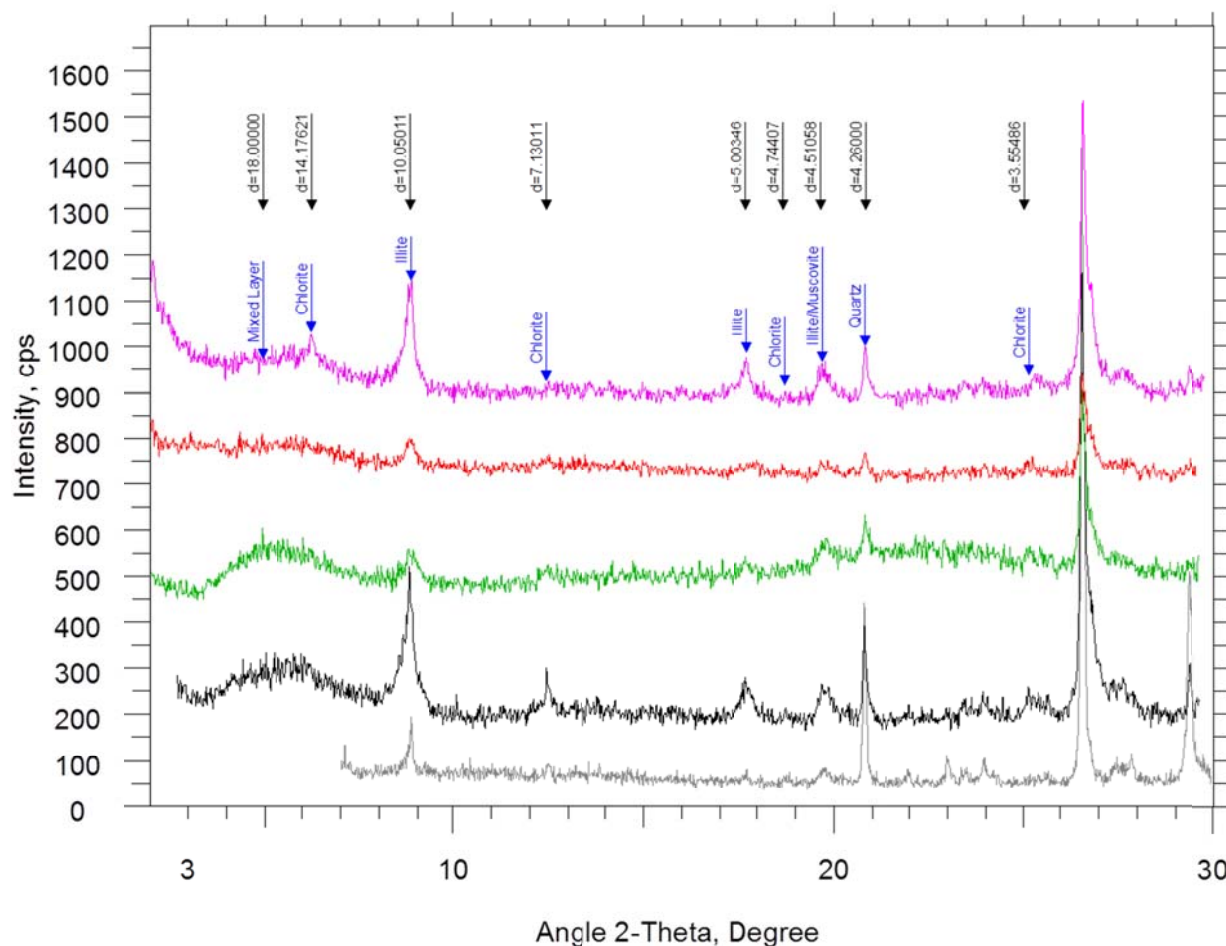
X-RAY DIFFRACTION (XRD) MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	21.7
Quartz	SiO_2	31.0
Ferroan Dolomite	$\text{CaMg}_{0.8}\text{Fe}_{0.2}(\text{CO}_3)_2$	20.9
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	11.4
Illite	$(\text{K}, \text{H}_3\text{O})(\text{Al}, \text{Mg}, \text{Fe})_2(\text{Si}, \text{Al})_4\text{O}_{10}[(\text{OH})_2, (\text{H}_2\text{O})]$	9.1
K-Feldspar	KAlSi_3O_8	1.7
Ankerite	$\text{CaMg}_{0.45}\text{Fe}_{0.55}(\text{CO}_3)_2$	1.9
Pyrite	FeS_2	1.0
Rutile	TiO_2	1.3
Zircon	ZrSiO_4	Trace

	Applied Geology Laboratory		ID: 116218
	Middle Bakken 5	NDIC Well 8709, Burbank BIA 23-8	Depth: 10545.0'
	American Petroleum Institute (API) No.: 33025002320000		Lithology: Argillaceous to dolomitic siltstone

XRD Clay Typing



Clays Identified

Illite
Chlorite
Mixed-layer clay

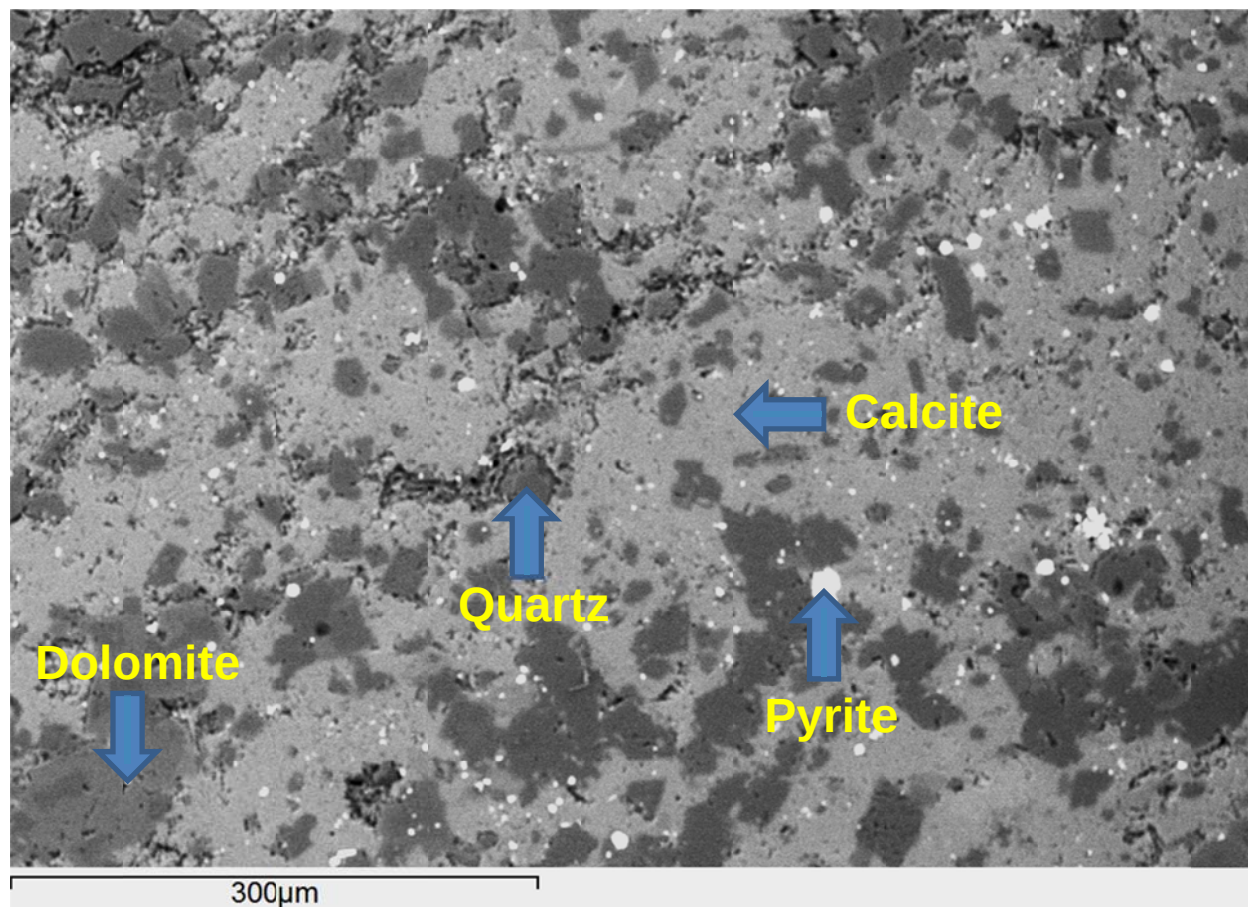
	Applied Geology Laboratory		ID: 116218
	Middle Bakken 5	NDIC Well 8709, Burbank BIA 23-8	Depth: 10545.0'
	American Petroleum Institute (API) No.: 33025002320000		Lithology: Argillaceous to dolomitic siltstone

SCANNING ELECTRON MICROSCOPY (SEM)

Observed Minerals

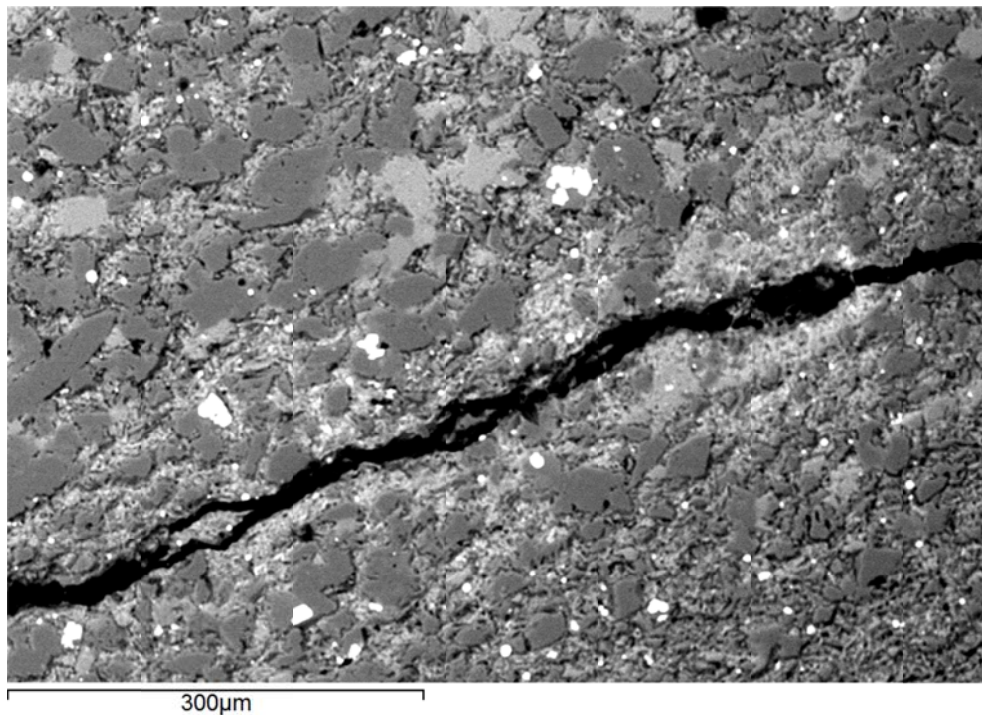
Mineral Phase	Mineral Phase
Calcite	Halite
Quartz	K-Feldspar
Rutile	Illite
Pyrite	Albite
Fluorapatite	Zircon
Dolomite	

High-Magnification Backscattered Electron (BSE) Image Annotated with Examples of Mineral Phases Identified

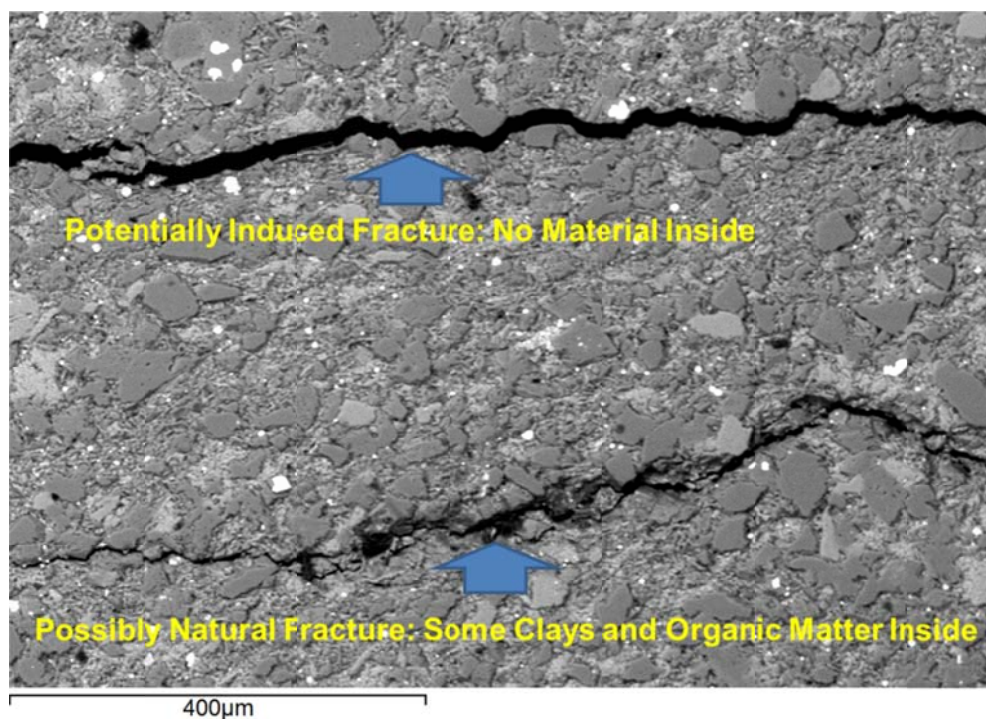


	Applied Geology Laboratory		ID: 116218
	Middle Bakken 5	NDIC Well 8709, Burbank BIA 23-8	Depth: 10545.0'
	American Petroleum Institute (API) No.: 33025002320000		Lithology: Argillaceous to dolomitic siltstone

Fracture Analysis on BSE Images



A halite coating was noted along the fracture.



	Applied Geology Laboratory		ID: 116219
	Middle Bakken 5	NDIC Well 8709, Burbank BIA 23-8	Depth: 10547.0'
	API No.: 33025002320000		Lithology: Dolomitic siltstone

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION



Depth 10547.0': Mottled and dense but still shows some degree of bioturbation. The lighter strip down the center is the result of acid testing.

PHYSICAL PROPERTIES

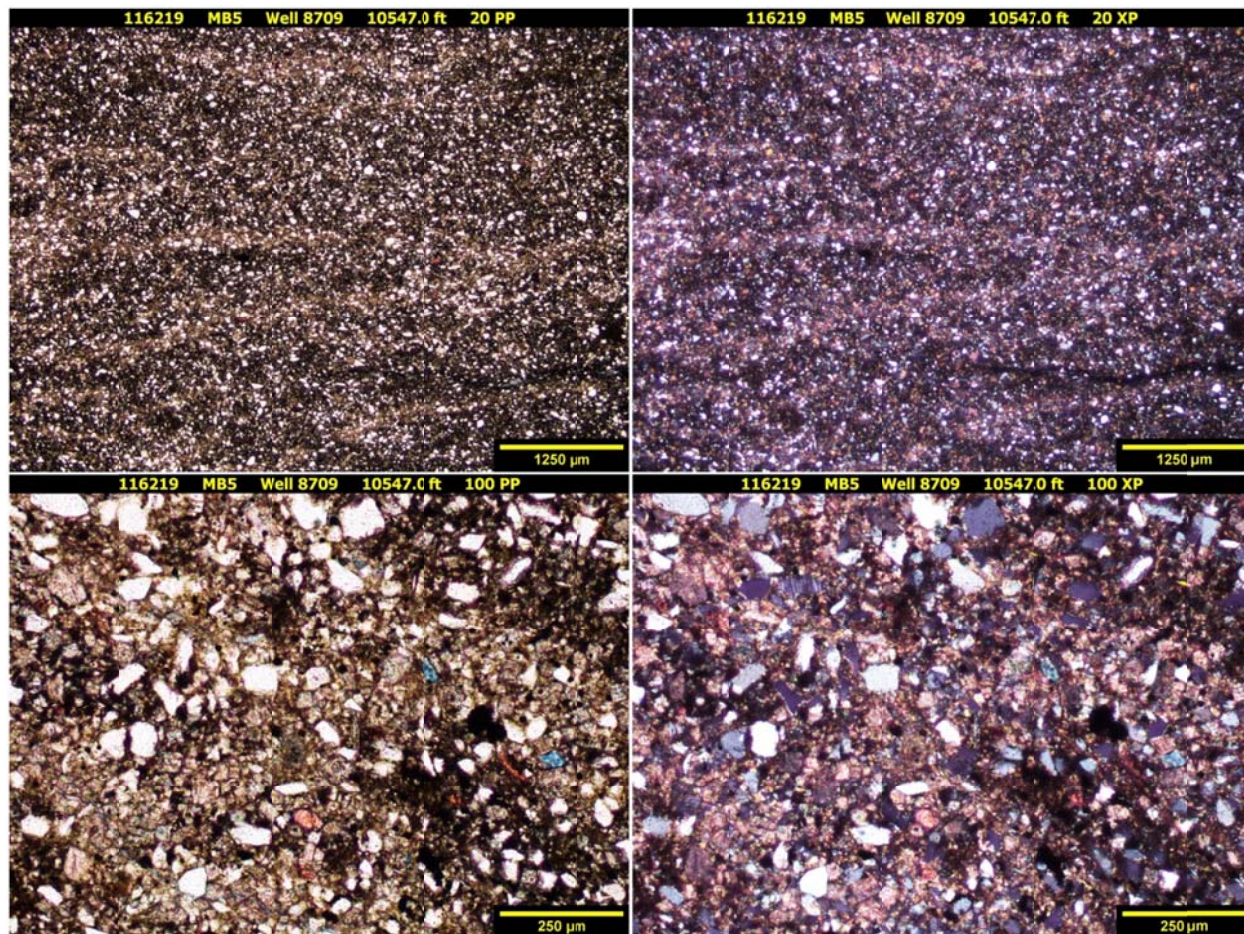
Porosity and Related Measurements Performed by MetaRock Laboratories

Pycnometer Effective Porosity, vol%	Bulk Volume, cm ³	Bulk Density, g/cm ³	Grain Volume, cm ³	Grain Density, g/cm ³
5.50	50.68	2.54	47.89	2.69

	Applied Geology Laboratory		ID: 116219
	Middle Bakken 5	NDIC Well 8709, Burbank BIA 23-8	Depth: 10547.0'
	API No.: 33025002320000		Lithology: Dolomitic siltstone

PHOTOMICROGRAPHS

Transmission



This sample represents dolomitic siltstone. The dominant replacement mineral present is dolomite, seen as very fine crystalline mud to fine subhedral to euhedral crystals. Quartz grains are predominantly monocrystalline and subangular. Trace amounts of pyrite, calcite clasts, feldspars, and well-oriented muscovite are observed. Open, horizontal, nonconnected fractures display small amounts of porosity. Other fractures are observed to have opaque infill (organics, clay, and pyrite). Additional porosity noted at very tiny levels is interparticle likely because of dolomite growth. No identifiable fossils are observed.

	Applied Geology Laboratory		ID: 116219
	Middle Bakken 5	NDIC Well 8709, Burbank BIA 23-8	Depth: 10547.0'
	API No.: 33025002320000		Lithology: Dolomitic siltstone

PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	50	Fine to very fine grain
Calcite	Trace	Rare clasts
Dolomite	40	Anhedral to euhedral
Clay	5	
Metals	Trace	Pyrite
Muscovite	Trace	Largely horizontal orientation
Organics	Trace	Globular

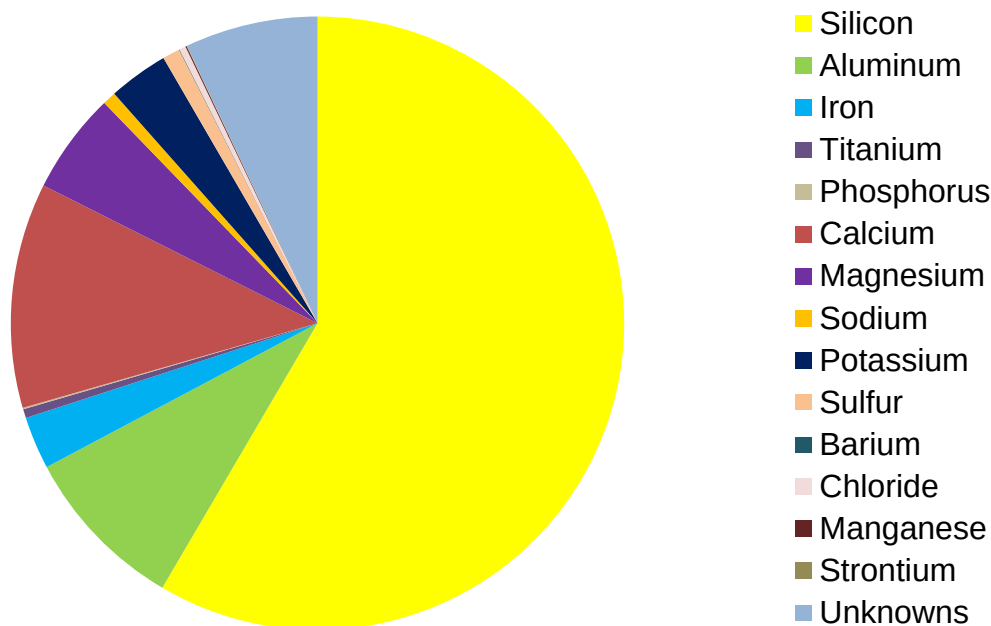
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through XRF and XRD data sets.

Detrital Texture

Category	Classification
Grain Size	Fine to very fine
Sorting	Moderately
Roundness	Predominantly subangular

	Applied Geology Laboratory		ID: 116219
	Middle Bakken 5	NDIC Well 8709, Burbank BIA 23-8	Depth: 10547.0'
	API No.: 33025002320000		Lithology: Dolomitic siltstone

XRF BULK CHEMICAL COMPOSITION

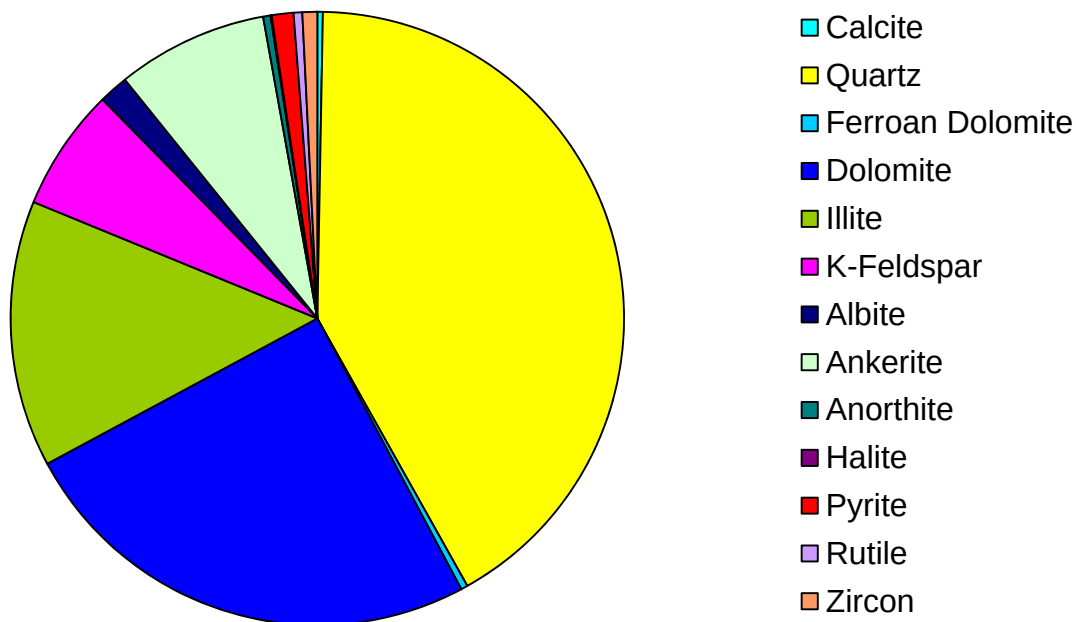


Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	58.44
Al (aluminum)	Al ₂ O ₃	8.79
Fe (iron)	Fe ₂ O ₃	2.77
Ti (titanium)	TiO ₂	0.47
P (phosphorus)	P ₂ O ₅	0.08
Ca (calcium)	CaO	11.86
Mg (magnesium)	MgO	5.35
Na (sodium)	Na ₂ O	0.70
K (potassium)	K ₂ O	3.17
S (sulfur)	SO ₃	0.91
Ba (barium)	BaO	0.03
Cl (chloride)	Cl	0.34
Mn (manganese)	MnO	0.07
Sr (strontium)	SrO	0.02
Unknowns	Due to the presence of carbonates*	7.00
Total		100.00

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

	Applied Geology Laboratory		ID: 116219
	Middle Bakken 5	NDIC Well 8709, Burbank BIA 23-8	Depth: 10547.0'
	API No.: 33025002320000		Lithology: Dolomitic siltstone

XRD MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	Trace
Quartz	SiO_2	41.6
Ferroan Dolomite	$\text{CaMg}_{0.8}\text{Fe}_{0.2}(\text{CO}_3)_2$	Trace
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	24.9
Illite	$(\text{K},\text{H}_3\text{O})(\text{Al},\text{Mg},\text{Fe})_2(\text{Si},\text{Al})_4\text{O}_{10}[(\text{OH})_2,(\text{H}_2\text{O})]$	14.1
K-Feldspar	KAlSi_3O_8	6.5
Albite	$\text{NaAlSi}_3\text{O}_8$	1.6
Ankerite	$\text{CaMg}_{0.45}\text{Fe}_{0.55}(\text{CO}_3)_2$	8.0
Anorthite	$\text{CaAl}_2\text{Si}_2\text{O}_4$	Trace
Halite	NaCl	Trace
Pyrite	FeS_2	1.1
Rutile	TiO_2	Trace
Zircon	ZrSiO_4	0.8

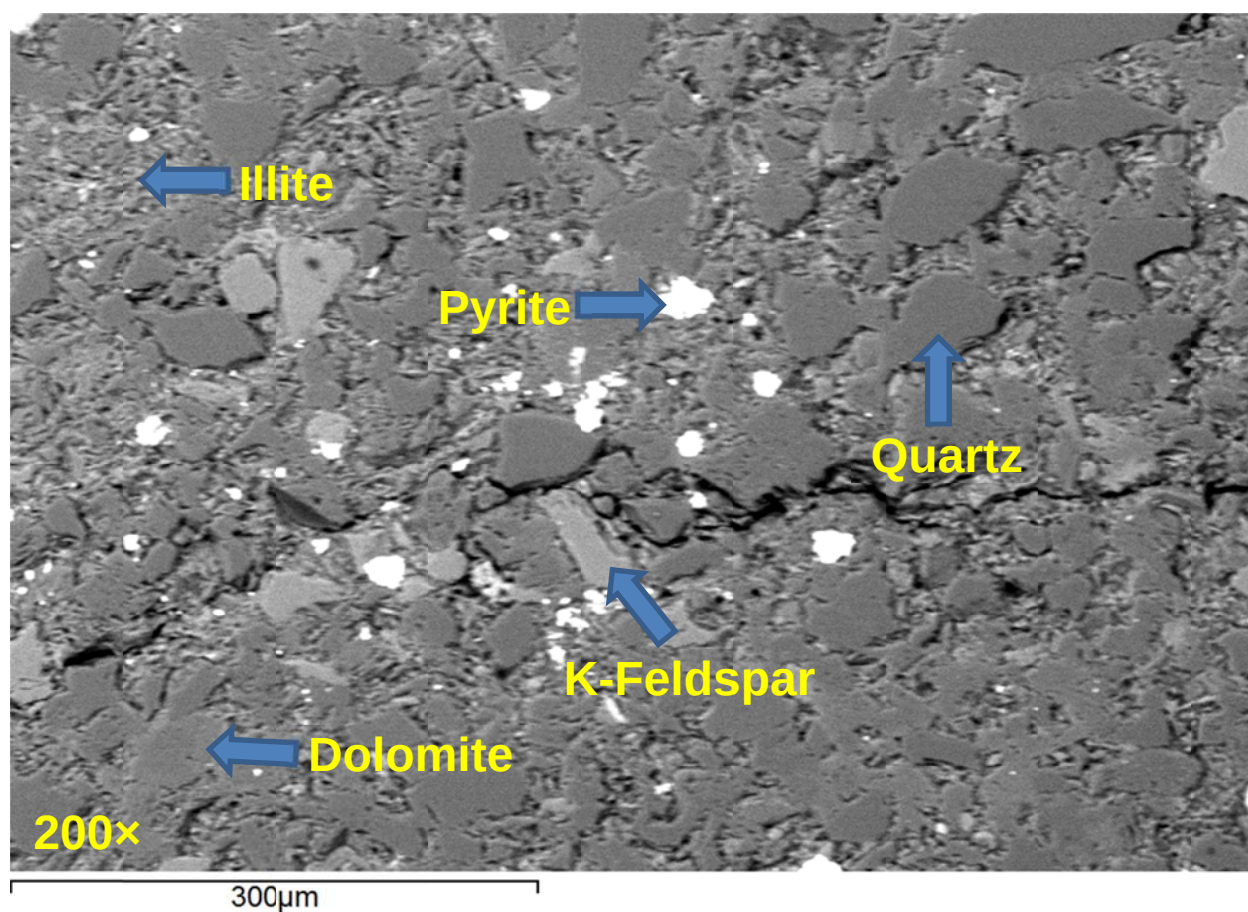
	Applied Geology Laboratory		ID: 116219
	Middle Bakken 5	NDIC Well 8709, Burbank BIA 23-8	Depth: 10547.0'
	API No.: 33025002320000		Lithology: Dolomitic siltstone

SEM

Observed Minerals

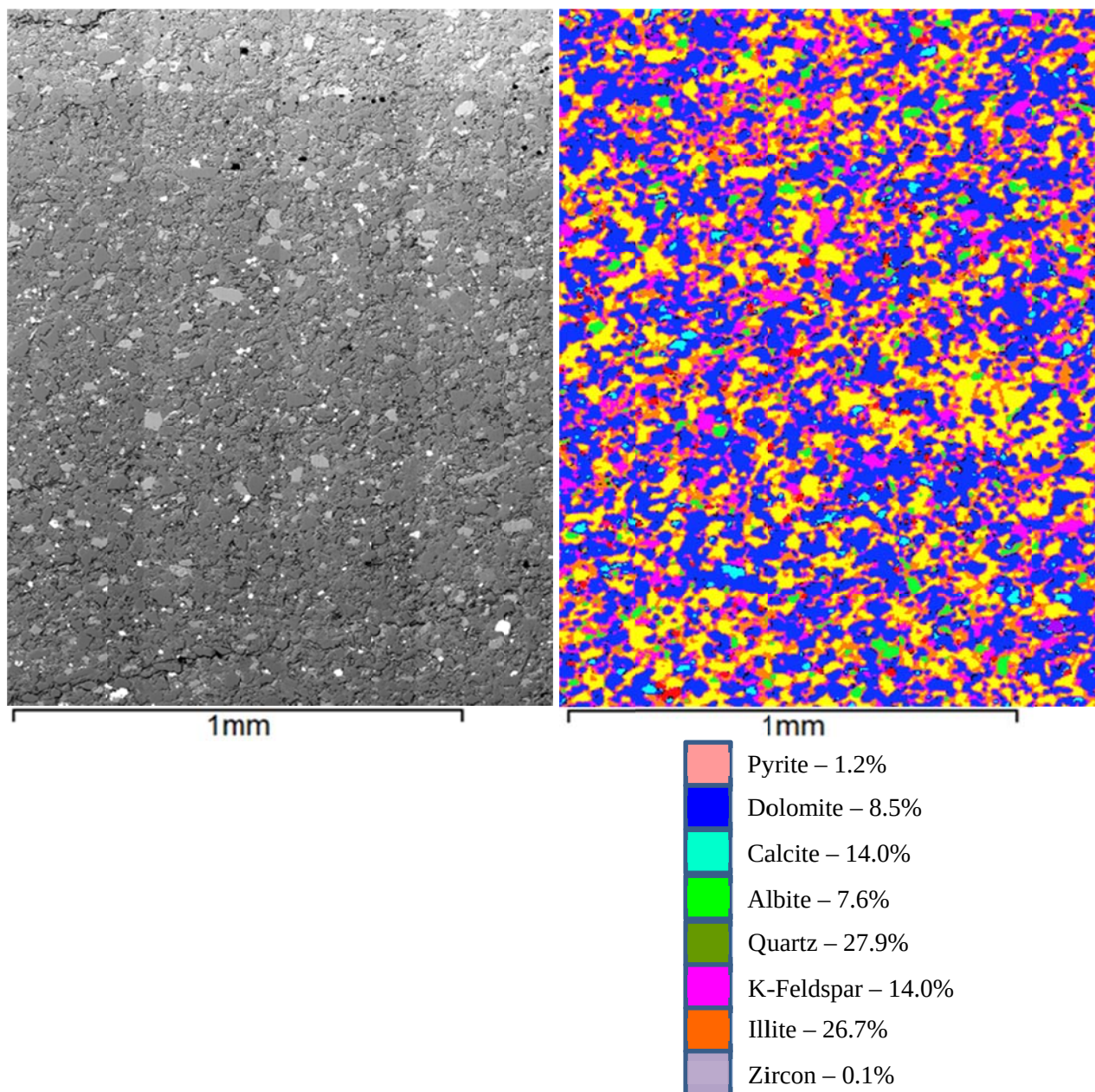
Mineral Phase	Mineral Phase
Quartz	Pyrite
Calcite	Zircon
Illite	Apatite
K-Feldspar	Rutile
Dolomite	Albite
Halite	

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified



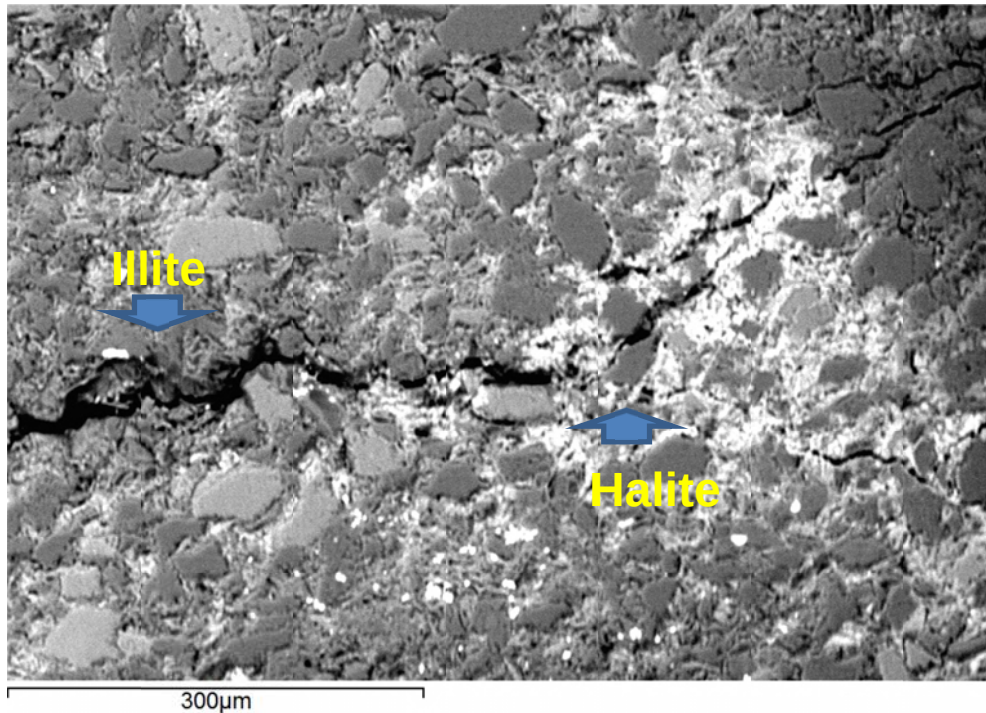
	Applied Geology Laboratory		ID: 116219
	Middle Bakken 5	NDIC Well 8709, Burbank BIA 23-8	Depth: 10547.0'
	API No.: 33025002320000		Lithology: Dolomitic siltstone

SEM BSE Image and Corresponding Digital Composite Mineral Map Image Overlaid on BSE Image with Mineral-Phase 2-D Area Percentages

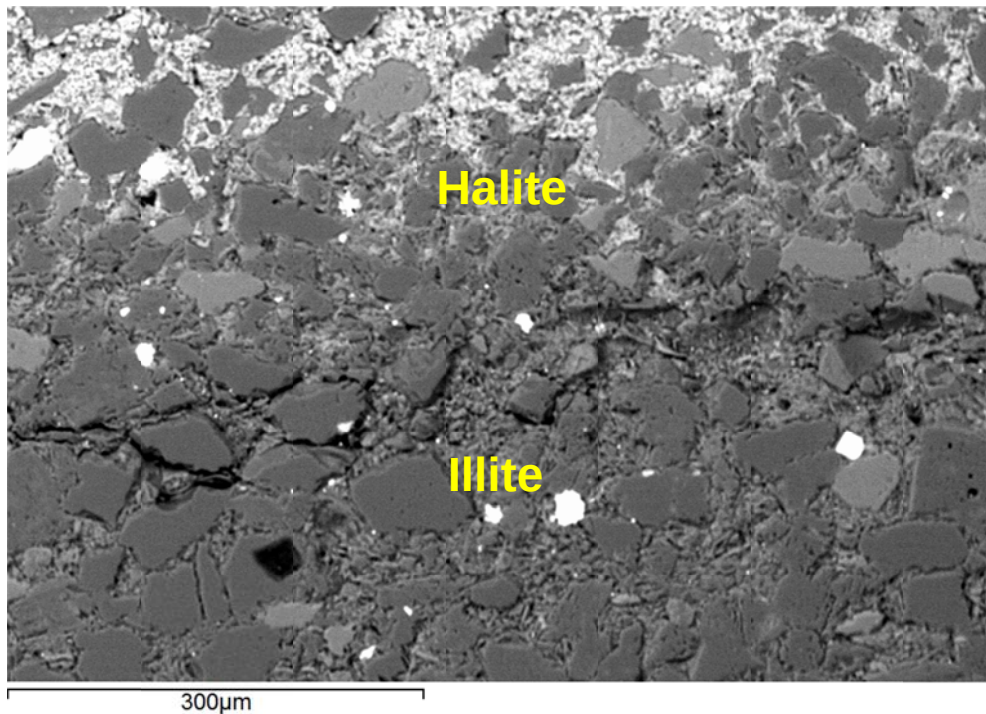


	Applied Geology Laboratory		ID: 116219
	Middle Bakken 5	NDIC Well 8709, Burbank BIA 23-8	Depth: 10547.0'
	API No.: 33025002320000		Lithology: Dolomitic siltstone

Fracture Analysis on BSE Images



Illite partially fills the fracture. A halite coating is noted around the fracture branch point.



Halite is found in the intergranular spaces. Illite completely fills what was once a fracture.

	Applied Geology Laboratory		ID: 116220
	Middle Bakken 4	NDIC Well 8709, Burbank BIA 23-8	Depth: 10549.8'
	API #: 33025002320000		Lithology: Silty limestone

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION



Depth 10549.8': Displays faint bedding and slight bioturbation features.

PHYSICAL PROPERTIES

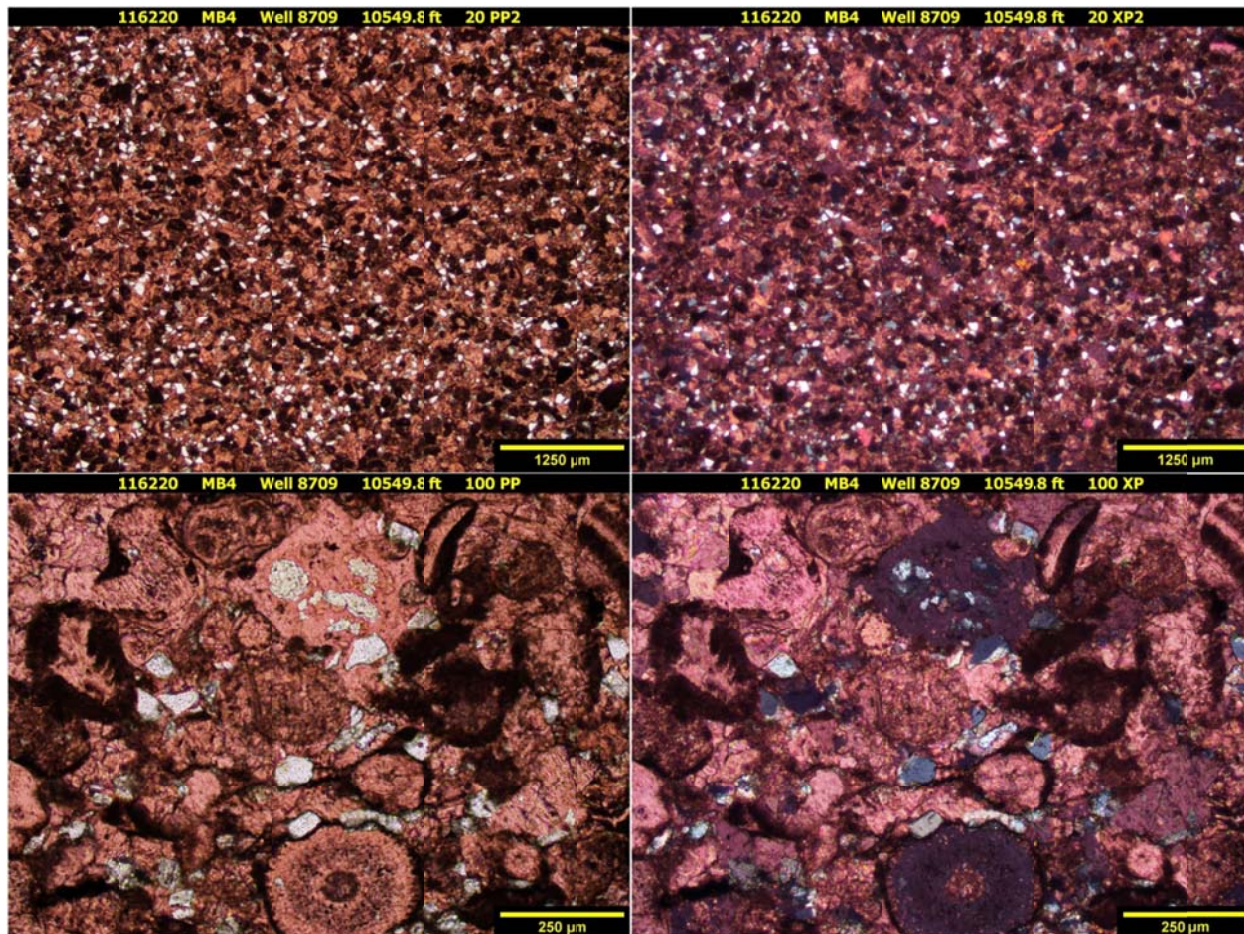
Porosity and Related Measurements Performed by MetaRock Laboratories

Pycnometer Effective Porosity, vol%	Bulk Volume, cm ³	Bulk Density, g/cm ³	Grain Volume, cm ³	Grain Density, g/cm ³
0.77	51.68	2.66	51.29	2.68

	Applied Geology Laboratory		ID: 116220
	Middle Bakken 4	NDIC Well 8709, Burbank BIA 23-8	Depth: 10549.8'
	API #: 33025002320000		Lithology: Silty limestone

PHOTOMICROGRAPHS

Transmission



This sample represents silty limestone. Subangular, monocrystalline quartz is the abundant detrital mineral. Minor amount of feldspars, trace levels of clay, and no muscovite are observed. Allochems are common. Ooids, peloids, and calcareous nonskeletal clast fragments are scattered throughout. Bioclast (likely bryozoans, brachiopods, and echinoderms) fragments are also disseminated throughout. Evidence of micritization, iron-oxide coating, and pyrite replacement are observed on both skeletal and nonskeletal grains. The combination of common pore-filling sparry calcite cement with rare dolomitic cement eliminates any observed porosity in the thin section. Trace levels of replacement gypsum are observed. No fractures are detected through traditional optical methods.

	Applied Geology Laboratory		ID: 116220
	Middle Bakken 4	NDIC Well 8709, Burbank BIA 23-8	Depth: 10549.8'
	API #: 33025002320000		Lithology: Silty limestone

PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	10	Very fine grained
Calcite	90	Cement, allochems
Dolomite	Trace	
Clay	0	Not observed
Metals	Trace	Pyrite
Muscovite	0	Not observed
Organics	Trace	Tiny globs

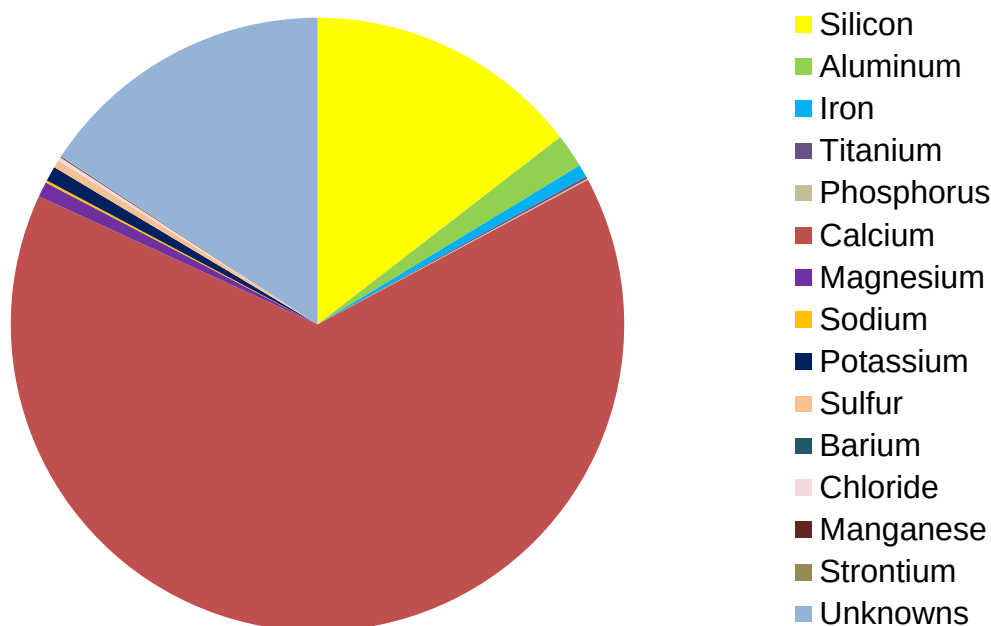
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through XRF and XRD data sets.

Detrital Texture

Category	Classification
Grain Size	Very fine
Sorting	Poor
Roundness	Subangular to subrounded

	Applied Geology Laboratory		ID: 116220
	Middle Bakken 4	NDIC Well 8709, Burbank BIA 23-8	Depth: 10549.8'
	API #: 33025002320000		Lithology: Silty limestone

XRF BULK CHEMICAL COMPOSITION

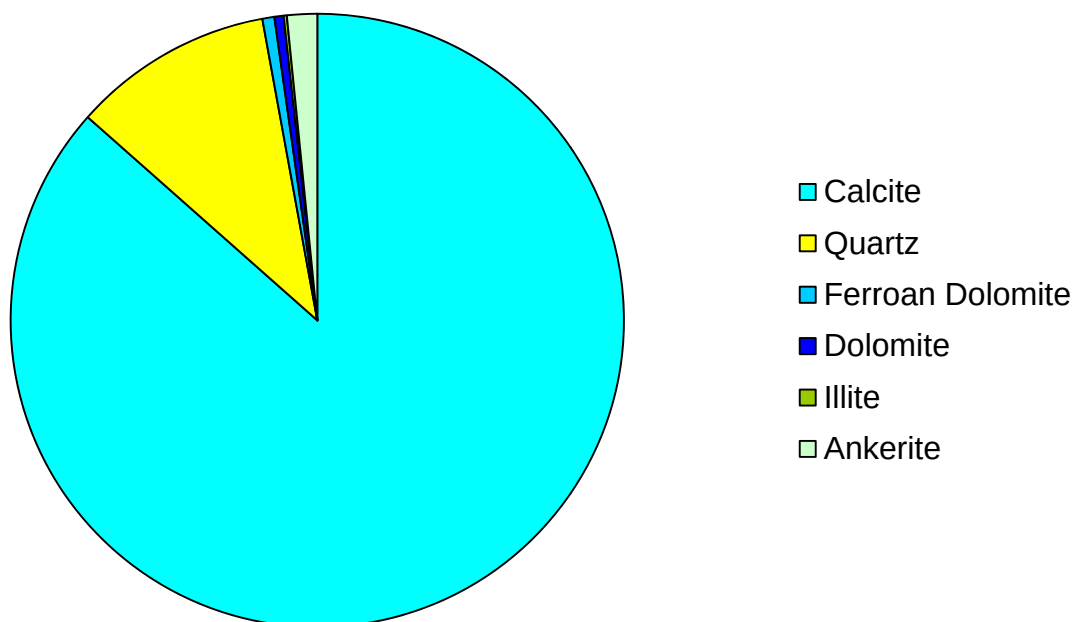


Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	14.54
Al (aluminum)	Al ₂ O ₃	1.78
Fe (iron)	Fe ₂ O ₃	0.68
Ti (titanium)	TiO ₂	0.12
P (phosphorus)	P ₂ O ₅	0.07
Ca (calcium)	CaO	64.68
Mg (magnesium)	MgO	0.80
Na (sodium)	Na ₂ O	0.12
K (potassium)	K ₂ O	0.79
S (sulfur)	SO ₃	0.38
Ba (barium)	BaO	0.01
Cl (chloride)	Cl	0.21
Mn (manganese)	MnO	0.05
Sr (strontium)	SrO	0.02
Unknowns	Due to the presence of carbonates*	15.76
Total		100.01

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

	Applied Geology Laboratory		ID: 116220
	Middle Bakken 4	NDIC Well 8709, Burbank BIA 23-8	Depth: 10549.8'
	API #: 33025002320000		Lithology: Silty limestone

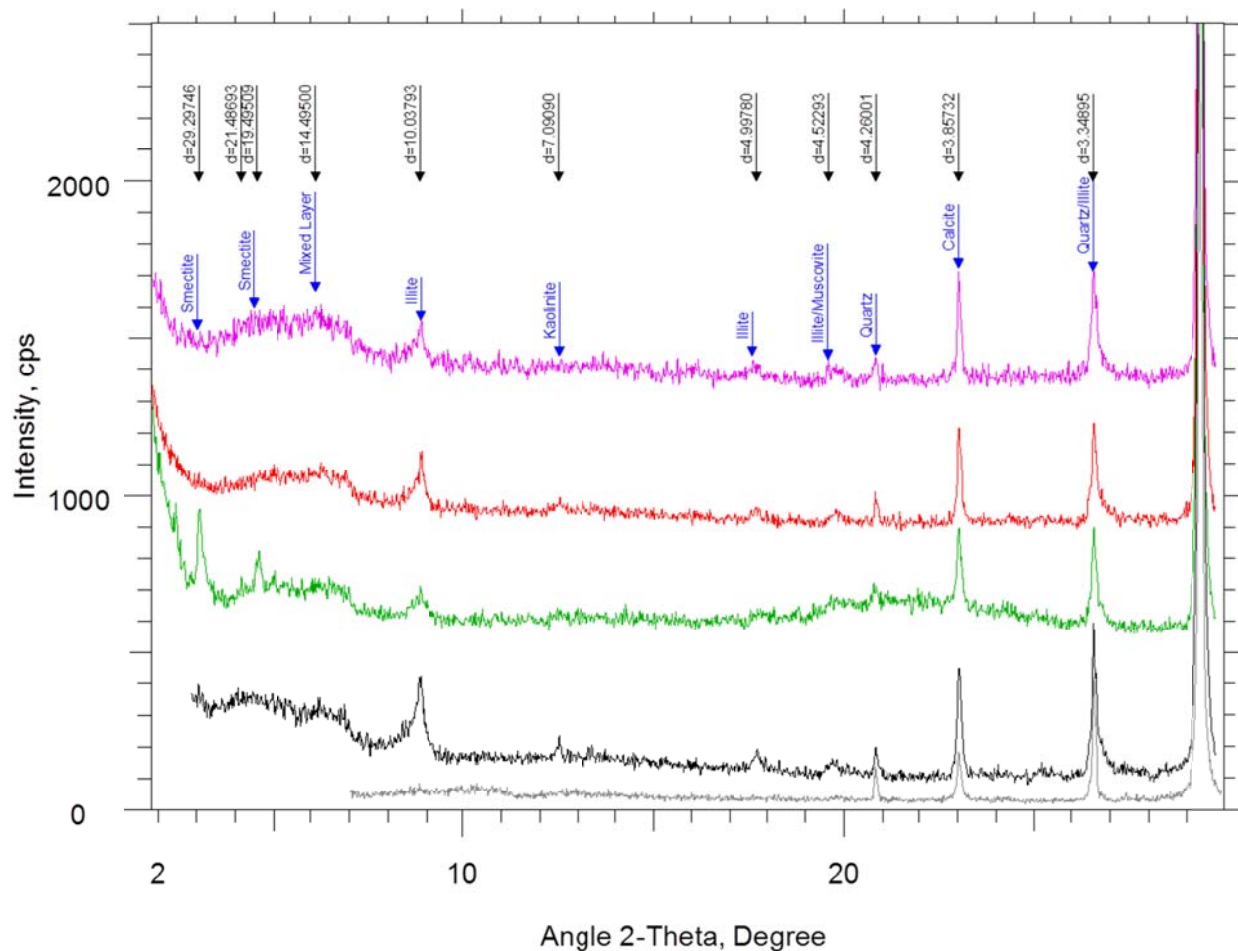
XRD MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	86.5
Quartz	SiO_2	10.6
Ferroan Dolomite	$\text{CaMg}_{0.8}\text{Fe}_{0.2}(\text{CO}_3)_2$	0.6
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	Trace
Illite	$(\text{K}, \text{H}_3\text{O})(\text{Al}, \text{Mg}, \text{Fe})_2(\text{Si}, \text{Al})_4\text{O}_{10}[(\text{OH})_2, (\text{H}_2\text{O})]$	Trace
Ankerite	$\text{CaMg}_{0.45}\text{Fe}_{0.55}(\text{CO}_3)_2$	1.6

	Applied Geology Laboratory		ID: 116220
	Middle Bakken 4	NDIC Well 8709, Burbank BIA 23-8	Depth: 10549.8'
	API #: 33025002320000		Lithology: Silty limestone

XRD Clay Typing



Clays Identified

Illite

Smectite

Low amounts of kaolinite

Evidence of mixed-layer clays

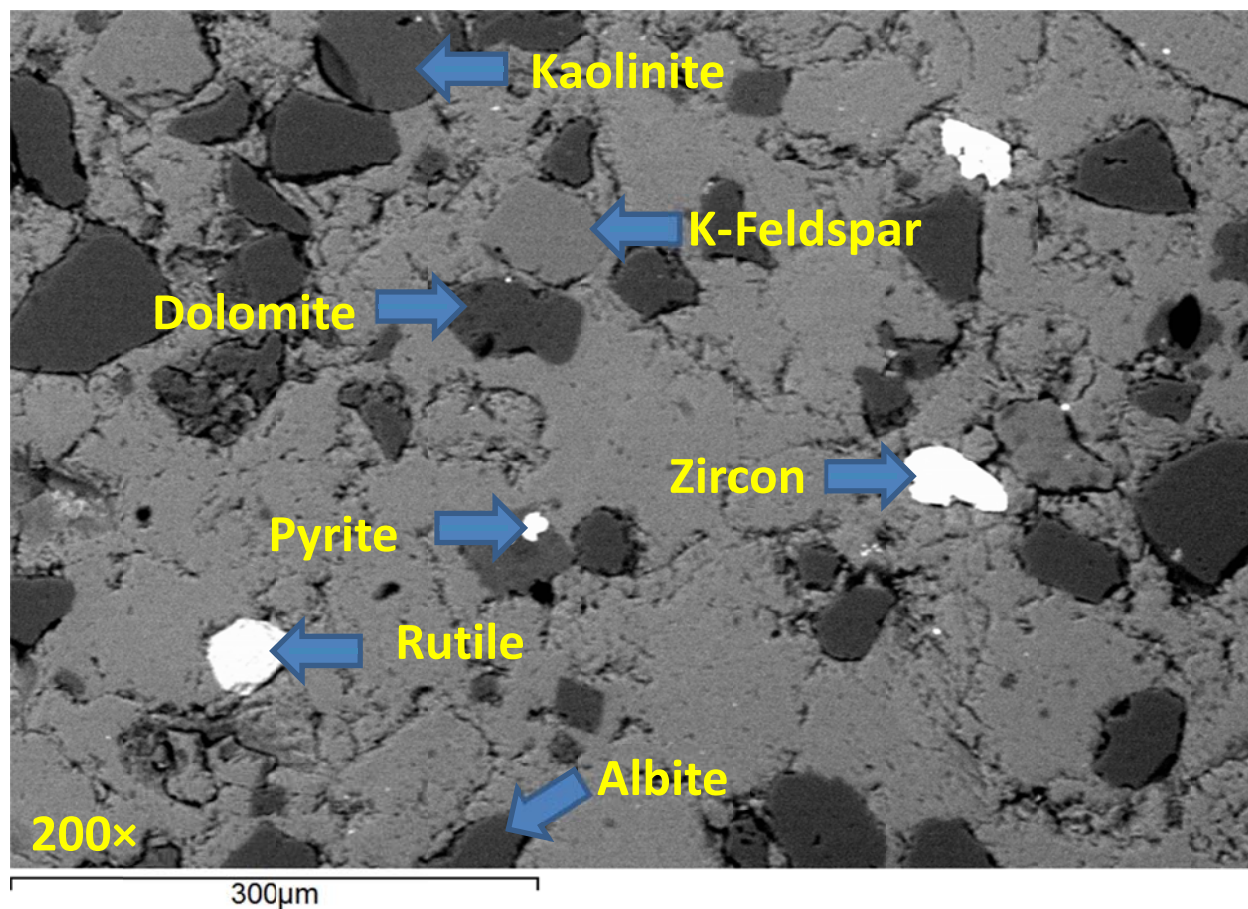
	Applied Geology Laboratory		ID: 116220
	Middle Bakken 4	NDIC Well 8709, Burbank BIA 23-8	Depth: 10549.8'
	API #: 33025002320000		Lithology: Silty limestone

SEM

Observed Minerals

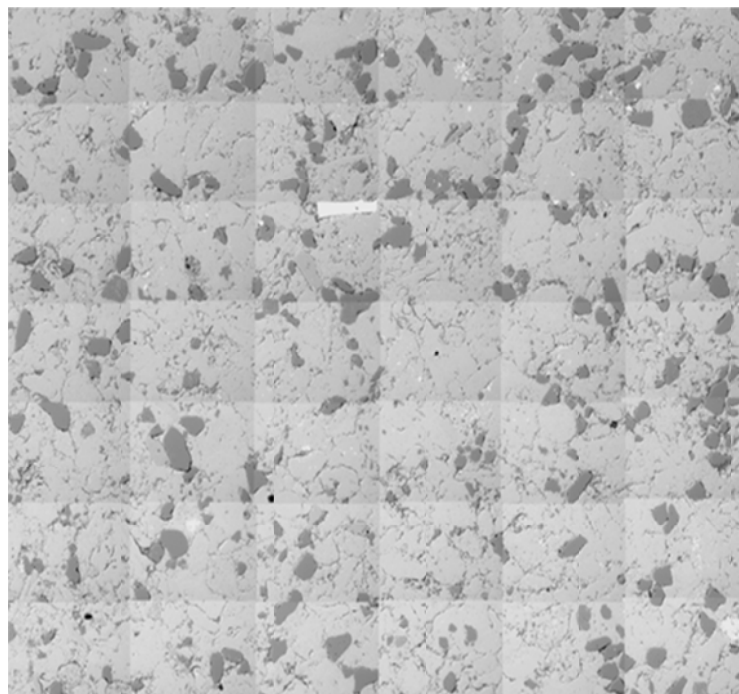
Mineral Phase	Mineral Phase
Calcite	Apatite
Quartz	Pyrite
Zircon	Albite
Rutile	Dolomite
K-Feldspar	Kaolinite

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified

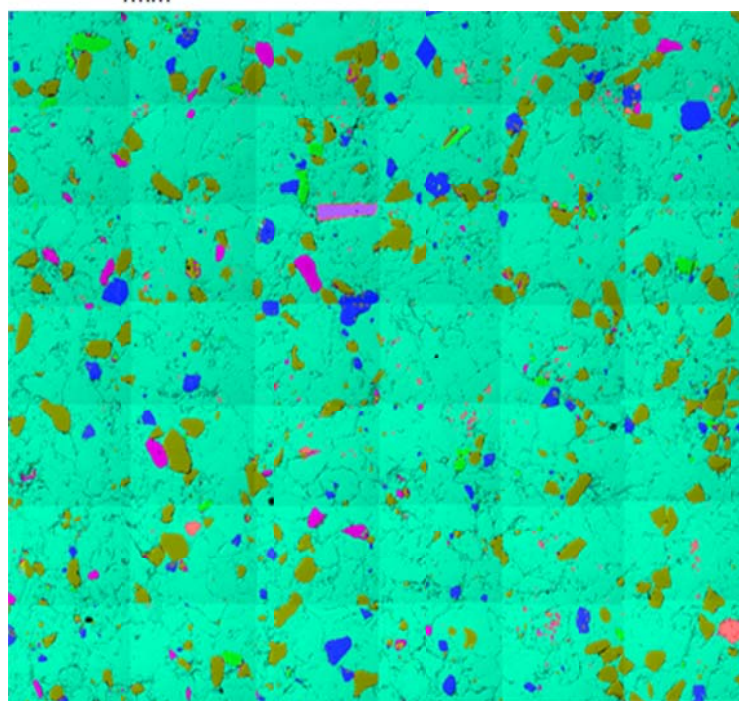


	Applied Geology Laboratory		ID: 116220
	Middle Bakken 4	NDIC Well 8709, Burbank BIA 23-8	Depth: 10549.8'
	API #: 33025002320000		Lithology: Silty limestone

SEM BSE Image and Corresponding Digital Composite Mineral Map Image Overlaid on BSE Image with Mineral-Phase 2-D Area Percentages



1mm

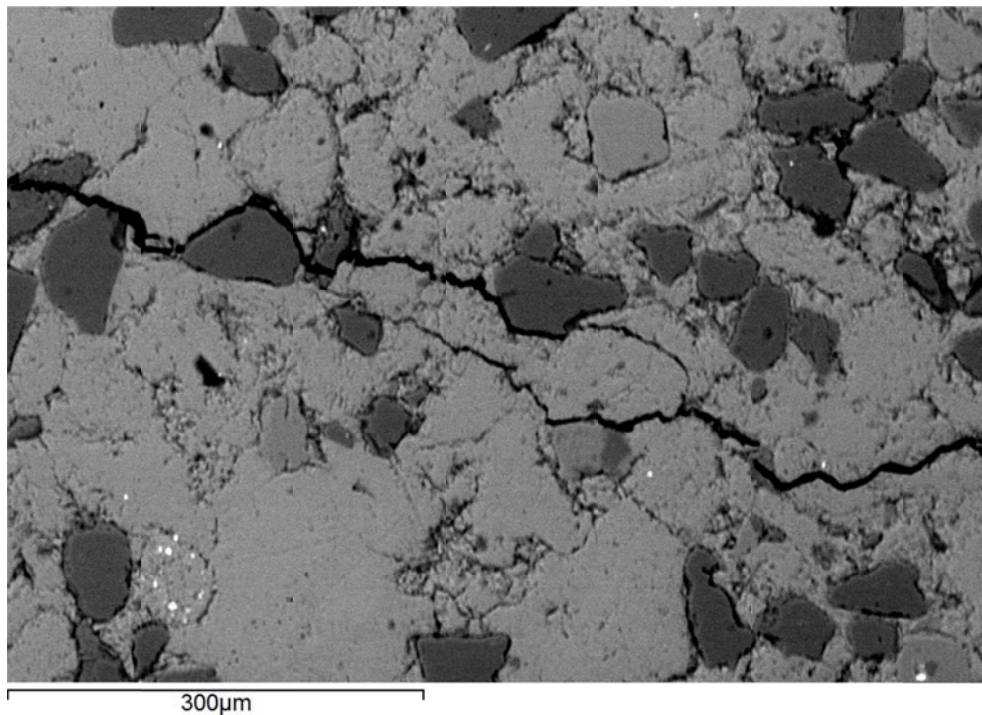


1mm

	Pyrite – 0.4%
	Dolomite – 2.1%
	Calcite – 87.1%
	Albite – 0.7%
	Quartz – 8.6%
	K-Feldspar – 0.9%
	Apatite – 0.1%

	Applied Geology Laboratory		ID: 116220
	Middle Bakken 4	NDIC Well 8709, Burbank BIA 23-8	Depth: 10549.8'
	API #: 33025002320000		Lithology: Silty limestone

Fracture Analysis on BSE Images



The fracture through the middle of the image is possibly induced, as it contains no fill material.

	Applied Geology Laboratory		ID: 116220
	Middle Bakken 4	NDIC Well 8709, Burbank BIA 23-8	Depth: 10549.8'
	API #: 33025002320000	Lithology: Silty limestone	

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	Applied Geology Laboratory		ID: 116221
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10555.0'
	API No.: 33025002320000	Lithology: Dolomitic to calcareous siltstone	

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION



Depth 10555.0': A thinly paralleled laminated siltstone, perhaps a rhythmite feature.

PHYSICAL PROPERTIES

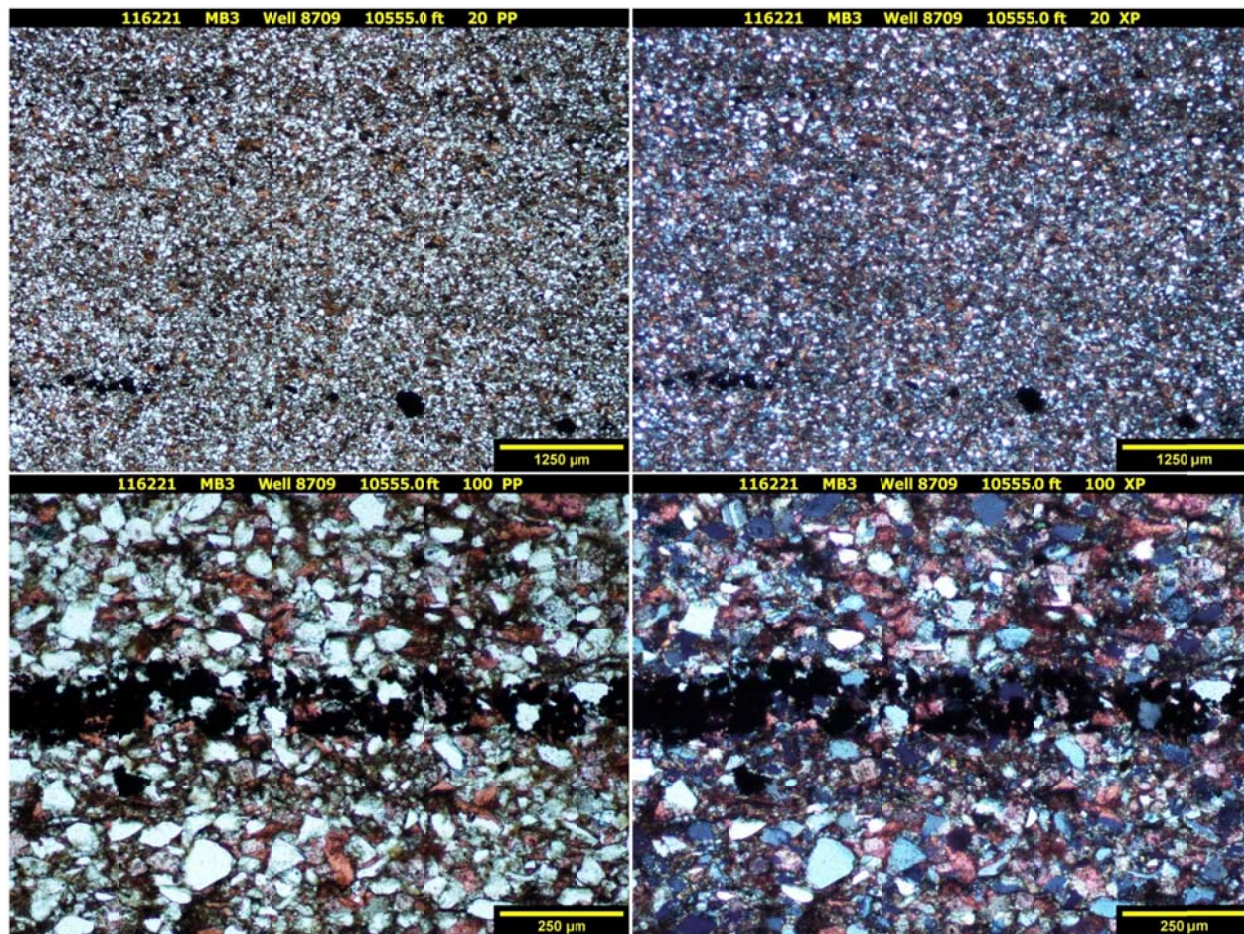
Porosity and Related Measurements Performed by MetaRock Laboratories

Pycnometer Effective Porosity, vol%	Bulk Volume, cm ³	Bulk Density, g/cm ³	Grain Volume, cm ³	Grain Density, g/cm ³
4.13	49.77	2.56	47.72	2.67

	Applied Geology Laboratory		ID: 116221
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10555.0'
	API No.: 33025002320000		Lithology: Dolomitic to calcareous siltstone

PHOTOMICROGRAPHS

Transmission



This sample shows dolomitic to calcareous siltstone. Quartz grains are monocrystalline and largely subangular to subrounded. Calcareous clasts and microcrystalline to cryptocrystalline dolomite commonly occur. Rhombohedral crystallization is extremely rare. Trace amounts of feldspars and muscovite are observed. Thin, incomplete pyrite laminations are present repeatedly throughout the sample. Pyrite also exists in a globular fashion as a result of grain replacement. Organics are found dispersed throughout in varying globular quantities. Porosity is observed only by trace nonconnected horizontal fractures. No distinguishable fossils are noted.

	Applied Geology Laboratory		ID: 116221
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10555.0'
	API No.: 33025002320000	Lithology: Dolomitic to calcareous siltstone	

PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	50	Fine to very fine grain
Calcite	20	Rare clasts
Dolomite	20	Anhedral to euhedral
Clay	10	
Metals	Trace	Pyrite
Muscovite	Trace	Largely horizontal orientation
Organics	Trace	Globular

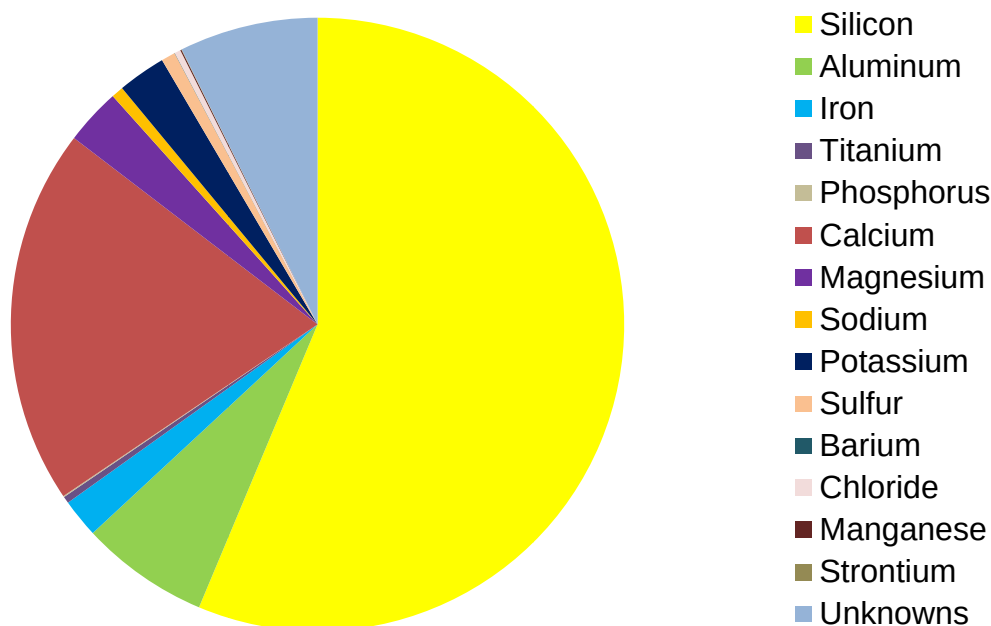
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through XRF and XRD data sets.

Detrital Texture

Category	Classification
Grain Size	Very fine
Sorting	Moderately well
Roundness	Subangular to subrounded

	Applied Geology Laboratory		ID: 116221
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10555.0'
	API No.: 33025002320000	Lithology: Dolomitic to calcareous siltstone	

XRF BULK CHEMICAL COMPOSITION

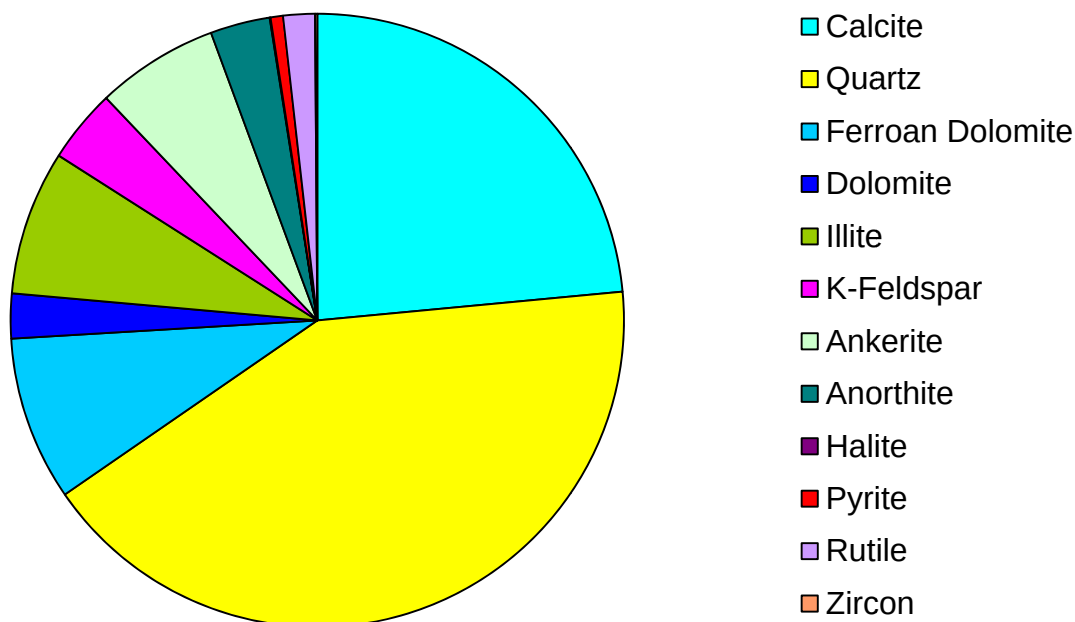


Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	56.31
Al (aluminum)	Al ₂ O ₃	6.77
Fe (iron)	Fe ₂ O ₃	2.04
Ti (titanium)	TiO ₂	0.36
P (phosphorus)	P ₂ O ₅	0.06
Ca (calcium)	CaO	19.85
Mg (magnesium)	MgO	2.97
Na (sodium)	Na ₂ O	0.63
K (potassium)	K ₂ O	2.54
S (sulfur)	SO ₃	0.74
Ba (barium)	BaO	0.02
Cl (chloride)	Cl	0.32
Mn (manganese)	MnO	0.06
Sr (strontium)	SrO	0.02
Unknowns	Due to the presence of carbonates*	7.30
Total		99.99

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

	Applied Geology Laboratory		ID: 116221
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10555.0'
	API No.: 33025002320000		Lithology: Dolomitic to calcareous siltstone

XRD MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	23.5
Quartz	SiO_2	41.9
Ferroan Dolomite	$\text{CaMg}_{0.8}\text{Fe}_{0.2}(\text{CO}_3)_2$	8.7
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	2.4
Illite	$(\text{K},\text{H}_3\text{O})(\text{Al},\text{Mg},\text{Fe})_2(\text{Si},\text{Al})_4\text{O}_{10}[(\text{OH})_2,(\text{H}_2\text{O})]$	7.6
K-Feldspar	KAlSi_3O_8	3.9
Ankerite	$\text{CaMg}_{0.45}\text{Fe}_{0.55}(\text{CO}_3)_2$	6.5
Anorthite	$\text{CaAl}_2\text{Si}_2\text{O}_4$	3.2
Halite	NaCl	Trace
Pyrite	FeS_2	0.7
Rutile	TiO_2	1.7
Zircon	ZrSiO_4	Trace

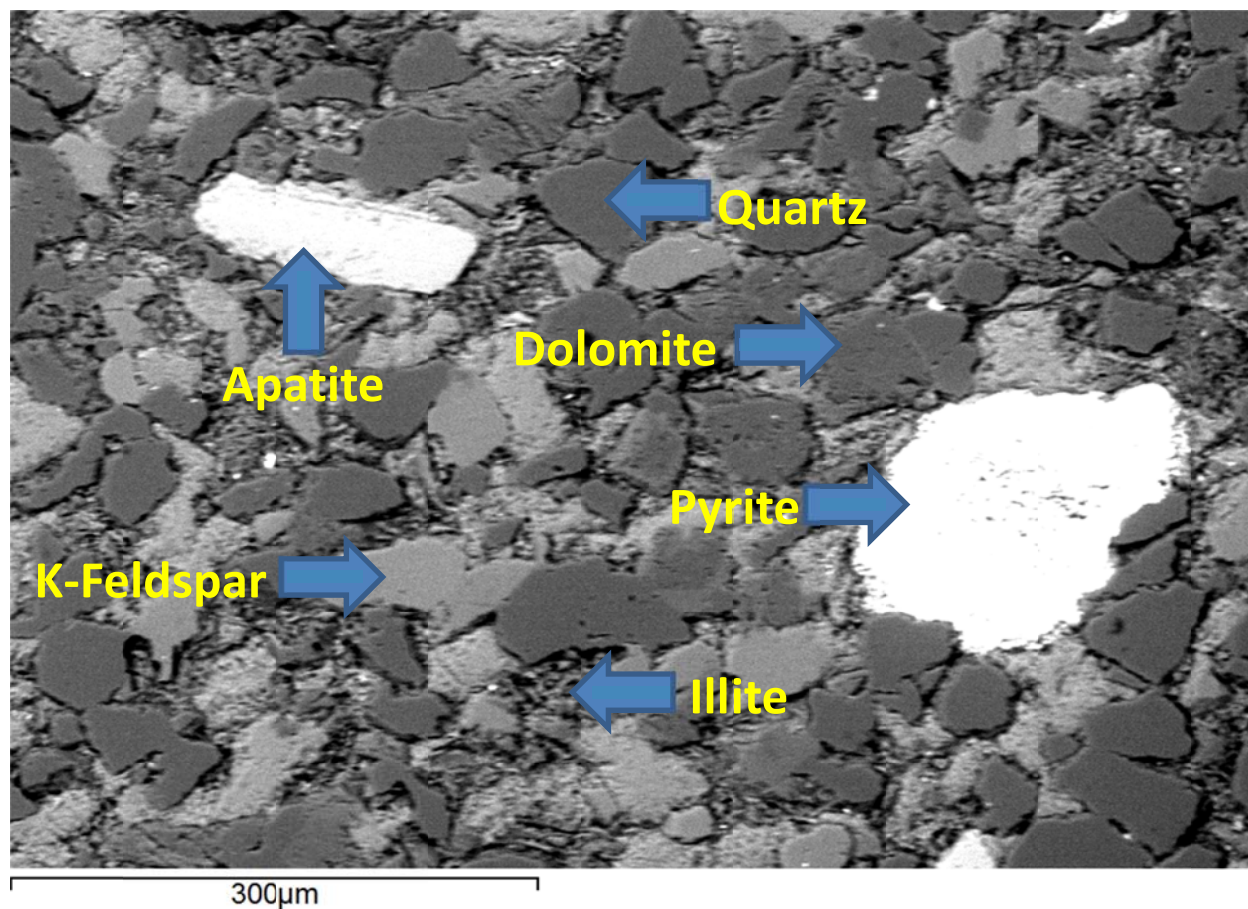
	Applied Geology Laboratory		ID: 116221
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10555.0'
	API No.: 33025002320000	Lithology: Dolomitic to calcareous siltstone	

SEM

Observed Minerals

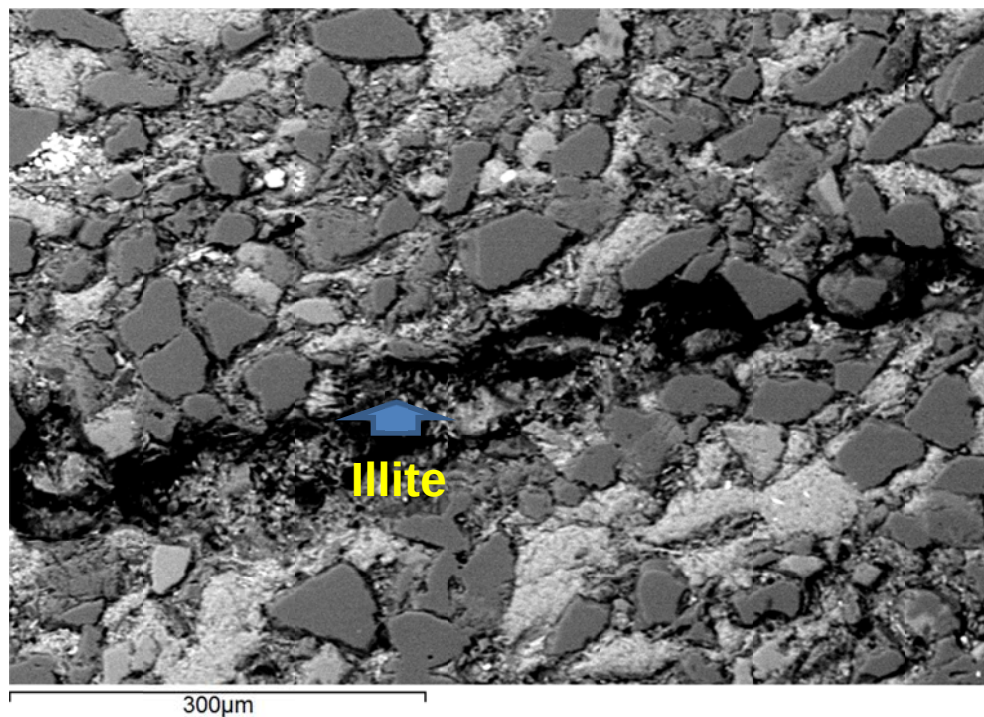
Mineral Phase	Mineral Phase
Calcite	K-Feldspar
Dolomite	Apatite
Quartz	Halite
Pyrite	Rutile
Illite	Zircon

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified

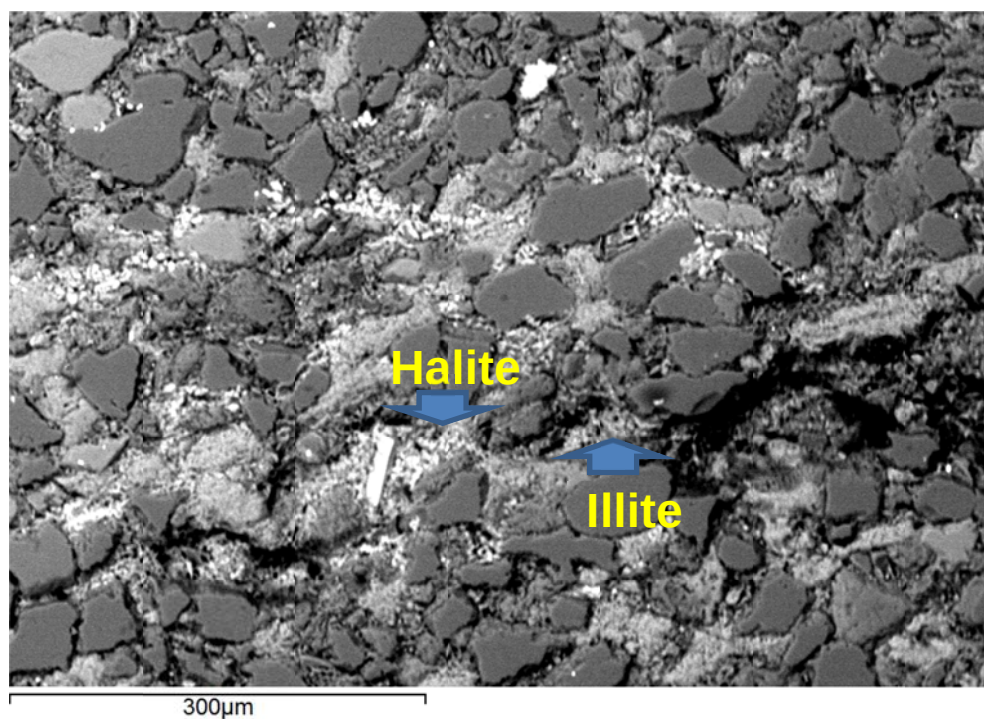


	Applied Geology Laboratory		ID: 116221
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10555.0'
	API No.: 33025002320000	Lithology: Dolomitic to calcareous siltstone	

Fracture Analysis on BSE Images



Illite is filling in the fracture.



Halite and illite fill the fracture.

	Applied Geology Laboratory		ID: 116221
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10555.0'
	API No.: 33025002320000	Lithology: Dolomitic to calcareous siltstone	

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	Applied Geology Laboratory		ID: 116222
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10559.8'
	API No.: 33025002320000		Lithology: Calcareous siltstone

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION



Depth 10559.8': Displaying beds of slightly undulating shale and silty zones. Some burrowing is present, creating lensing and globular features.

PHYSICAL PROPERTIES

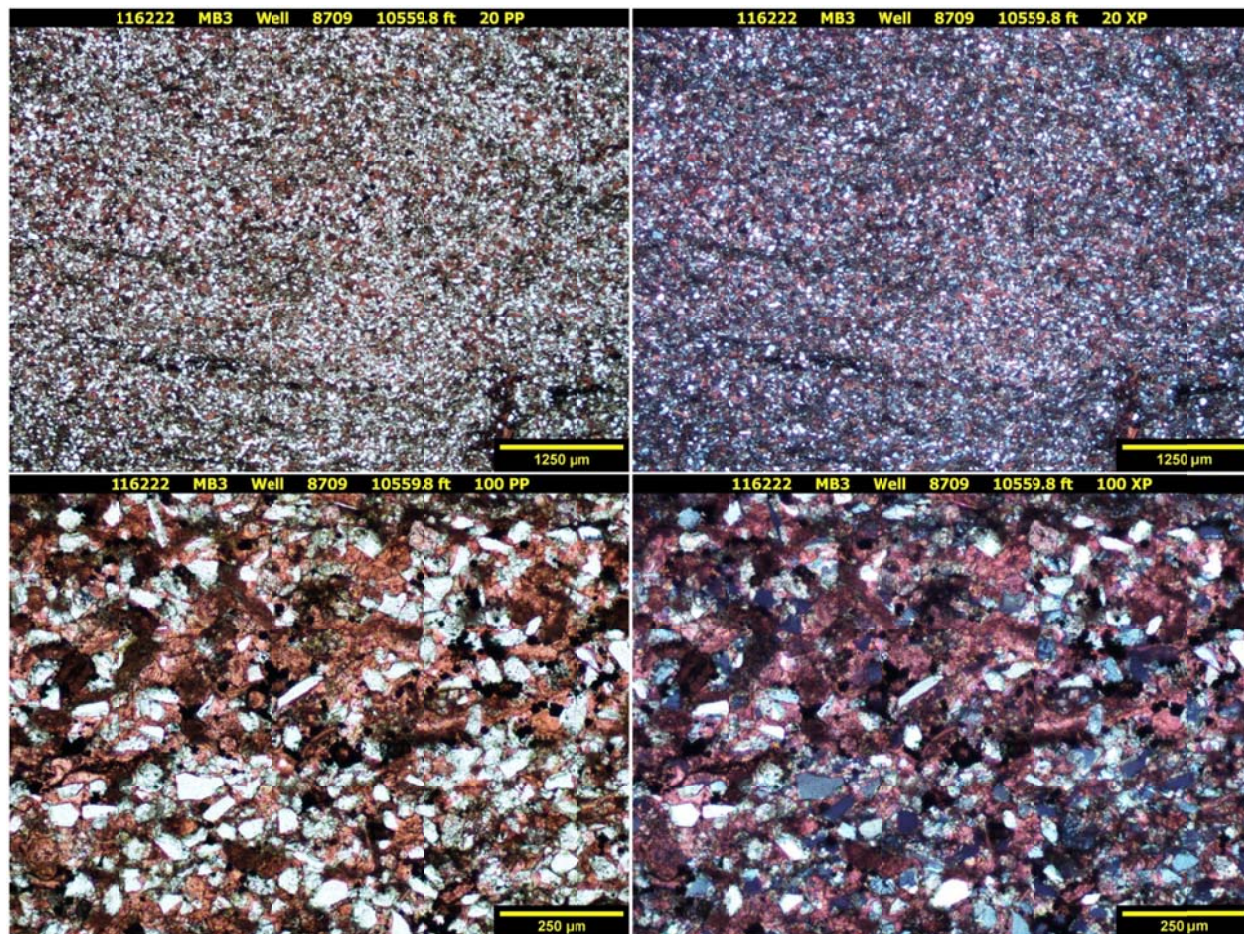
Porosity and Related Measurements Performed by MetaRock Laboratories

Pycnometer Effective Porosity, vol%	Bulk Volume, cm ³	Bulk Density, g/cm ³	Grain Volume, cm ³	Grain Density, g/cm ³
3.02	53.08	2.60	51.48	2.68

	Applied Geology Laboratory		ID: 116222
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10559.8'
	API No.: 33025002320000		Lithology: Calcareous siltstone

PHOTOMICROGRAPHS

Transmission



This sample shows calcareous siltstone. Quartz grains are monocrystalline and largely subangular to subrounded. Calcareous clasts and euhedral dolomite commonly occur. Clays and microcrystalline to cryptocrystalline dolomite compose the majority of the cementing agents. Trace amounts of feldspars and muscovite are observed. Diagenetical replacement pyrite is present repeatedly throughout the sample. Porosity is observed only by nonconnected horizontal fractures that may be the result of the coring and sampling process.

	Applied Geology Laboratory		ID: 116222
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10559.8'
	API No.: 33025002320000		Lithology: Calcareous siltstone

PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	40	Very fine grained
Calcite	20	Allochem, cement
Dolomite	15	Microcrystalline
Clay	20	
Metals	Trace	Pyrite
Muscovite	Trace	
Organics	Trace	Globular

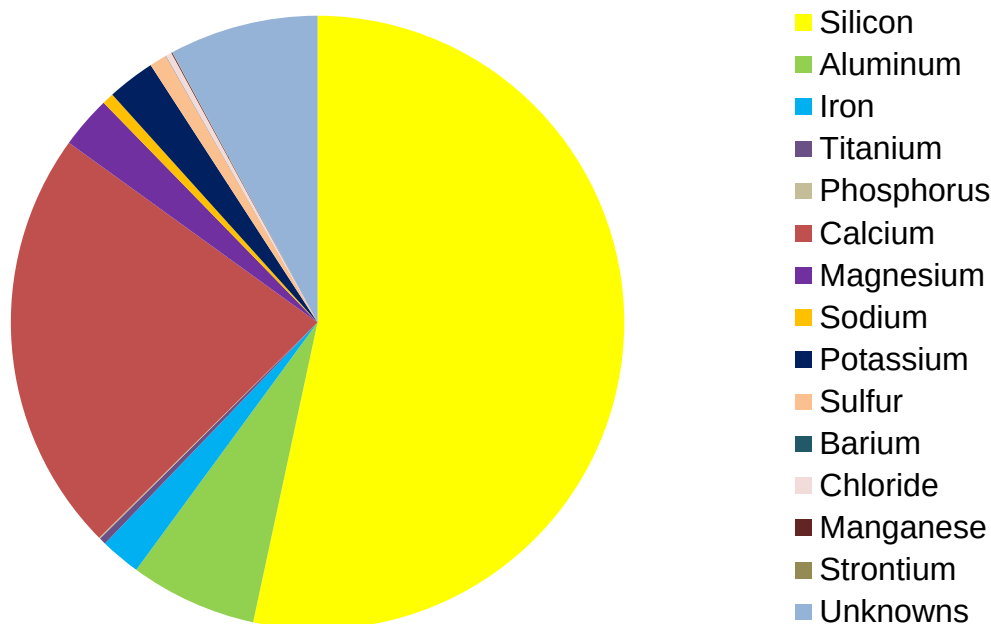
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through XRF and XRD data sets.

Detrital Texture

Category	Classification
Grain Size	Very fine
Sorting	Moderately well
Roundness	Largely subangular

	Applied Geology Laboratory		ID: 116222
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10559.8'
	API No.: 33025002320000		Lithology: Calcareous siltstone

XRF BULK CHEMICAL COMPOSITION

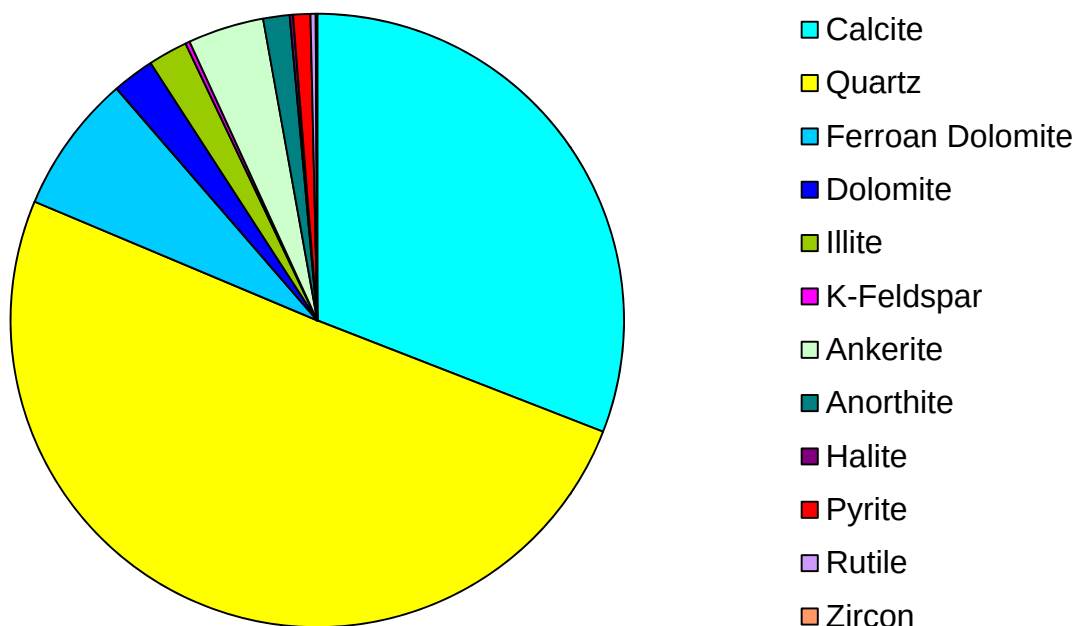


Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	53.38
Al (aluminum)	Al ₂ O ₃	6.69
Fe (iron)	Fe ₂ O ₃	2.13
Ti (titanium)	TiO ₂	0.36
P (phosphorus)	P ₂ O ₅	0.06
Ca (calcium)	CaO	22.36
Mg (magnesium)	MgO	2.75
Na (sodium)	Na ₂ O	0.62
K (potassium)	K ₂ O	2.51
S (sulfur)	SO ₃	0.92
Ba (barium)	BaO	0.02
Cl (chloride)	Cl	0.31
Mn (manganese)	MnO	0.05
Sr (strontium)	SrO	0.02
Unknowns	Due to the presence of carbonates*	7.84
Total		100.02

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

	Applied Geology Laboratory		ID: 116222
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10559.8'
	API No.: 33025002320000		Lithology: Calcareous siltstone

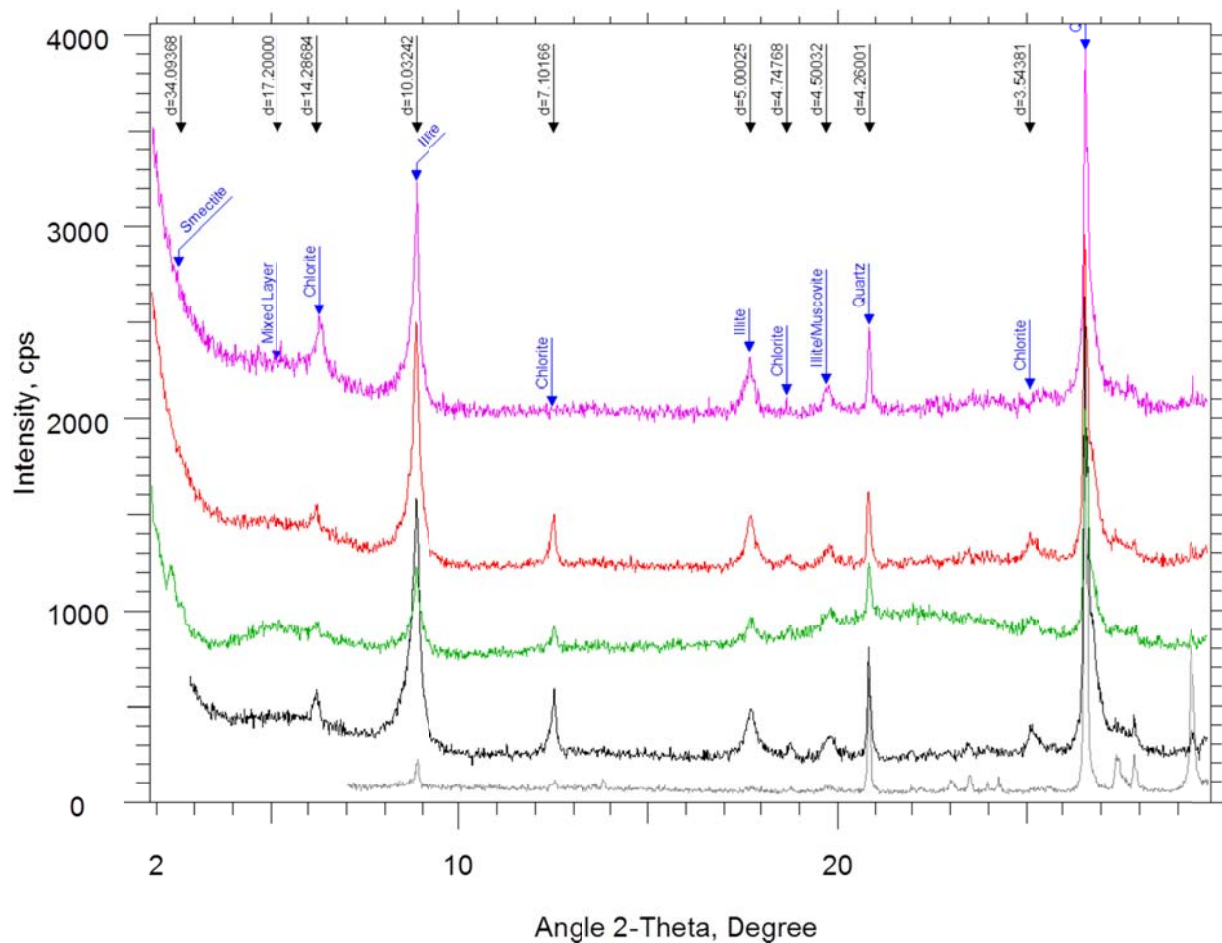
XRD MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	30.9
Quartz	SiO_2	50.4
Ferroan Dolomite	$\text{CaMg}_{0.8}\text{Fe}_{0.2}(\text{CO}_3)_2$	7.3
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	2.2
Illite	$(\text{K},\text{H}_3\text{O})(\text{Al},\text{Mg},\text{Fe})_2(\text{Si},\text{Al})_4\text{O}_{10}[(\text{OH})_2,(\text{H}_2\text{O})]$	2.1
K-Feldspar	KAlSi_3O_8	Trace
Ankerite	$\text{CaMg}_{0.45}\text{Fe}_{0.55}(\text{CO}_3)_2$	4.0
Anorthite	$\text{CaAl}_2\text{Si}_2\text{O}_4$	1.4
Halite	NaCl	Trace
Pyrite	FeS_2	0.9
Rutile	TiO_2	Trace
Zircon	ZrSiO_4	Trace

	Applied Geology Laboratory		ID: 116222
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10559.8'
	API No.: 33025002320000		Lithology: Calcareous siltstone

XRD Clay Typing



Clays Identified

Illite
Chlorite
Smectite
Mixed-layer clay

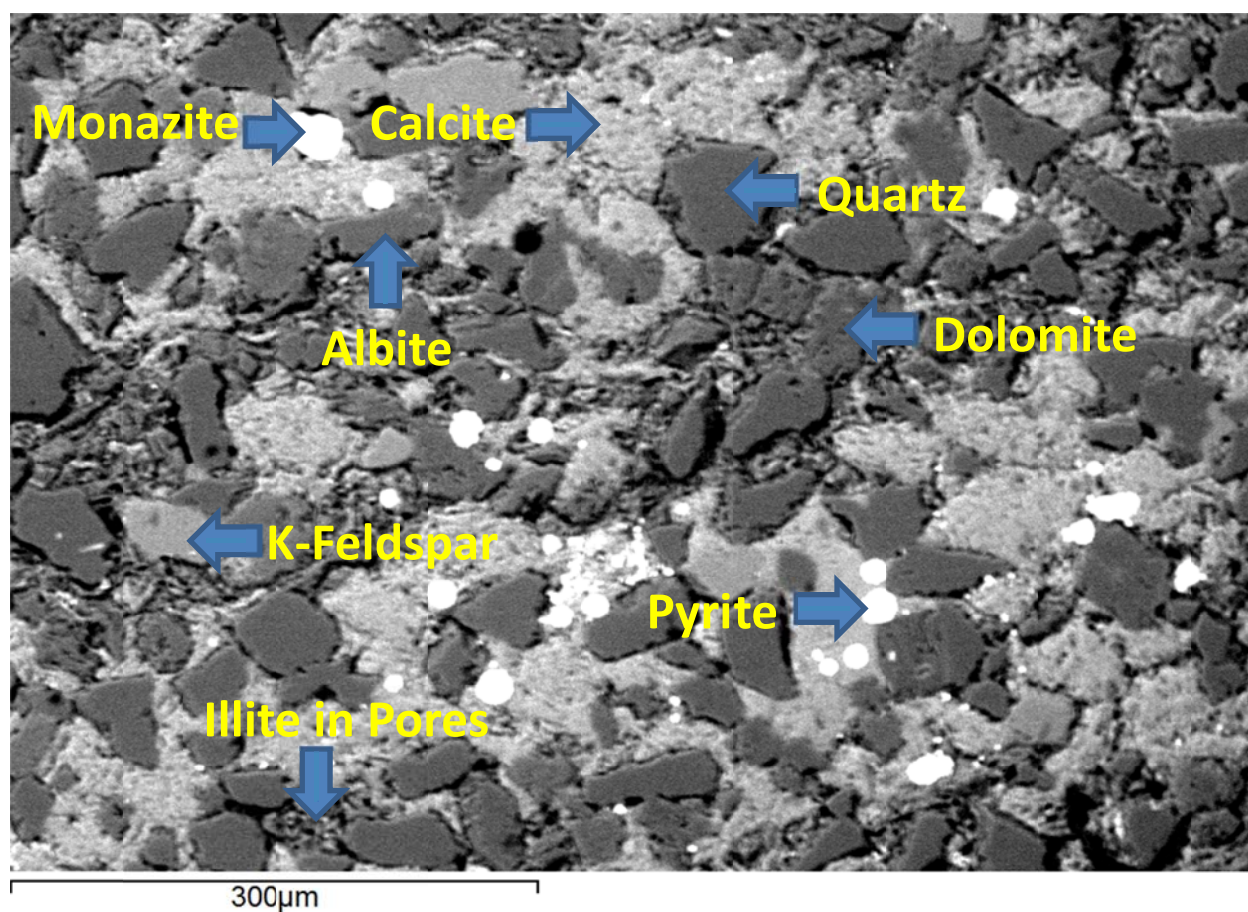
	Applied Geology Laboratory		ID: 116222
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10559.8'
	API No.: 33025002320000		Lithology: Calcareous siltstone

SEM

Observed Minerals

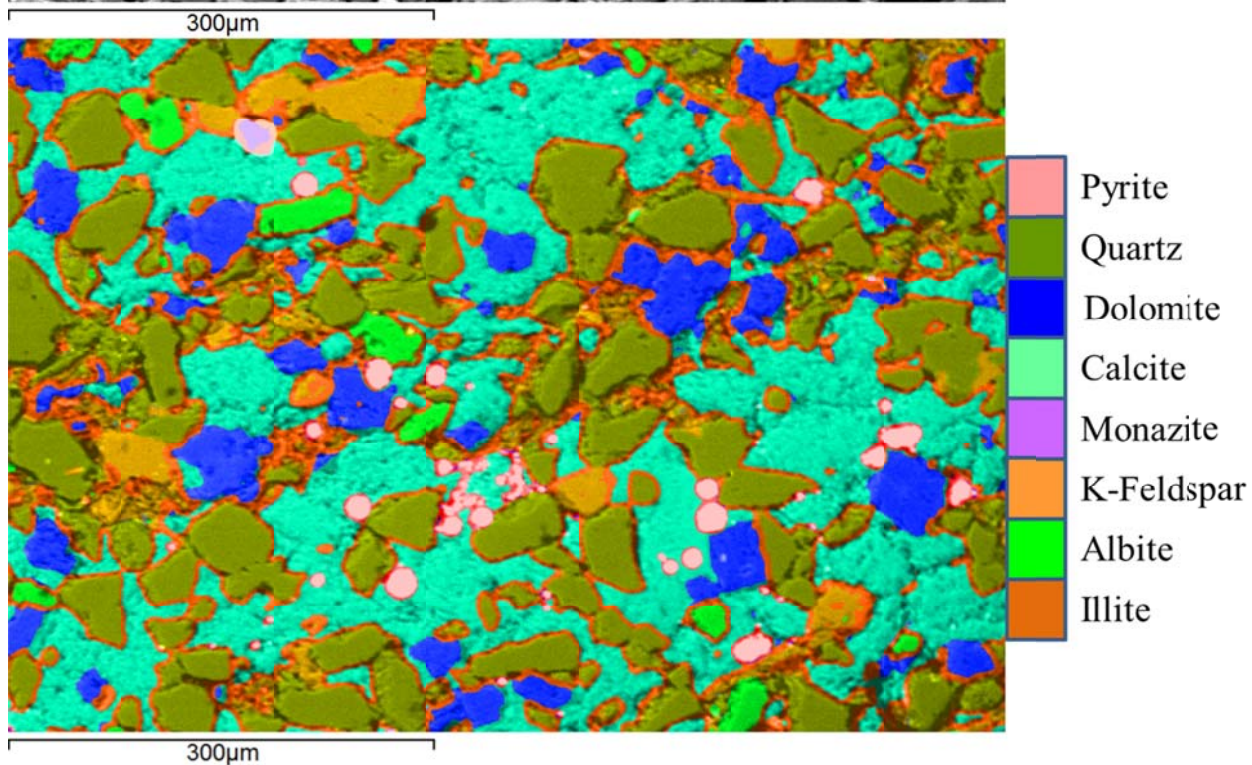
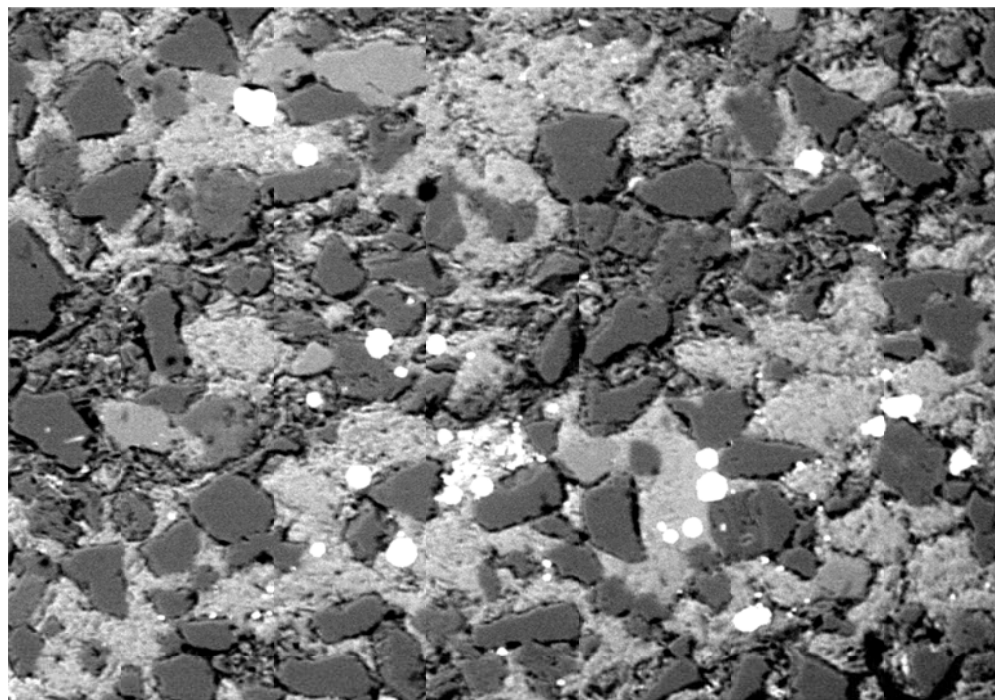
Mineral Phase	Mineral Phase
Calcite	Rutile
Quartz	Illite
K-Feldspar	Zircon
Halite	Monazite
Dolomite	Albite
Pyrite	Chromite

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified



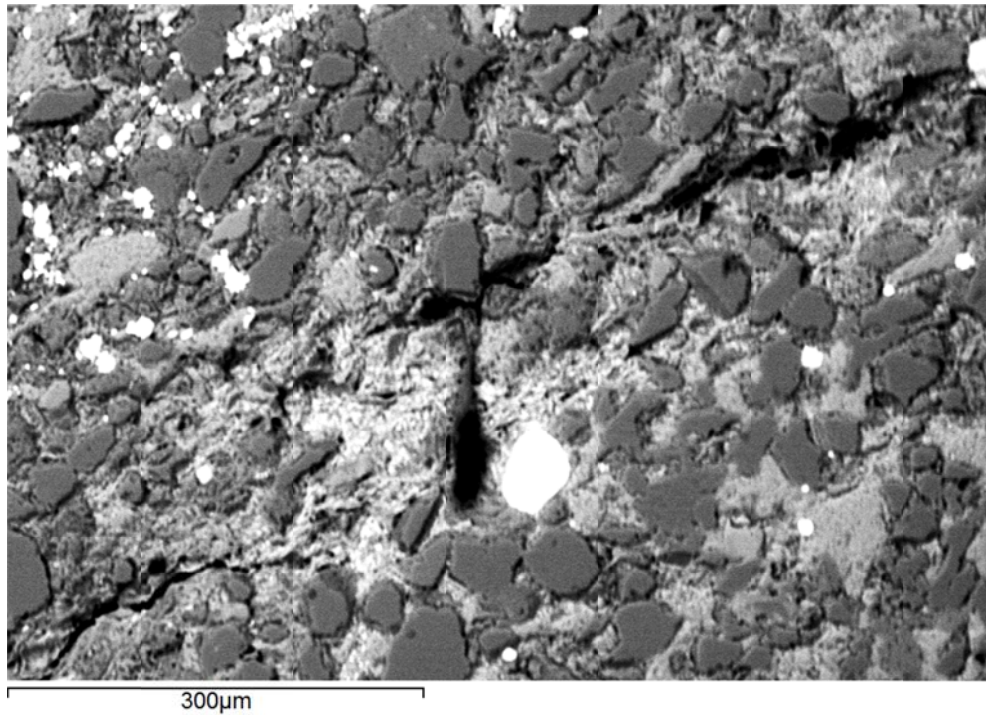
	Applied Geology Laboratory		ID: 116222
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10559.8'
	API No.: 33025002320000		Lithology: Calcareous siltstone

SEM BSE Image and Corresponding Digital Mineral Map Overlaid on BSE Image

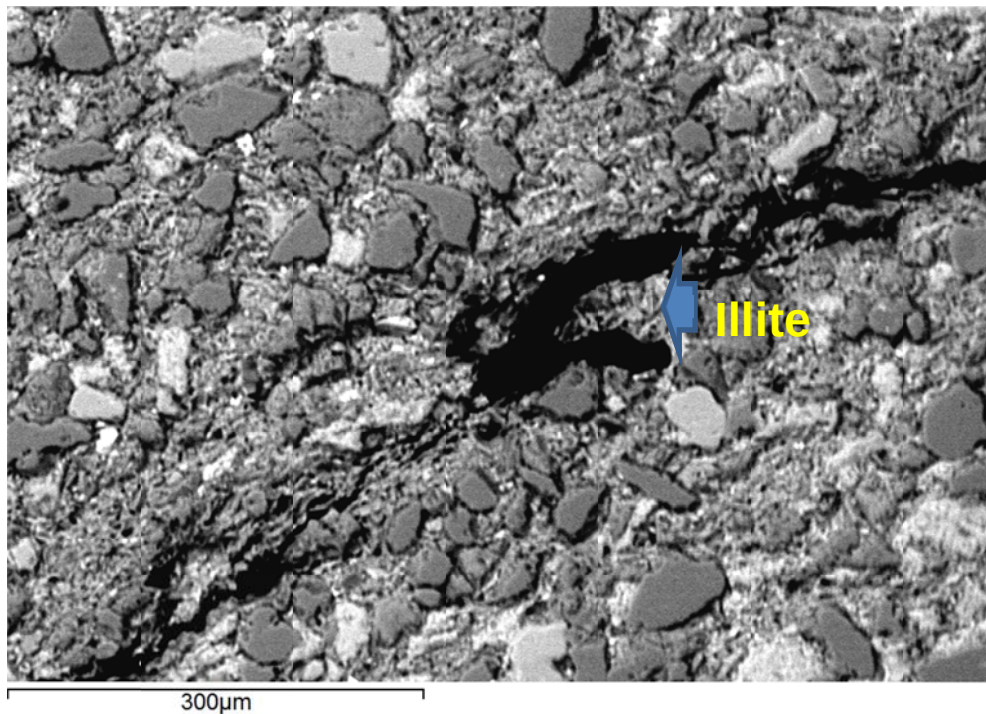


	Applied Geology Laboratory		ID: 116222
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10559.8'
	API No.: 33025002320000		Lithology: Calcareous siltstone

Fracture Analysis on BSE Images



Halite and illite are noted as material in the fracture.



Illite has started to fill the fracture.

	Applied Geology Laboratory		ID: 116222
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10559.8'
	API No.: 33025002320000		Lithology: Calcareous siltstone

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	Applied Geology Laboratory		ID: 116223
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10561.1'
	API No.: 33025002320000	Lithology: Calcareous to dolomitic siltstone	

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION



Depth 10561.1': A thinly rhythmic laminated siltstone. Bedding is angled.

PHYSICAL PROPERTIES

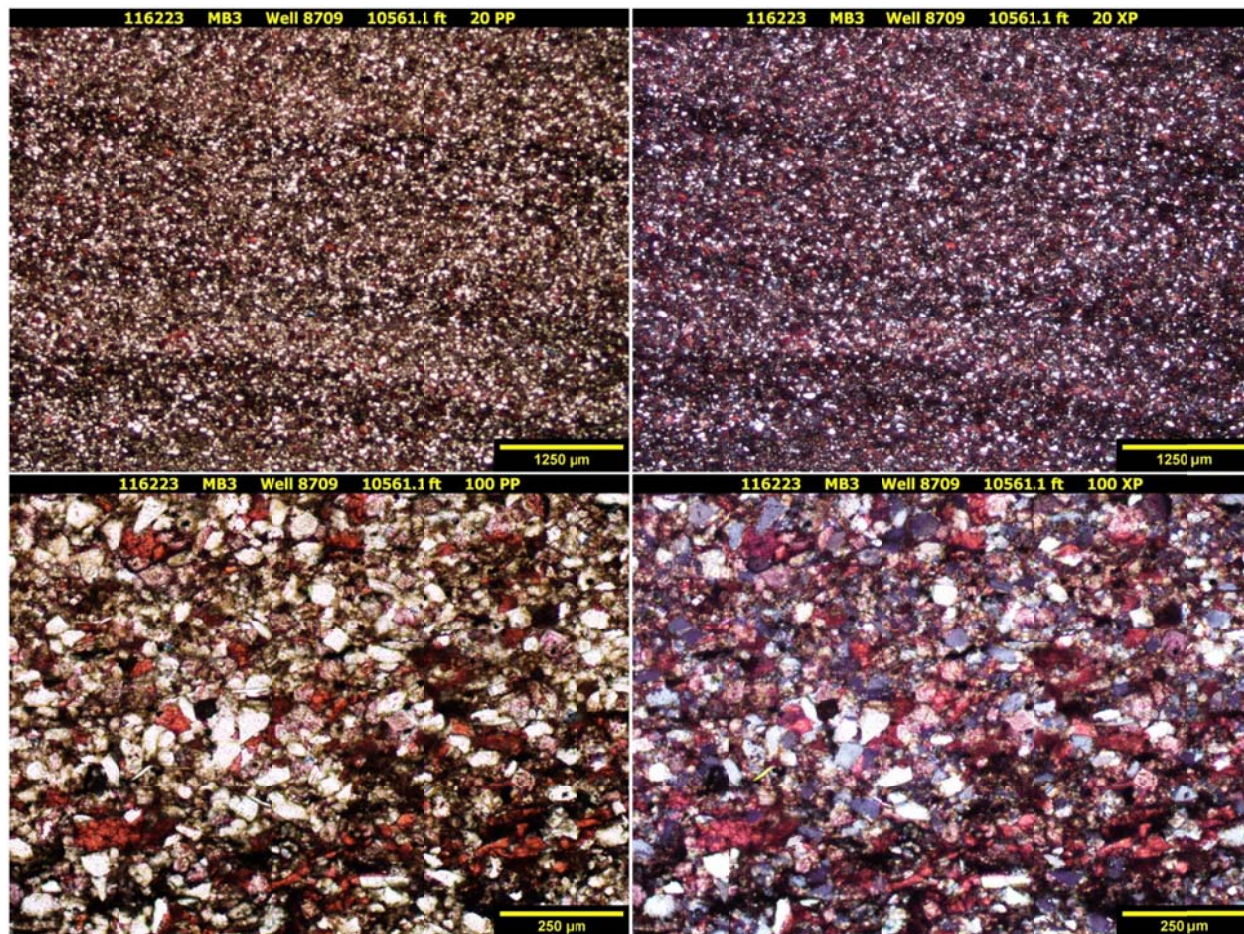
Porosity and Related Measurements Performed by MetaRock Laboratories

Pycnometer Effective Porosity, vol%	Bulk Volume, cm ³	Bulk Density, g/cm ³	Grain Volume, cm ³	Grain Density, g/cm ³
5.03	54.16	2.54	51.44	2.68

	Applied Geology Laboratory		ID: 116223
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10561.1'
	API No.: 33025002320000		Lithology: Calcareous to dolomitic siltstone

PHOTOMICROGRAPHS

Transmission



This sample expresses calcareous to dolomitic siltstone. Quartz grains are monocrystalline and largely subangular to subrounded. Abundant amounts of calcareous clast have been preserved. Some partial pyrite replacement has occurred within allochems. Trace amounts of feldspars and moderately well orientated muscovite are noted. Rare levels of ankerite or perhaps ferroan calcite are present. Concentrations of clays and finely crystalline dolomitic are found randomly throughout the sample. Weak, slightly wavy laminations of clays, organics, and pyrite concentrations occur throughout the section. Sporadic dolomite rhombs are observed. By traditional optical methods, only trace amounts of interparticle porosity are seen. No natural fractures are detected.

	Applied Geology Laboratory		ID: 116223
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10561.1'
	API No.: 33025002320000	Lithology: Calcareous to dolomitic siltstone	

PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	60	Very fine grained
Calcite	10	Clasts
Dolomite	15	Microcrystalline, euhedral
Clay	10	
Metals	Trace	Pyrite
Muscovite	Trace	
Organics	Trace	Globular

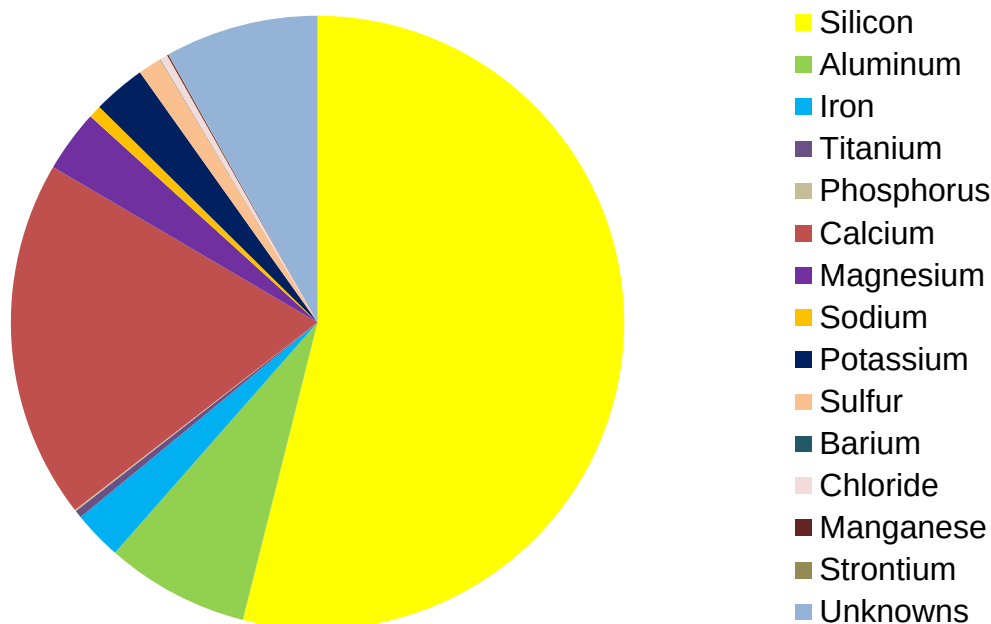
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through XRF and XRD data sets.

Detrital Texture

Category	Classification
Grain Size	Very fine
Sorting	Well
Roundness	Subangular to subrounded

	Applied Geology Laboratory		ID: 116223
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10561.1'
	API No.: 33025002320000	Lithology: Calcareous to dolomitic siltstone	

XRF BULK CHEMICAL COMPOSITION

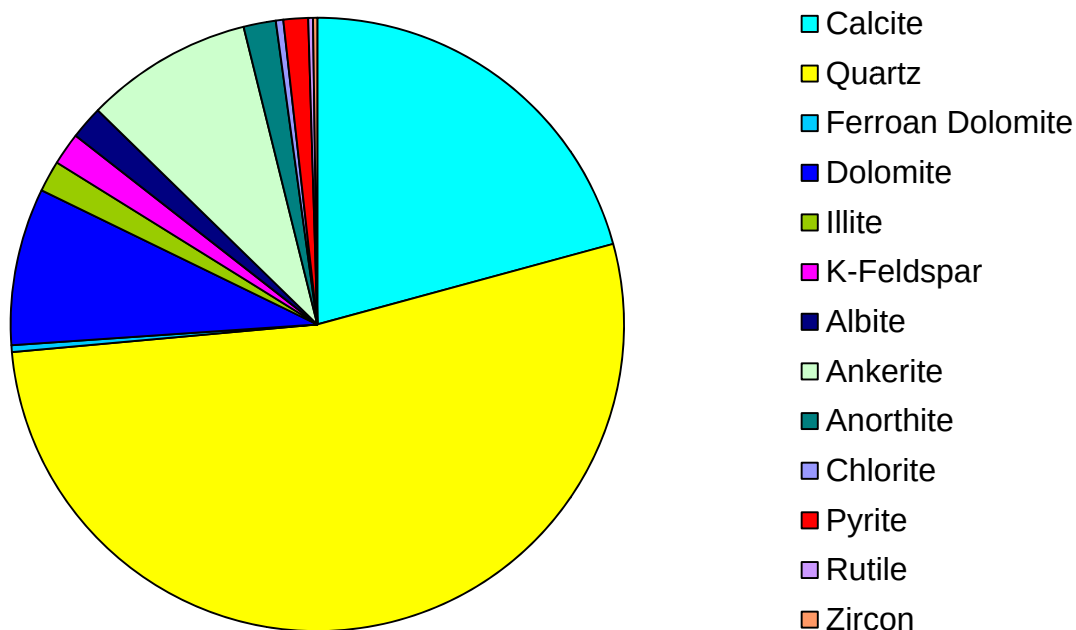


Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	53.92
Al (aluminum)	Al ₂ O ₃	7.57
Fe (iron)	Fe ₂ O ₃	2.57
Ti (titanium)	TiO ₂	0.40
P (phosphorus)	P ₂ O ₅	0.08
Ca (calcium)	CaO	18.92
Mg (magnesium)	MgO	3.28
Na (sodium)	Na ₂ O	0.67
K (potassium)	K ₂ O	2.77
S (sulfur)	SO ₃	1.24
Ba (barium)	BaO	0.02
Cl (chloride)	Cl	0.41
Mn (manganese)	MnO	0.07
Sr (strontium)	SrO	0.02
Unknowns	Due to the presence of carbonates*	8.07
Total		100.01

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

	Applied Geology Laboratory		ID: 116223
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10561.1'
	API No.: 33025002320000		Lithology: Calcareous to dolomitic siltstone

XRD MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	20.8
Quartz	SiO_2	52.8
Ferroan Dolomite	$\text{CaMg}_{0.8}\text{Fe}_{0.2}(\text{CO}_3)_2$	Trace
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	8.3
Illite	$(\text{K}, \text{H}_3\text{O})(\text{Al}, \text{Mg}, \text{Fe})_2(\text{Si}, \text{Al})_4\text{O}_{10}[(\text{OH})_2, (\text{H}_2\text{O})]$	1.7
K-Feldspar	KAlSi_3O_8	1.7
Albite	$\text{NaAlSi}_3\text{O}_8$	1.7
Ankerite	$\text{CaMg}_{0.45}\text{Fe}_{0.55}(\text{CO}_3)_2$	8.8
Anorthite	$\text{CaAl}_2\text{Si}_2\text{O}_4$	1.7
Chlorite	$\text{Mg}_{2.96}\text{Fe}_{1.55}\text{Fe}_{0.14}\text{Al}_{1.28}(\text{Si}_{2.62}\text{Al}_{1.38}\text{O}_{10})(\text{OH})_8$	Trace
Pyrite	FeS_2	1.3
Rutile	TiO_2	Trace
Zircon	ZrSiO_4	Trace

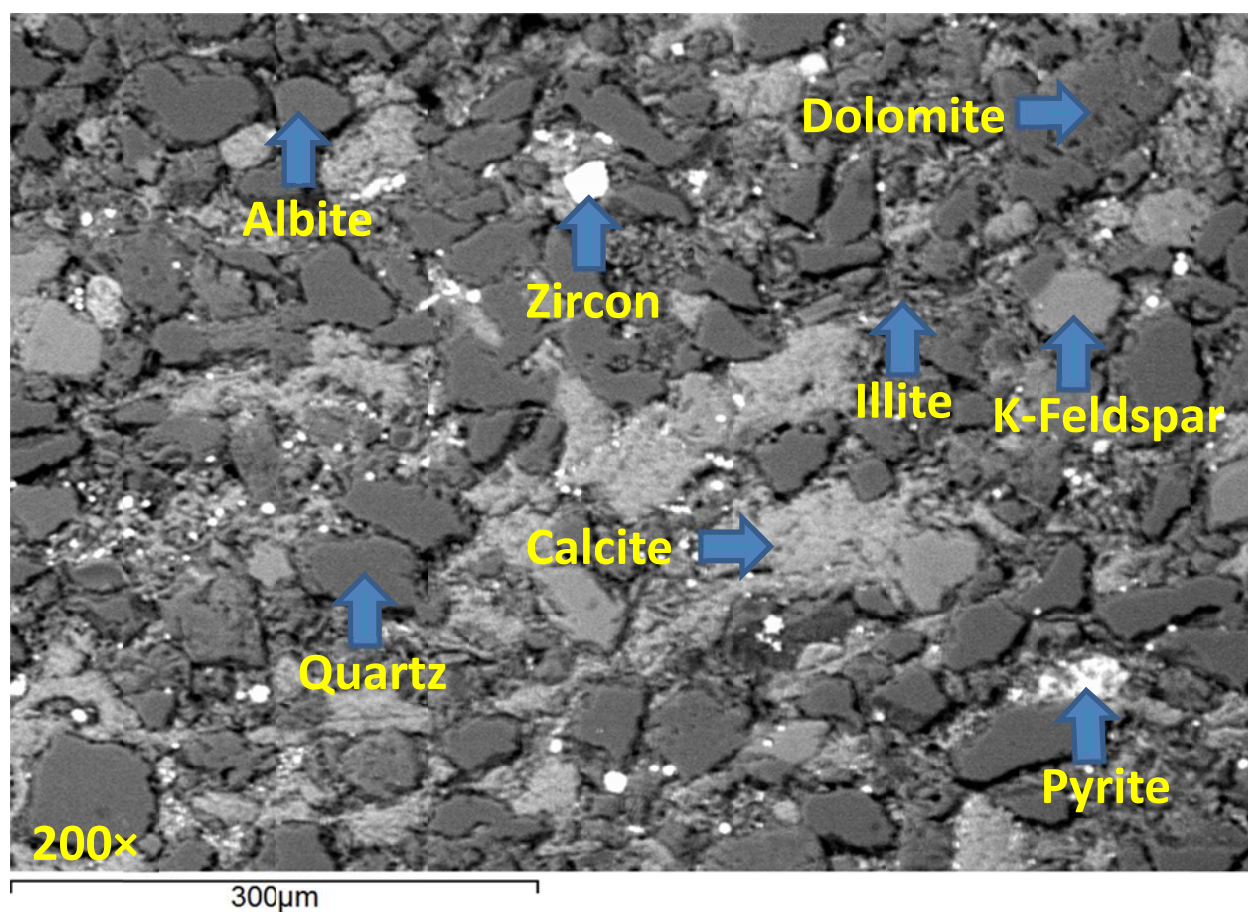
	Applied Geology Laboratory		ID: 116223
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10561.1'
	API No.: 33025002320000	Lithology: Calcareous to dolomitic siltstone	

SEM

Observed Minerals

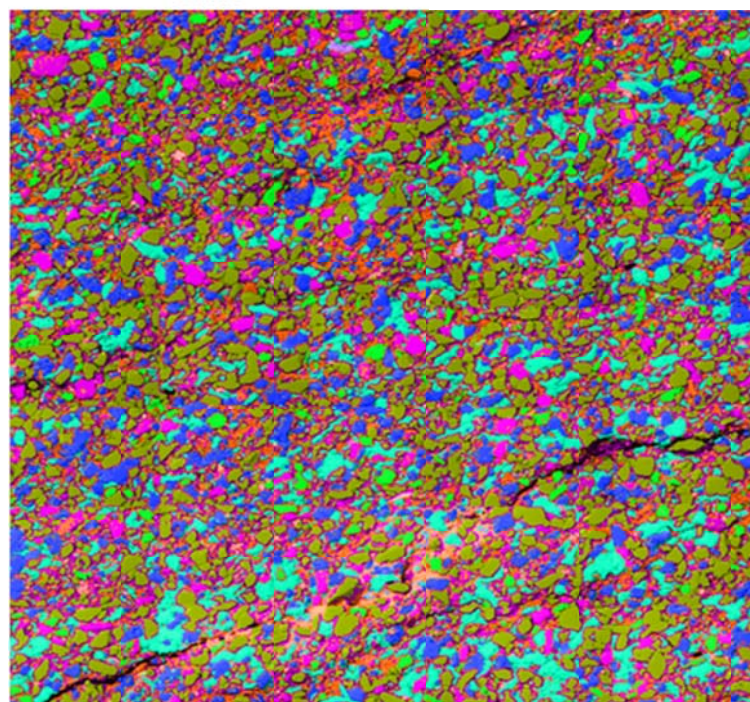
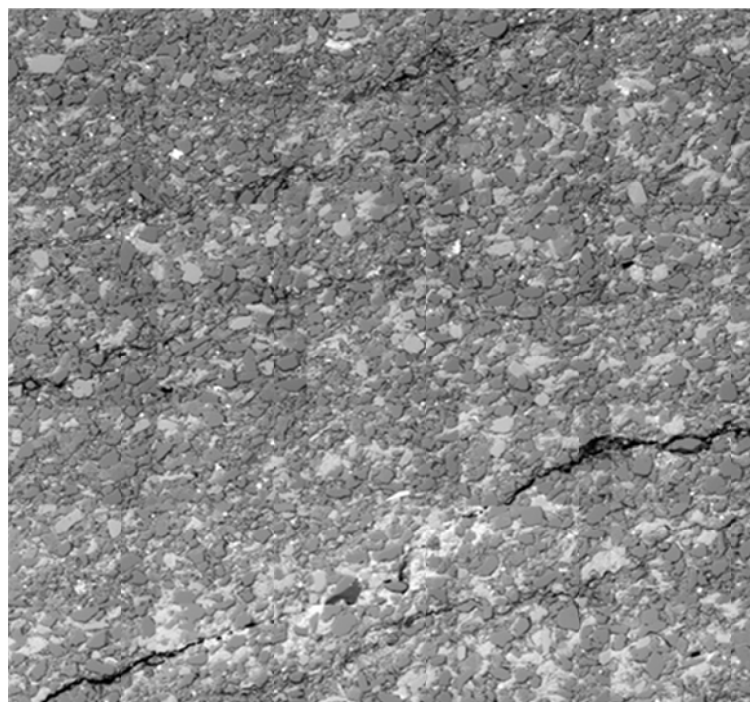
Mineral Phase	Mineral Phase
Calcite	Illite
Quartz	Halite
Dolomite	Pyrite
K-Feldspar	Zircon
Rutile	Albite
Apatite	

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified



	Applied Geology Laboratory		ID: 116223
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10561.1'
	API No.: 33025002320000	Lithology: Calcareous to dolomitic siltstone	

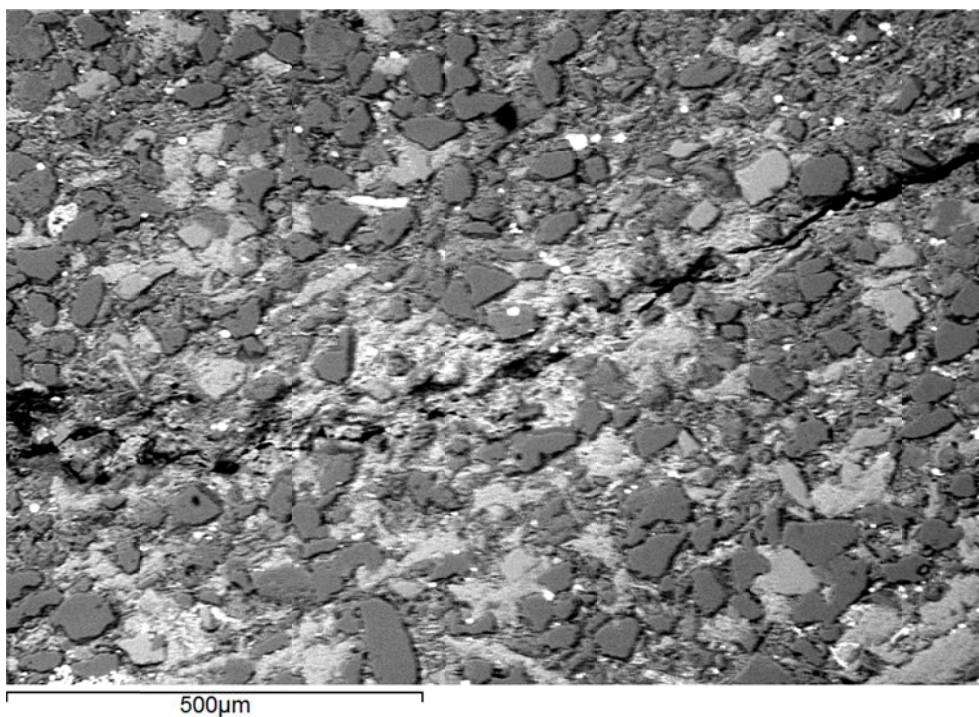
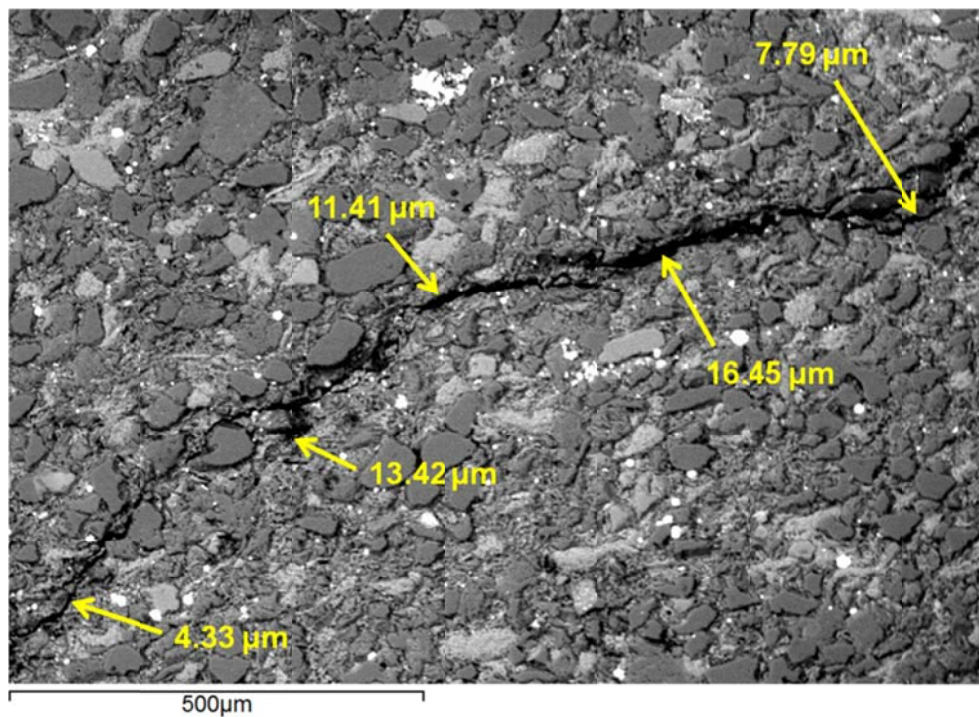
SEM BSE Image and Corresponding Digital Composite Mineral Map Image Overlaid on BSE Image with Mineral-Phase 2-D Area Percentages



	Pyrite – 0.9%
	Dolomite – 13.0%
	Calcite – 13.1%
	Albite – 4.6%
	Quartz – 28.4%
	K-Feldspar – 22.5%
	Illite – 17.4%
	Apatite – 0.1%

	Applied Geology Laboratory		ID: 116223
	Middle Bakken 3	NDIC Well 8709, Burbank BIA 23-8	Depth: 10561.1'
	API No.: 33025002320000		Lithology: Calcareous to dolomitic siltstone

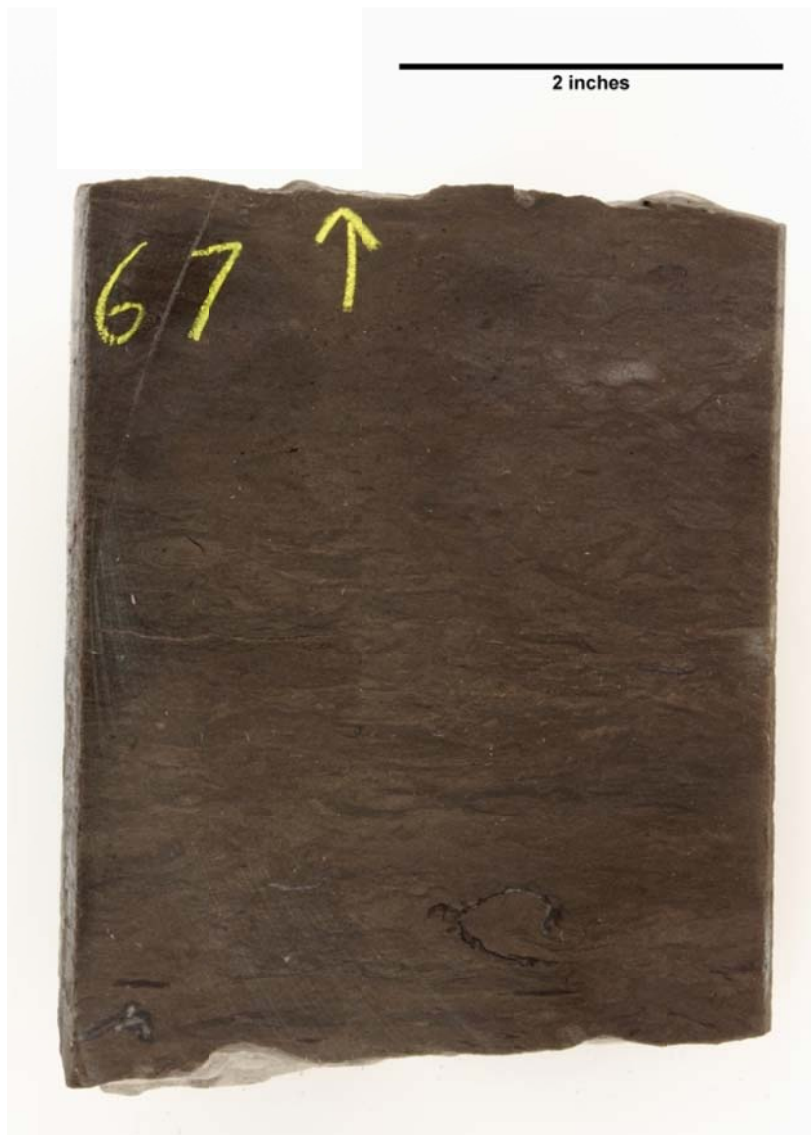
Fracture Analysis on BSE Images



The fracture is nearly filled with halite and illite.

	Applied Geology Laboratory		ID: 116224
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10567.0'
	API No.: 33025002320000	Lithology: Slightly argillaceous, calcareous siltstone	

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION



Depth 10567.0': A mottled fossiliferous siltstone. Brachiopods and helminthopsis/sclerituba are present.

PHYSICAL PROPERTIES

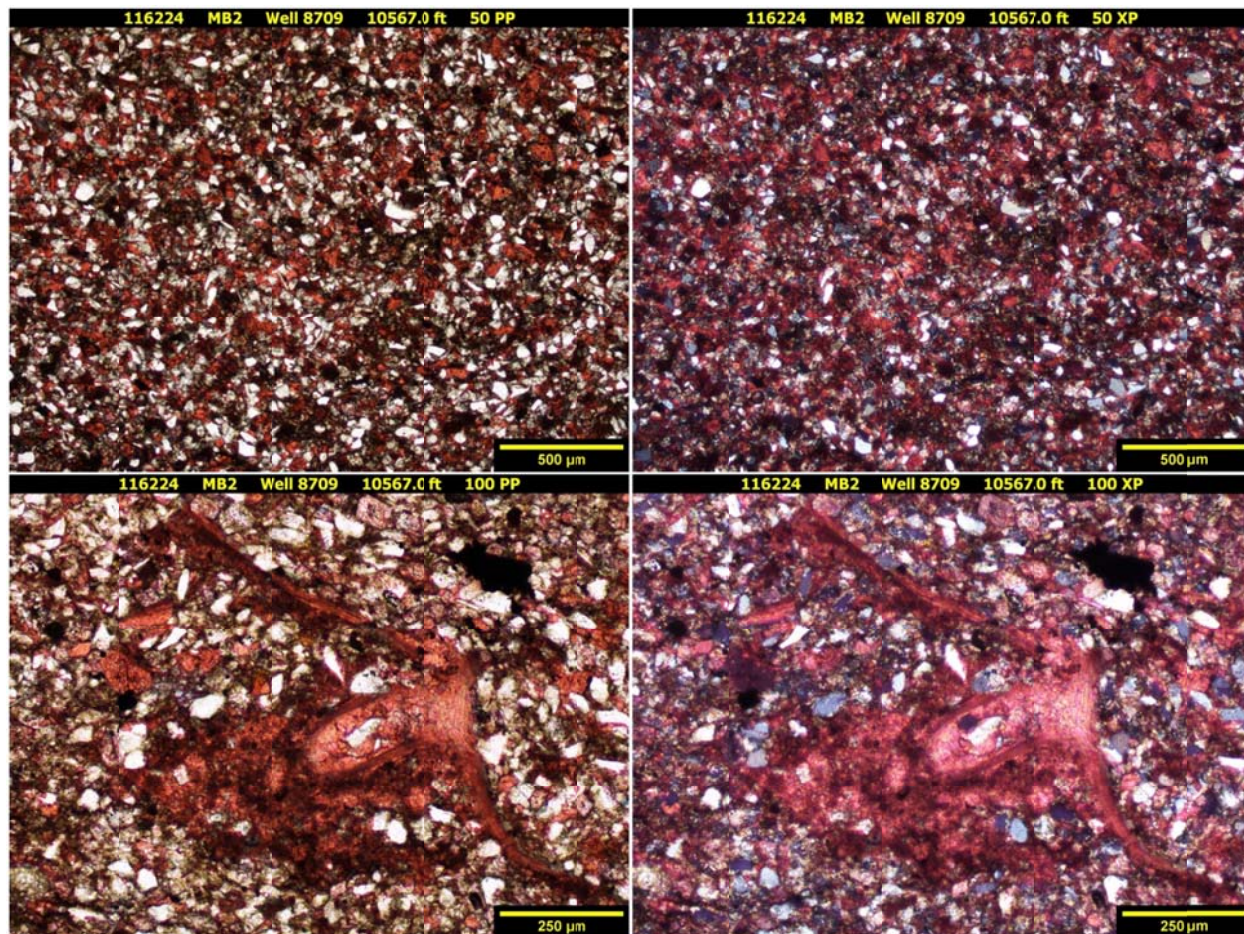
Porosity and Related Measurements Performed by MetaRock Laboratories

Pycnometer Effective Porosity, vol%	Bulk Volume, cm ³	Bulk Density, g/cm ³	Grain Volume, cm ³	Grain Density, g/cm ³
3.75	53.17	2.57	51.18	2.67

	Applied Geology Laboratory		ID: 116224
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10567.0'
	API No.: 33025002320000	Lithology: Slightly argillaceous, calcareous siltstone	

PHOTOMICROGRAPHS

Transmission



This calcareous, slightly argillaceous siltstone has monocrystalline, subangular to subrounded quartz grains. Common calcareous bioclast and sparry and micritic clasts are observed. Portions of fossils have been replaced by pyrite, anhydrite, and gypsum. Open horizontal fractures represent the only visible porosity; additional fractures noted are filled with an opaque composition and are shorter, with smaller apertures. Trace levels of feldspars and muscovite are observed.

	Applied Geology Laboratory		ID: 116224
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10567.0'
	API No.: 33025002320000	Lithology: Slightly argillaceous, calcareous siltstone	

PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	40	Very fine grained
Calcite	40	Clasts and bioclasts
Dolomite	10	Microcrystalline
Clay	5	Zonally concentrated
Salts	Trace	Anhydrite, gypsum
Metals	Trace	Pyrite
Muscovite	Trace	Random orientation
Organics	Trace	Globular, within laminations

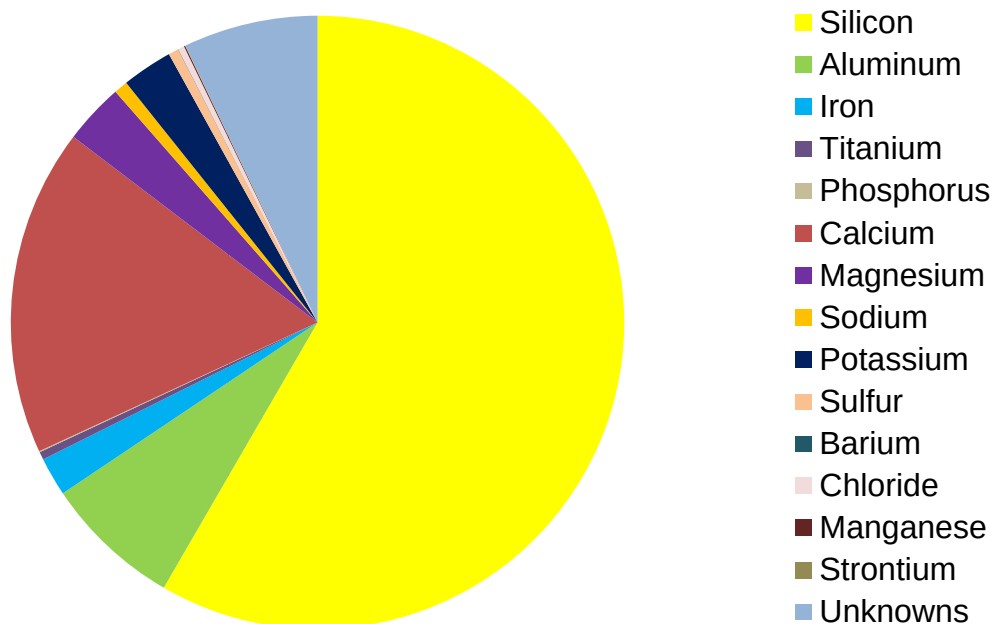
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through XRF and XRD data sets.

Detrital Texture

Category	Classification
Grain Size	Very fine
Sorting	Well
Roundness	Largely subangular

	Applied Geology Laboratory		ID: 116224
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10567.0'
	API No.: 33025002320000	Lithology: Slightly argillaceous, calcareous siltstone	

XRF BULK CHEMICAL COMPOSITION

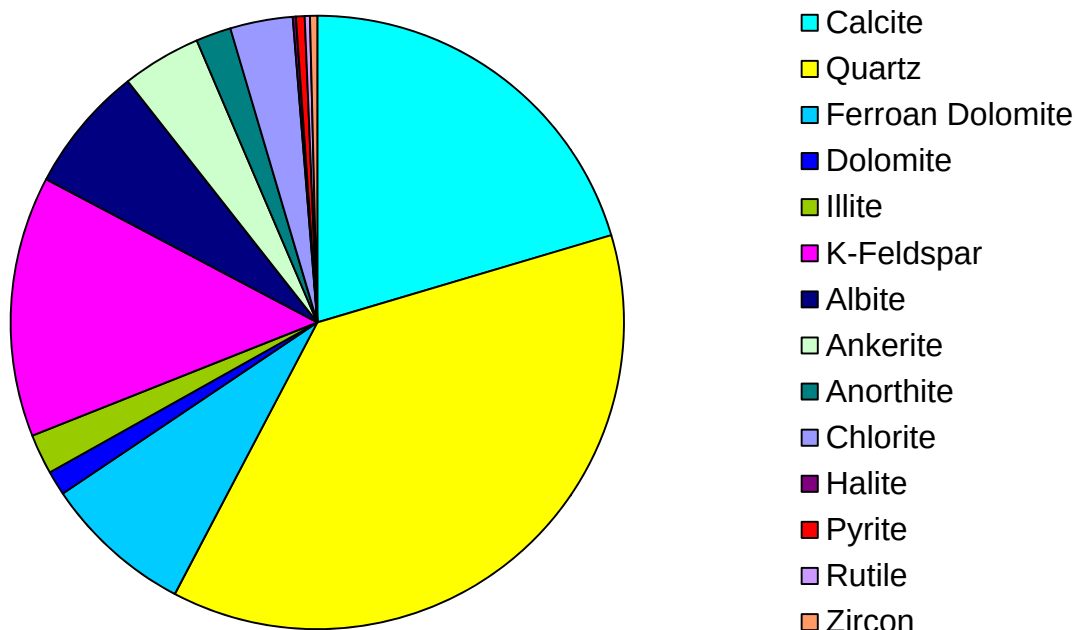


Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	58.38
Al (aluminum)	Al ₂ O ₃	7.24
Fe (iron)	Fe ₂ O ₃	2.04
Ti (titanium)	TiO ₂	0.41
P (phosphorus)	P ₂ O ₅	0.06
Ca (calcium)	CaO	17.25
Mg (magnesium)	MgO	3.21
Na (sodium)	Na ₂ O	0.73
K (potassium)	K ₂ O	2.67
S (sulfur)	SO ₃	0.53
Ba (barium)	BaO	0.02
Cl (chloride)	Cl	0.33
Mn (manganese)	MnO	0.06
Sr (strontium)	SrO	0.02
Unknowns	Due to the presence of carbonates*	7.09
Total		100.04

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

	Applied Geology Laboratory		ID: 116224
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10567.0'
	API No.: 33025002320000	Lithology: Slightly argillaceous, calcareous siltstone	

XRD MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	20.4
Quartz	SiO_2	37.3
Ferroan Dolomite	$\text{CaMg}_{0.8}\text{Fe}_{0.2}(\text{CO}_3)_2$	7.9
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	1.3
Illite	$(\text{K}, \text{H}_3\text{O})(\text{Al}, \text{Mg}, \text{Fe})_2(\text{Si}, \text{Al})_4\text{O}_{10}[(\text{OH})_2, (\text{H}_2\text{O})]$	2.1
K-Feldspar	KAlSi_3O_8	13.7
Albite	$\text{NaAlSi}_3\text{O}_8$	6.7
Ankerite	$\text{CaMg}_{0.45}\text{Fe}_{0.55}(\text{CO}_3)_2$	4.2
Anorthite	$\text{CaAl}_2\text{Si}_2\text{O}_4$	1.9
Chlorite	$\text{Mg}_{2.96}\text{Fe}_{1.55}\text{Fe}_{0.14}\text{Al}_{1.28}(\text{Si}_{2.62}\text{Al}_{1.38}\text{O}_{10})(\text{OH})_8$	3.3
Halite	NaCl	Trace
Pyrite	FeS_2	Trace
Rutile	TiO_2	Trace
Zircon	ZrSiO_4	Trace

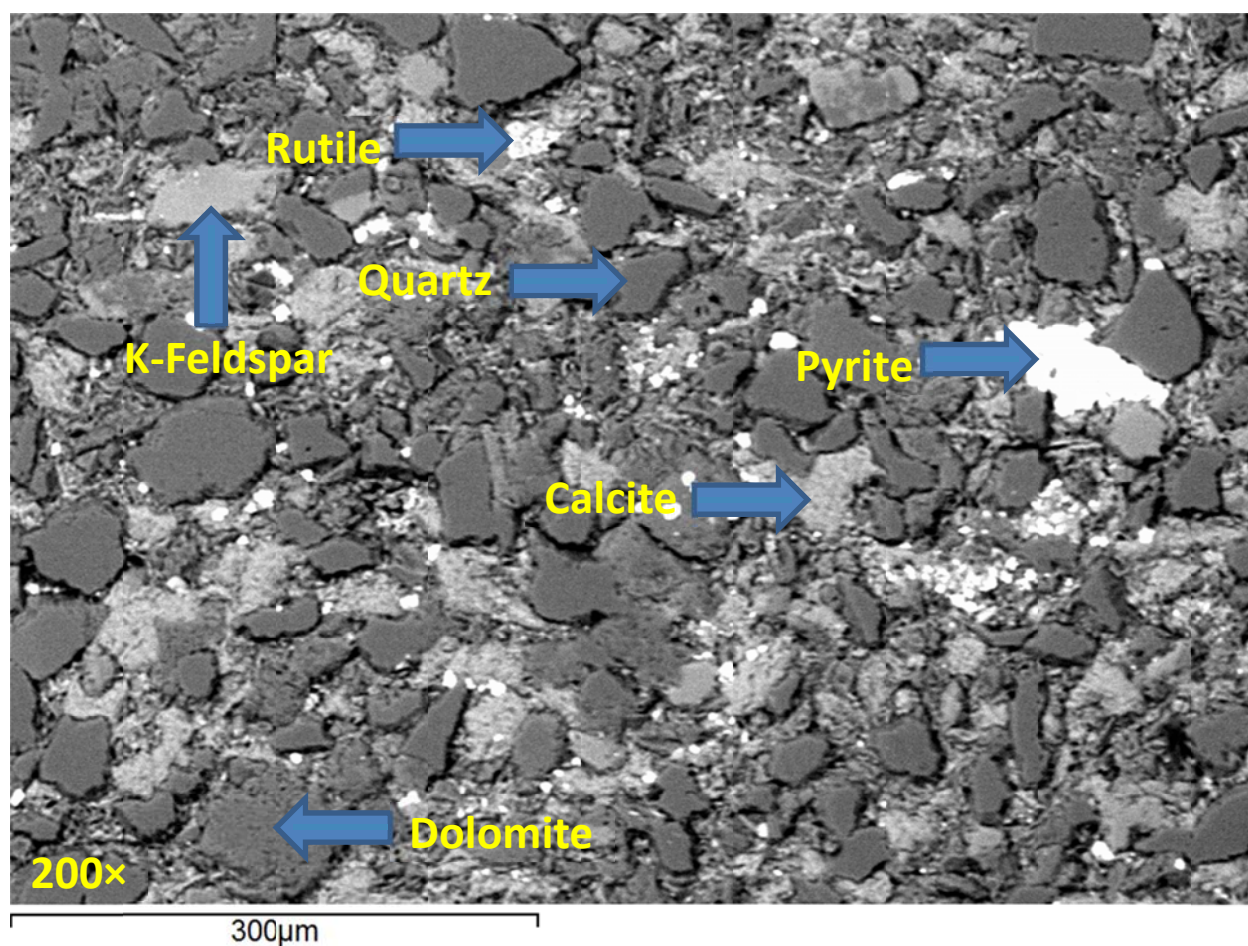
	Applied Geology Laboratory		ID: 116224
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10567.0'
	API No.: 33025002320000	Lithology: Slightly argillaceous, calcareous siltstone	

SEM

Observed Minerals

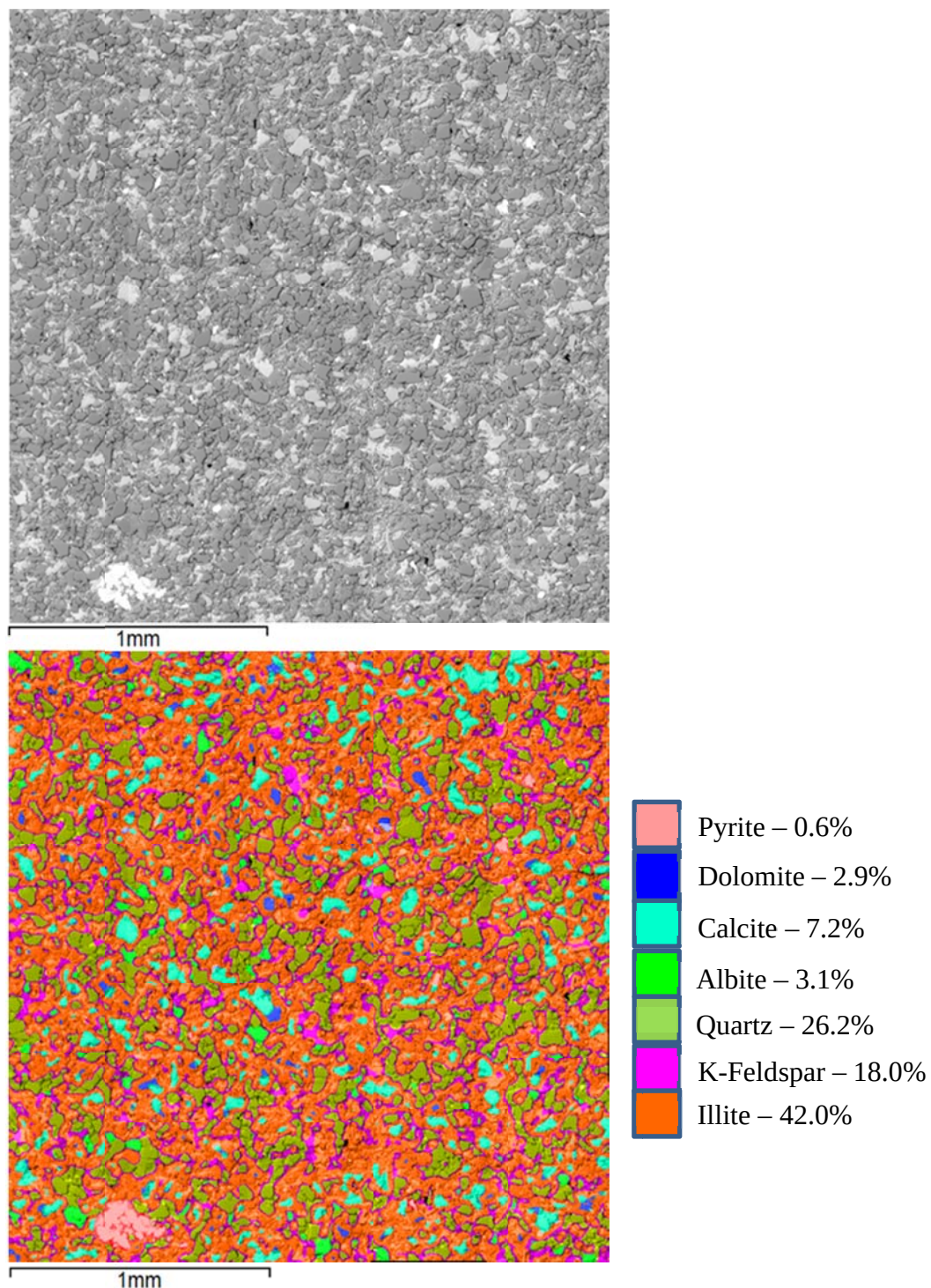
Mineral Phase	Mineral Phase
Calcite	Rutile
Quartz	Zircon
Pyrite	Albite
K-Feldspar	Halite
Dolomite	Chromite
Illite	

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified



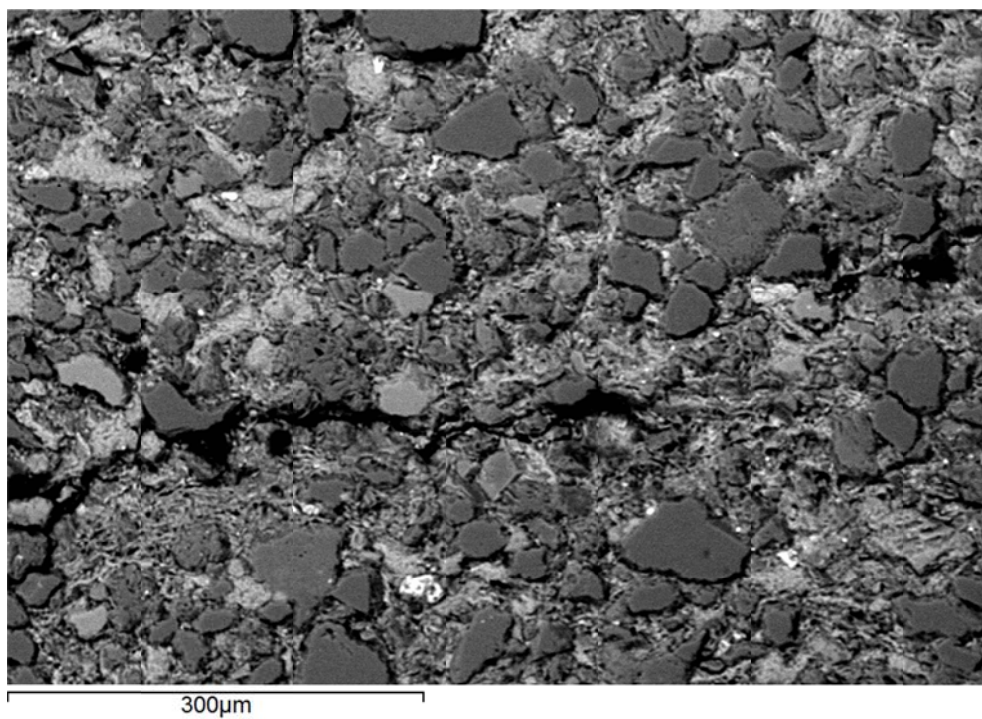
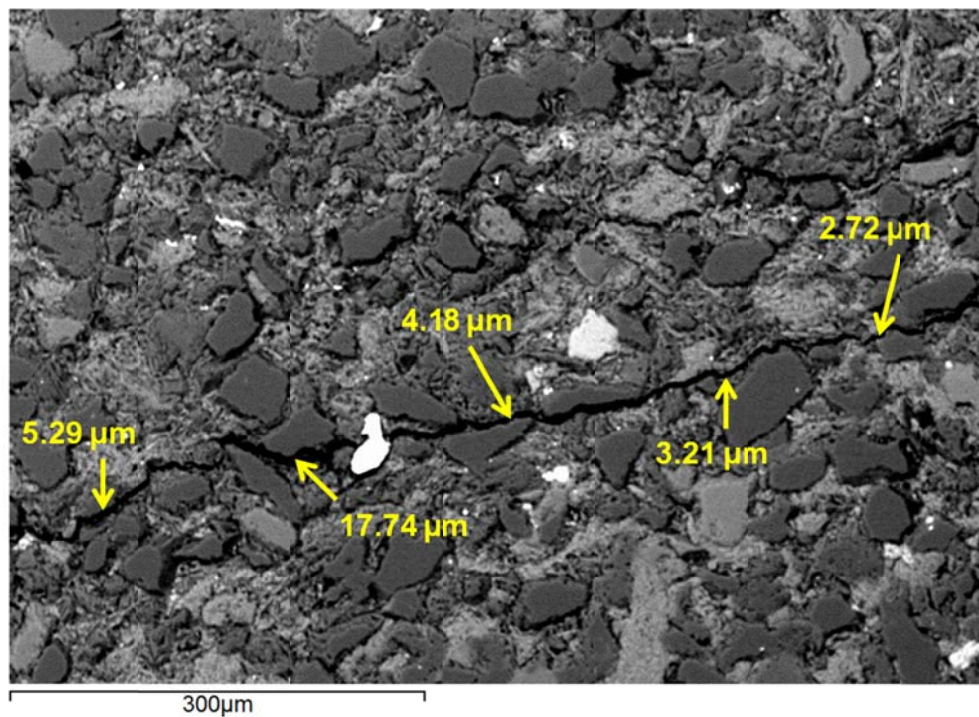
	Applied Geology Laboratory		ID: 116224
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10567.0'
	API No.: 33025002320000	Lithology: Slightly argillaceous, calcareous siltstone	

SEM BSE Image and Corresponding Digital Composite Mineral Map Image Overlaid on BSE Image with Mineral-Phase 2-D Area Percentages



	Applied Geology Laboratory		ID: 116224
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10567.0'
	API No.: 33025002320000	Lithology: Slightly argillaceous, calcareous siltstone	

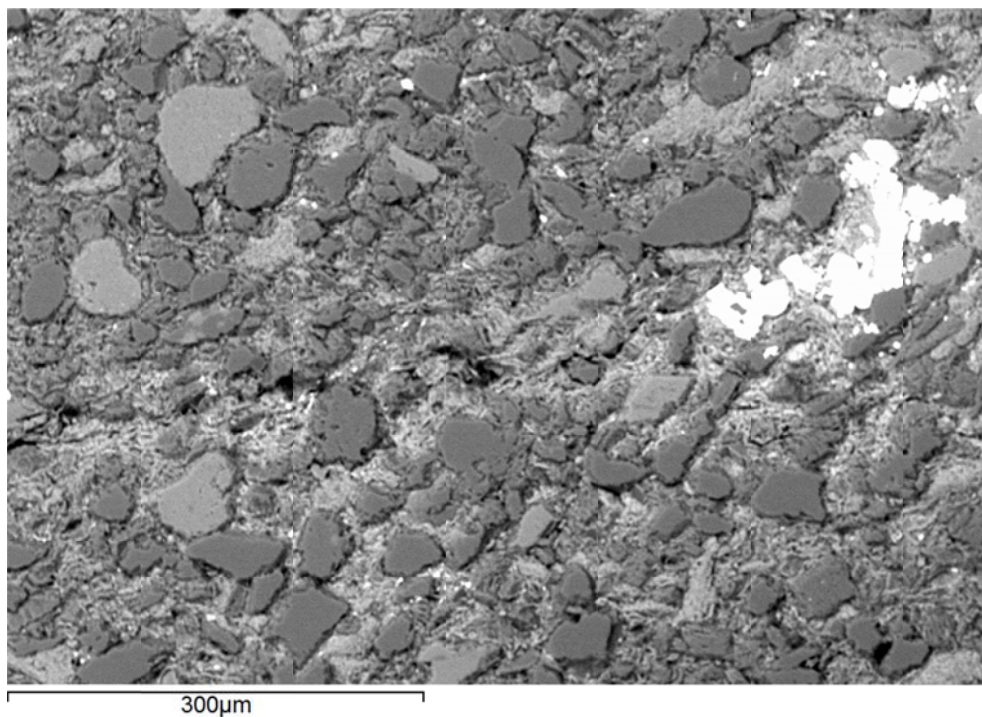
Fracture Analysis on BSE Images



Illite is filling the fracture.

	Applied Geology Laboratory		ID: 116224
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10567.0'
	API No.: 33025002320000	Lithology: Slightly argillaceous, calcareous siltstone	

Additional Fracture Analysis on BSE Images



Halite and illite have nearly filled the fracture.

	Applied Geology Laboratory		ID: 116224
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10567.0'
	API No.: 33025002320000	Lithology: Slightly argillaceous, calcareous siltstone	

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	Applied Geology Laboratory		ID: 116225
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10572.8'
	API No.: 33025002320000	Lithology: Slightly calcareous, dolomitic siltstone	

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION



Depth 10567.0': A mottled fossiliferous siltstone. Brachiopods and helminthopsis/sclerituba are present. Lighter areas are the result of acid testing. Markings on the left side of the sample are artifacts of core facing process.

PHYSICAL PROPERTIES

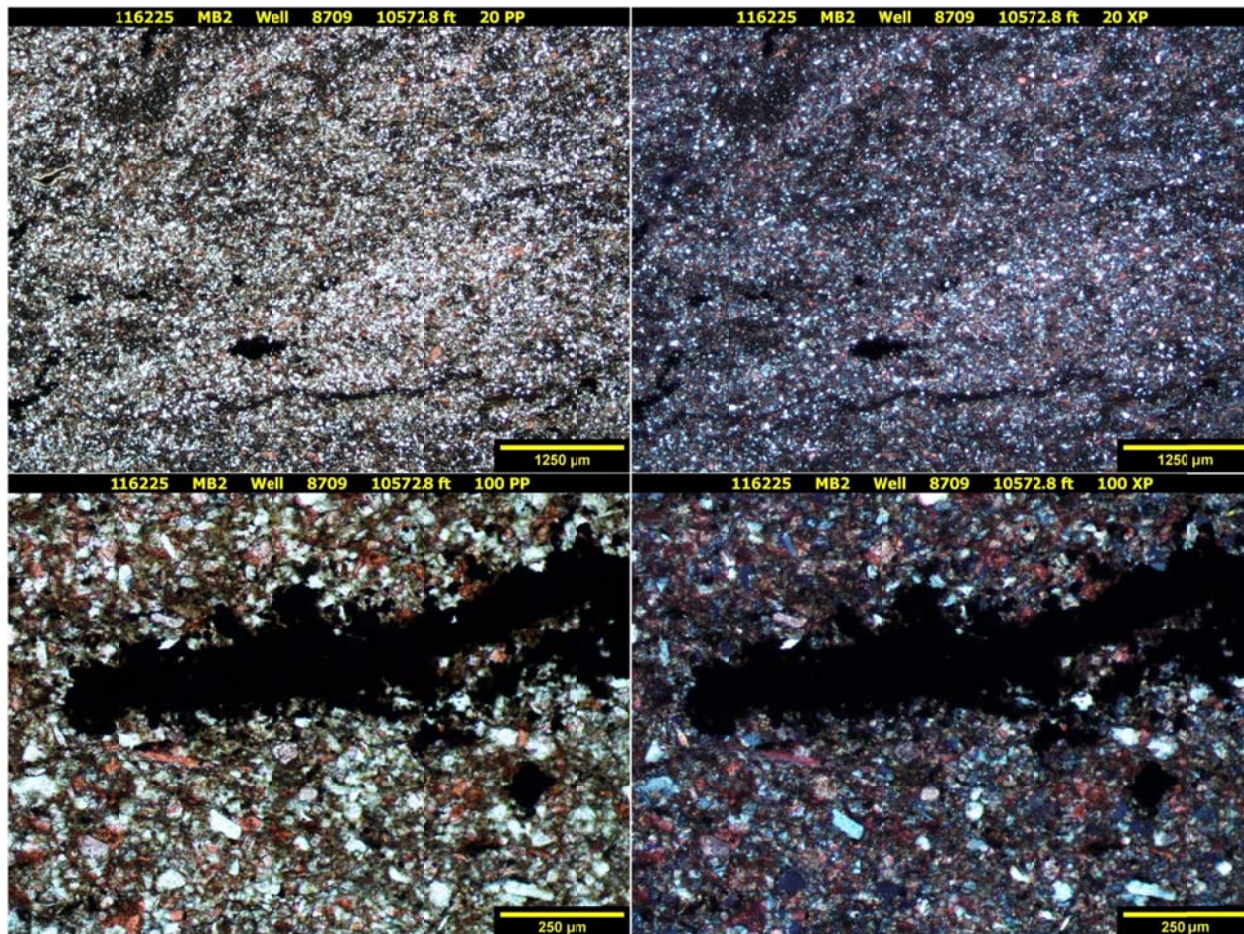
Porosity and Related Measurements Performed by MetaRock Laboratories

Pycnometer Effective Porosity, vol%	Bulk Volume, cm ³	Bulk Density, g/cm ³	Grain Volume, cm ³	Grain Density, g/cm ³
4.86	53.82	2.54	51.20	2.67

	Applied Geology Laboratory		ID: 116225
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10572.8'
	API No.: 33025002320000	Lithology: Slightly calcareous, dolomitic siltstone	

PHOTOMICROGRAPHS

Transmission



This sample is slightly calcareous, dolomitic siltstone. Subangular to angular monocrystalline quartz is the dominant detrital mineral. Calcareous clasts and bioclast commonly occur throughout the sample. Other detrital minerals observed at trace quantities are muscovite and feldspars. The matrix composes predominantly microcrystalline to cryptocrystalline dolomite and clays. Occasional replacement rhombohedral dolomite and pyrite are present. Small organic specs are found sporadically throughout and occasionally found in larger masses. Multiple small horizontal fractures are observed, which represent the only detected porosity.

	Applied Geology Laboratory		ID: 116225
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10572.8'
	API No.: 33025002320000	Lithology: Slightly calcareous, dolomitic siltstone	

PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	50	Very fine grained
Calcite	15	Clasts and bioclasts
Dolomite	15	Anhedral, few euhedral
Clay	15	
Metals	Trace	Pyrite
Muscovite	Trace	Random orientation
Organics	Trace	Globular

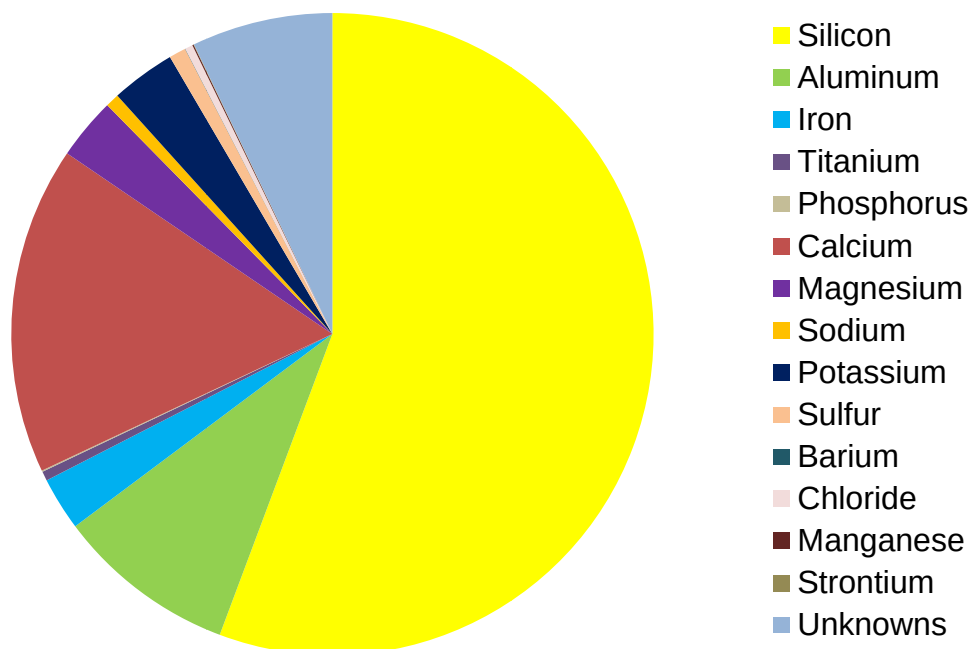
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through XRF and XRD data sets.

Detrital Texture

Category	Classification
Grain Size	Very fine
Sorting	Moderately well
Roundness	Angular to subangular

	Applied Geology Laboratory		ID: 116225
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10572.8'
	API No.: 33025002320000	Lithology: Slightly calcareous, dolomitic siltstone	

XRF BULK CHEMICAL COMPOSITION

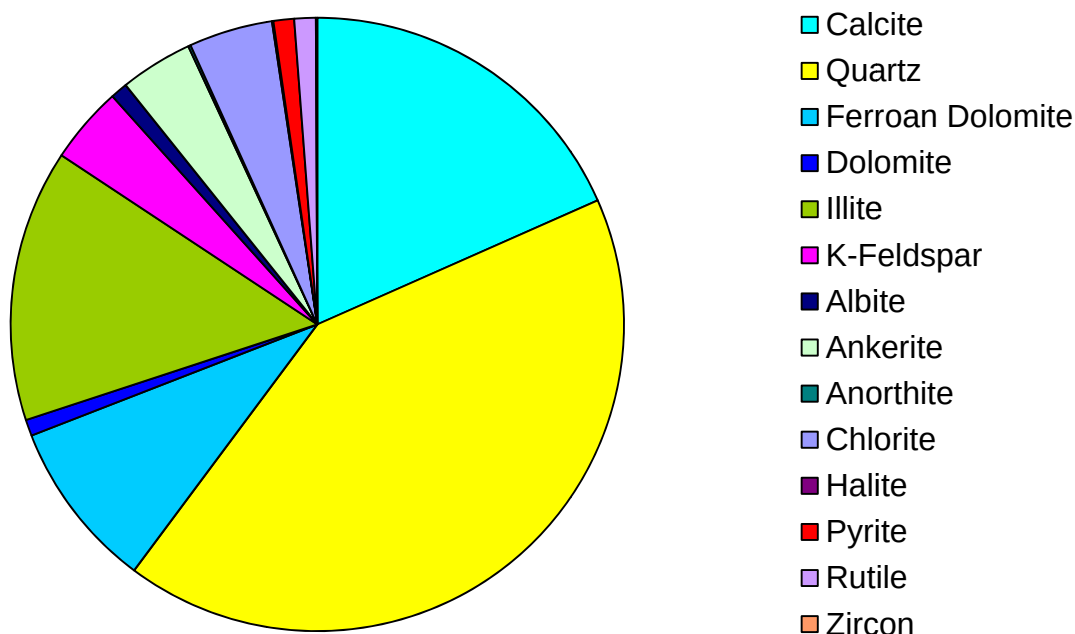


Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	55.70
Al (aluminum)	Al ₂ O ₃	9.08
Fe (iron)	Fe ₂ O ₃	2.68
Ti (titanium)	TiO ₂	0.48
P (phosphorus)	P ₂ O ₅	0.06
Ca (calcium)	CaO	16.51
Mg (magnesium)	MgO	3.11
Na (sodium)	Na ₂ O	0.69
K (potassium)	K ₂ O	3.24
S (sulfur)	SO ₃	0.85
Ba (barium)	BaO	0.02
Cl (chloride)	Cl	0.39
Mn (manganese)	MnO	0.06
Sr (strontium)	SrO	0.02
Unknowns	Due to the presence of carbonates*	7.10
Total		99.99

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

	Applied Geology Laboratory		ID: 116225
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10572.8'
	API No.: 33025002320000	Lithology: Slightly calcareous, dolomitic siltstone	

XRD MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	18.4
Quartz	SiO_2	41.8
Ferroan Dolomite	$\text{CaMg}_{0.8}\text{Fe}_{0.2}(\text{CO}_3)_2$	8.9
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	0.9
Illite	$(\text{K}, \text{H}_3\text{O})(\text{Al}, \text{Mg}, \text{Fe})_2(\text{Si}, \text{Al})_4\text{O}_{10}[(\text{OH})_2, (\text{H}_2\text{O})]$	14.3
K-Feldspar	KAlSi_3O_8	4.1
Albite	$\text{NaAlSi}_3\text{O}_8$	0.9
Ankerite	$\text{CaMg}_{0.45}\text{Fe}_{0.55}(\text{CO}_3)_2$	3.8
Anorthite	$\text{CaAl}_2\text{Si}_2\text{O}_4$	Trace
Chlorite	$\text{Mg}_{2.96}\text{Fe}_{1.55}\text{Fe}_{0.14}\text{Al}_{1.28}(\text{Si}_{2.62}\text{Al}_{1.38}\text{O}_{10})(\text{OH})_8$	4.4
Halite	NaCl	Trace
Pyrite	FeS_2	1.1
Rutile	TiO_2	1.1
Zircon	ZrSiO_4	Trace

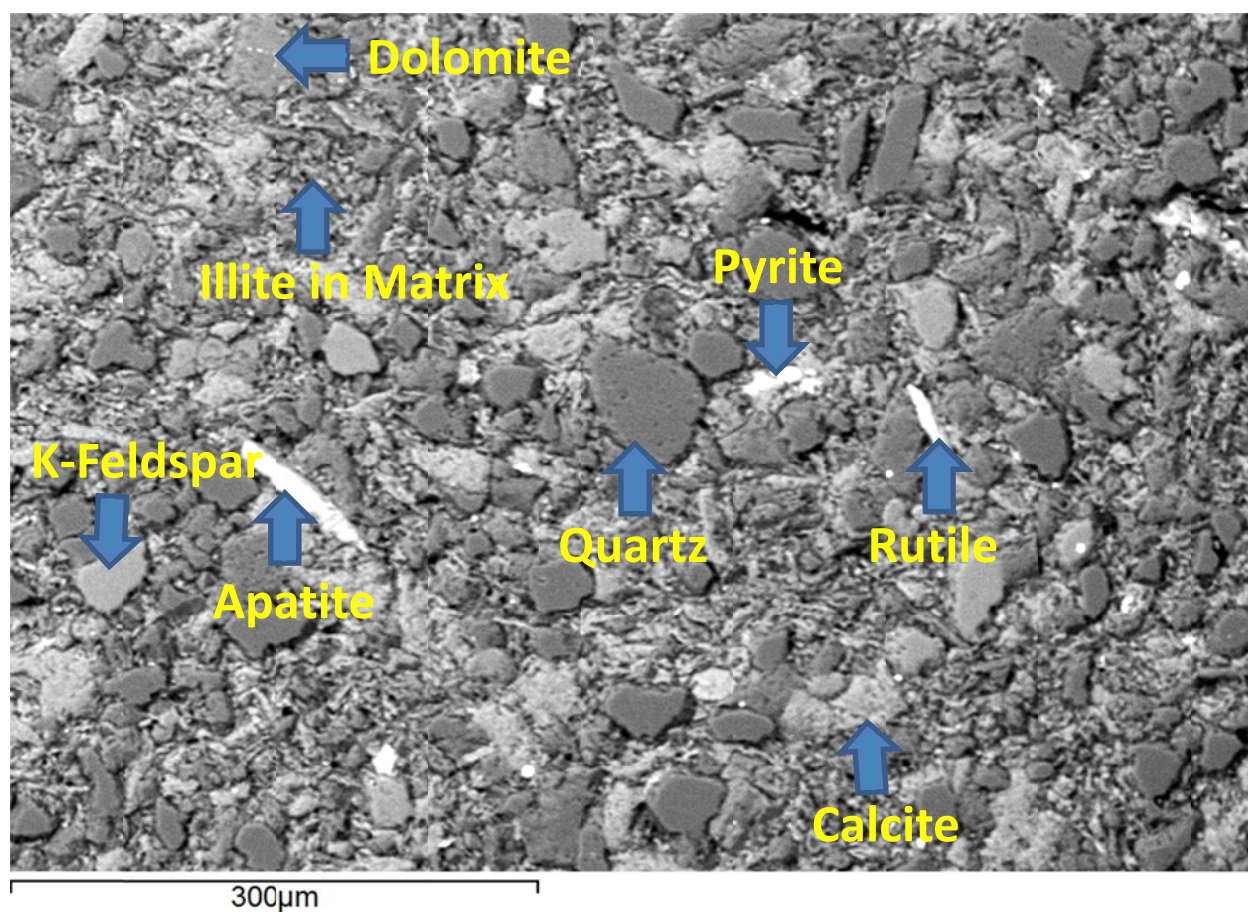
	Applied Geology Laboratory		ID: 116225
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10572.8'
	API No.: 33025002320000	Lithology: Slightly calcareous, dolomitic siltstone	

SEM

Observed Minerals

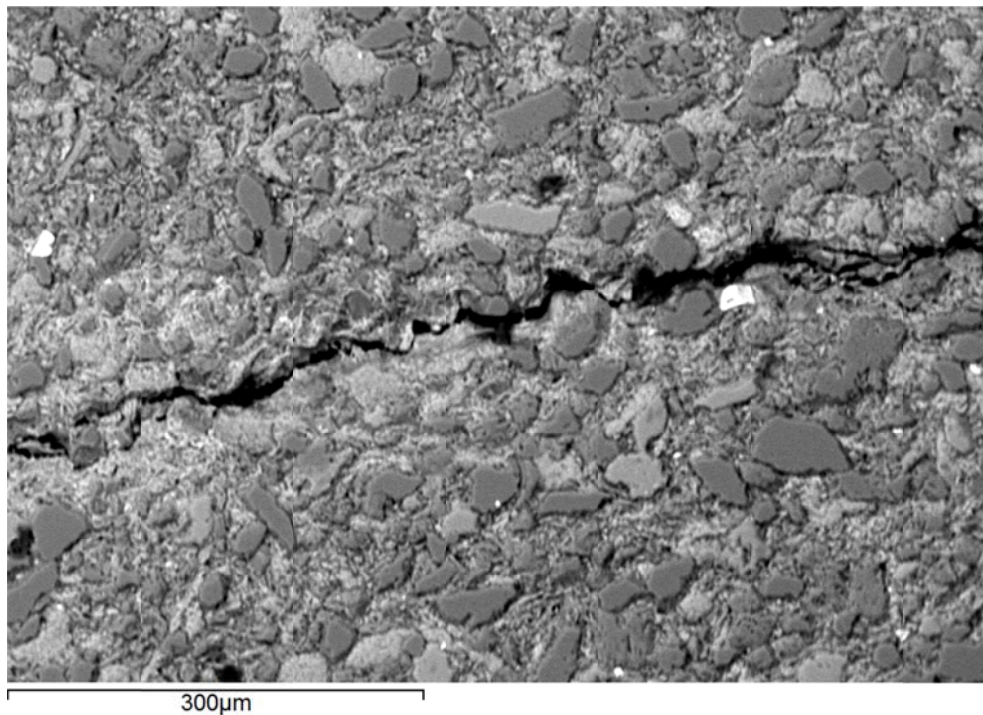
Mineral Phase	Mineral Phase
Calcite	Dolomite
Pyrite	Rutile
Quartz	Albite
Apatite	Zircon
K-Feldspar	Halite
Illite	

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified

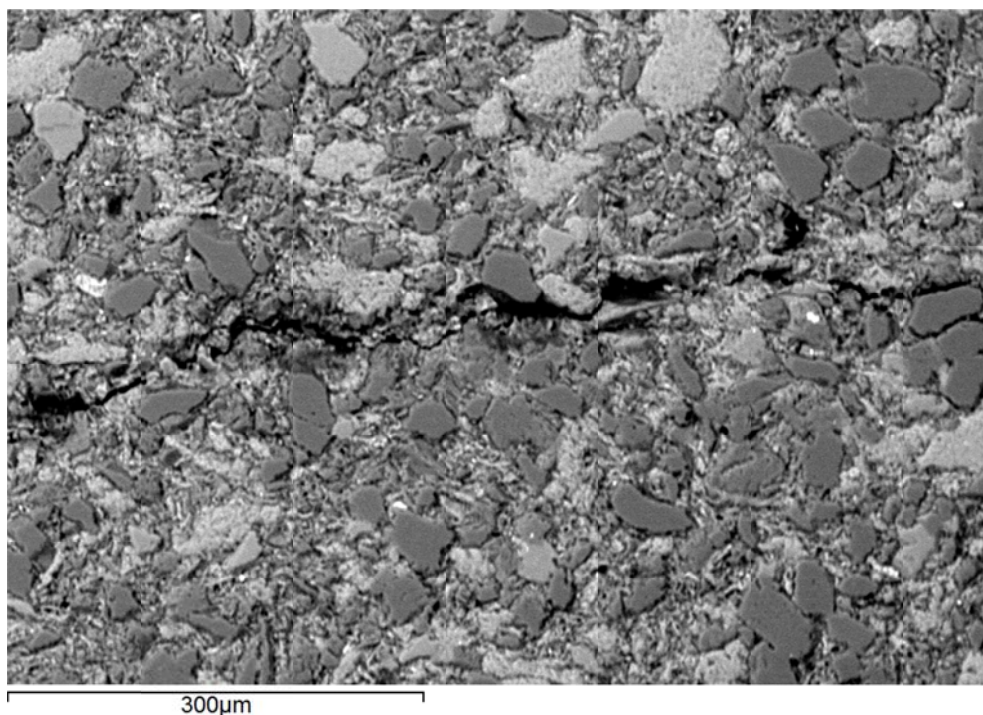


	Applied Geology Laboratory		ID: 116225
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10572.8'
	API No.: 33025002320000	Lithology: Slightly calcareous, dolomitic siltstone	

Fracture Analysis on BSE Images



Halite from the fracture coats the surface minerals.



The fracture contains a halite/illite mixture.

	Applied Geology Laboratory		ID: 116225
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10572.8'
	API No.: 33025002320000	Lithology: Slightly calcareous, dolomitic siltstone	

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	Applied Geology Laboratory		ID: 116226
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10575.8'
	API No.: 33025002320000	Lithology: Slightly argillaceous, calcareous siltstone	

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION



Depth 10567.0': A mottled fossiliferous, highly fractured siltstone. Brachiopods and helminthopsis/sclerituba are present. Lighter areas are the result of acid testing. Markings on the left side of the sample are artifacts of core facing process.

PHYSICAL PROPERTIES

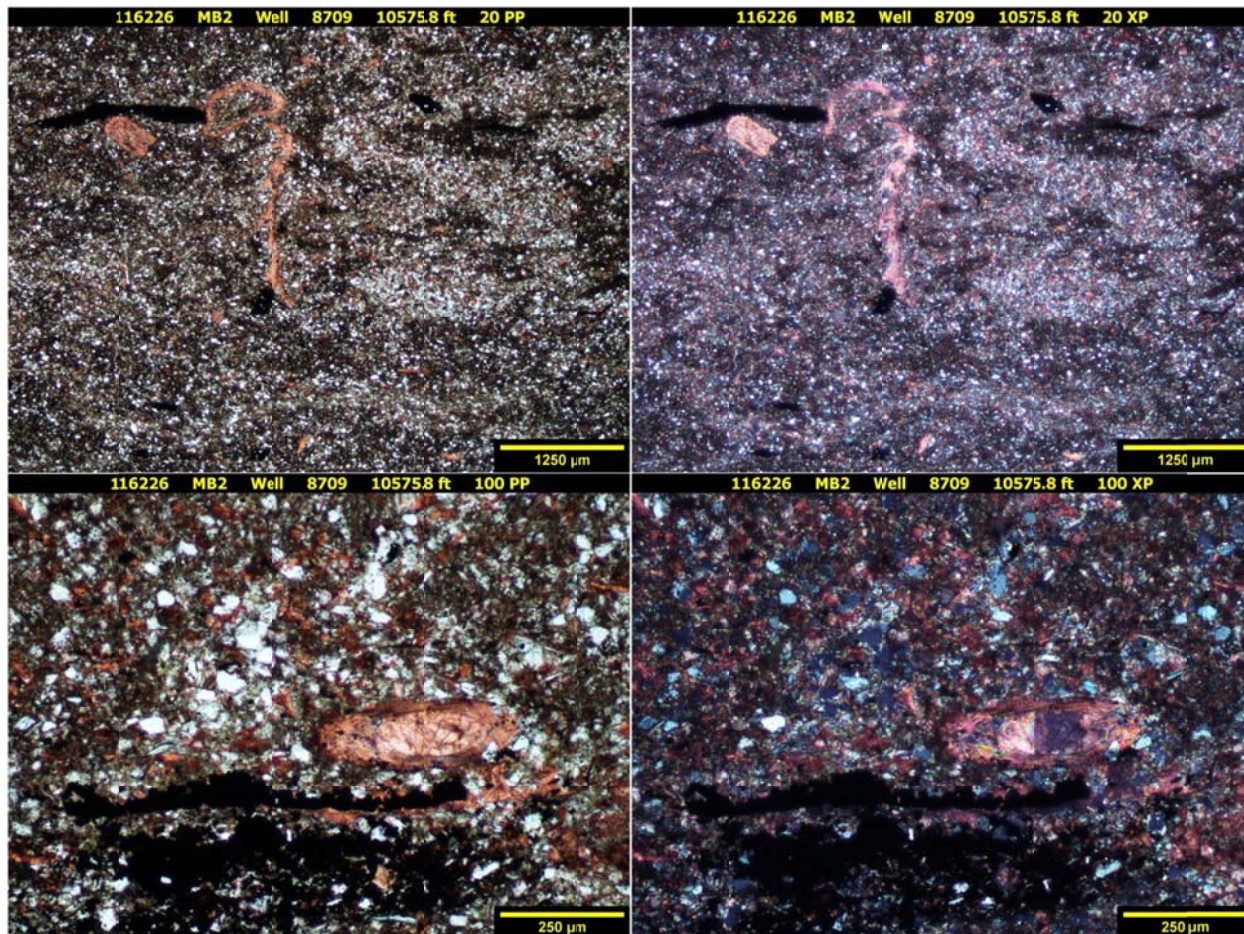
Porosity and Related Measurements Performed by MetaRock Laboratories

Pycnometer Effective Porosity, vol%	Bulk Volume, cm ³	Bulk Density, g/cm ³	Grain Volume, cm ³	Grain Density, g/cm ³
4.28	52.14	2.57	49.91	2.69

	Applied Geology Laboratory		ID: 116226
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10575.8'
	API No.: 33025002320000	Lithology: Slightly argillaceous, calcareous siltstone	

PHOTOMICROGRAPHS

Transmission



This sample is slightly argillaceous, calcareous siltstone. Subangular to angular monocrystalline quartz is the dominant detrital mineral. Calcareous clasts and bioclasts commonly occur throughout the sample. Other detrital minerals observed at trace quantities are muscovite and feldspars. The matrix composes predominantly microcrystalline to cryptocrystalline dolomite and clays. Occasional rhombohedral dolomite and allochem replacement pyrite are present. Small organics specs are found sporadically throughout and occasionally found in larger masses. Multiple small horizontal fractures are observed, which represent the only detected porosity.

	Applied Geology Laboratory		ID: 116226
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10575.8'
	API No.: 33025002320000	Lithology: Slightly argillaceous, calcareous siltstone	

PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	40	Very fine grained
Calcite	25	Clasts and bioclasts
Dolomite	10	Microcrystalline
Clay	25	
Metals	Trace	Pyrite
Muscovite	Trace	Moderately well orientation
Organics	Trace	Globular, within laminations

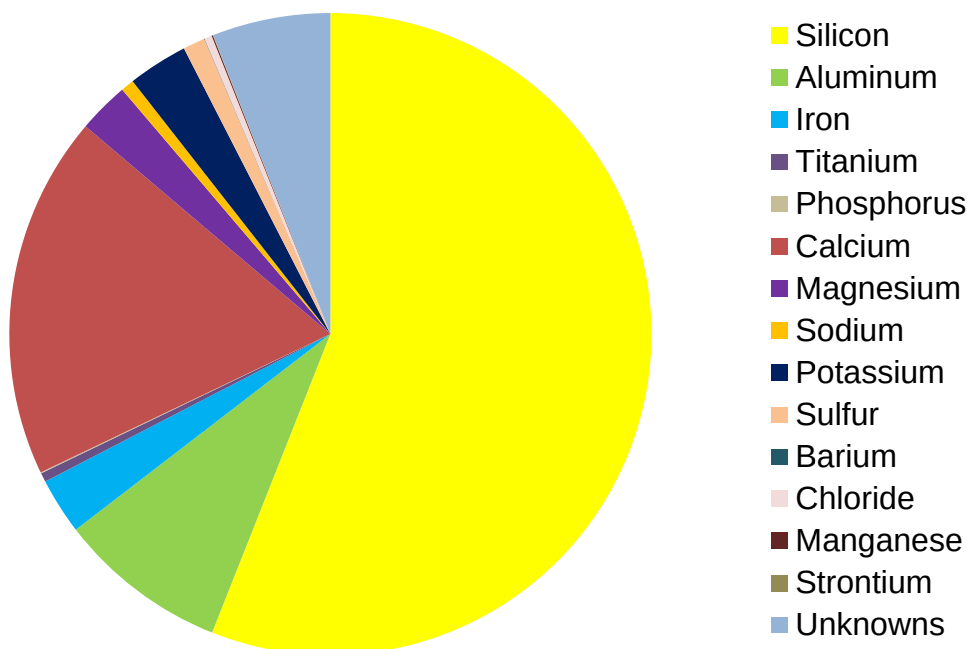
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through XRF and XRD data sets.

Detrital Texture

Category	Classification
Grain Size	Very fine
Sorting	Well
Roundness	Subangular to angular

	Applied Geology Laboratory		ID: 116226
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10575.8'
	API No.: 33025002320000	Lithology: Slightly argillaceous, calcareous siltstone	

XRF BULK CHEMICAL COMPOSITION

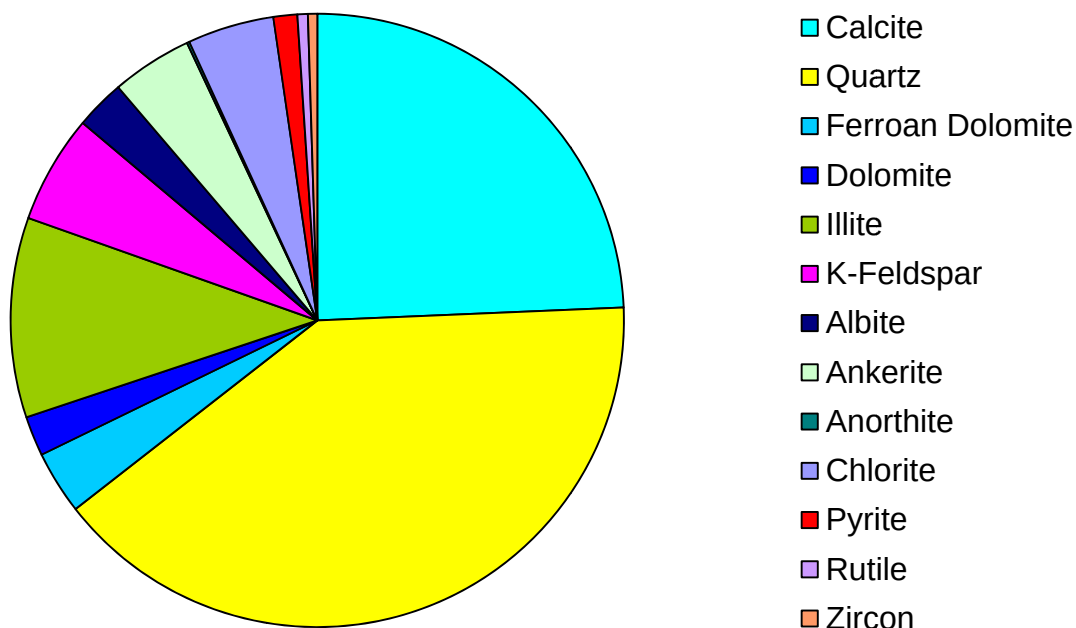


Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	56.01
Al (aluminum)	Al ₂ O ₃	8.57
Fe (iron)	Fe ₂ O ₃	2.83
Ti (titanium)	TiO ₂	0.46
P (phosphorus)	P ₂ O ₅	0.05
Ca (calcium)	CaO	18.29
Mg (magnesium)	MgO	2.57
Na (sodium)	Na ₂ O	0.66
K (potassium)	K ₂ O	3.03
S (sulfur)	SO ₃	1.11
Ba (barium)	BaO	0.02
Cl (chloride)	Cl	0.38
Mn (manganese)	MnO	0.06
Sr (strontium)	SrO	0.02
Unknowns	Due to the presence of carbonates*	5.95
Total		100.01

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

	Applied Geology Laboratory		ID: 116226
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10575.8'
	API No.: 33025002320000	Lithology: Slightly argillaceous, calcareous siltstone	

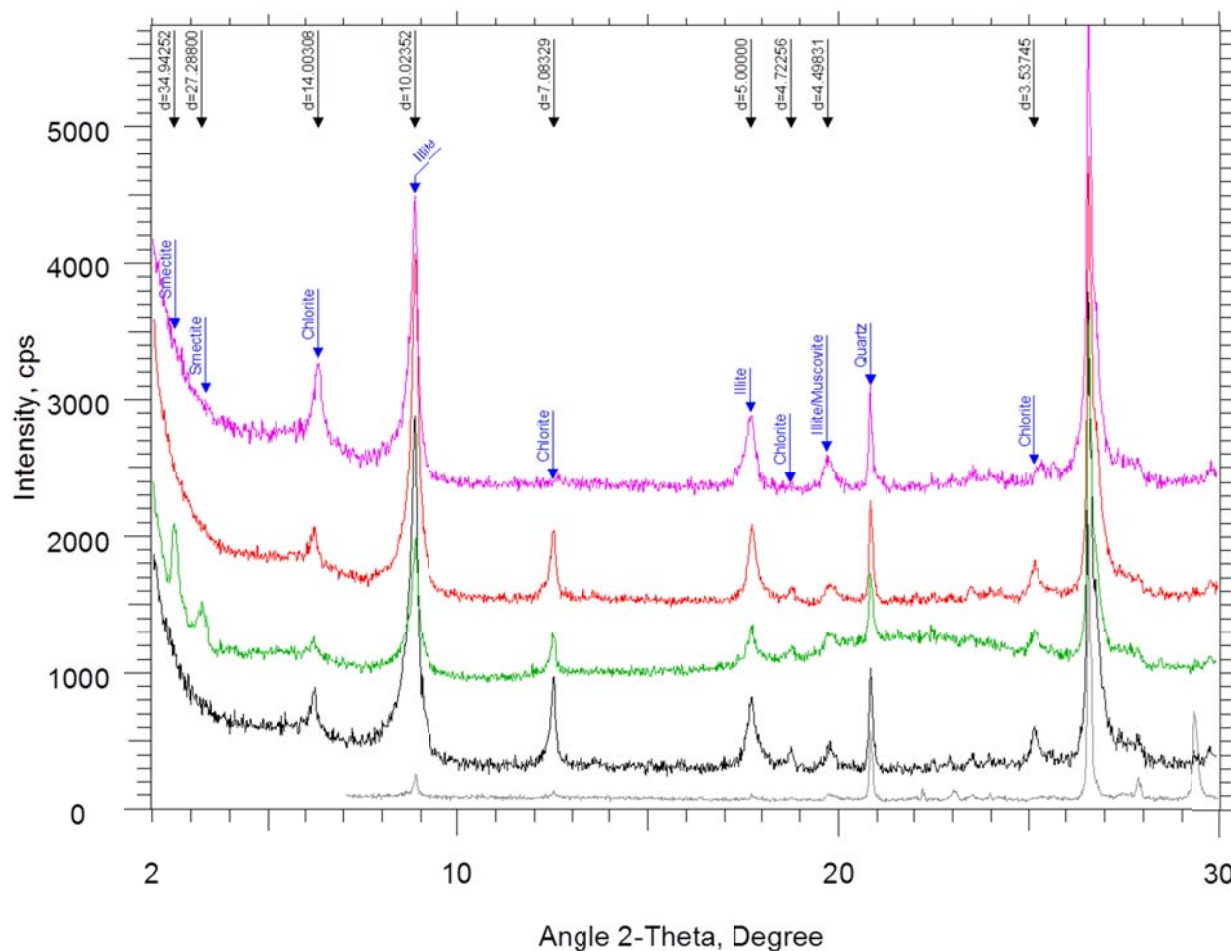
XRD MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	24.3
Quartz	SiO_2	40.1
Ferroan Dolomite	$\text{CaMg}_{0.8}\text{Fe}_{0.2}(\text{CO}_3)_2$	3.3
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	2.1
Illite	$(\text{K}, \text{H}_3\text{O})(\text{Al}, \text{Mg}, \text{Fe})_2(\text{Si}, \text{Al})_4\text{O}_{10}[(\text{OH})_2, (\text{H}_2\text{O})]$	10.5
K-Feldspar	KAlSi_3O_8	5.7
Albite	$\text{NaAlSi}_3\text{O}_8$	2.6
Ankerite	$\text{CaMg}_{0.45}\text{Fe}_{0.55}(\text{CO}_3)_2$	4.3
Anorthite	$\text{CaAl}_2\text{Si}_2\text{O}_4$	Trace
Chlorite	$\text{Mg}_{2.96}\text{Fe}_{1.55}\text{Fe}_{0.14}\text{Al}_{1.28}(\text{Si}_{2.62}\text{Al}_{1.38}\text{O}_{10})(\text{OH})_8$	4.6
Pyrite	FeS_2	1.3
Rutile	TiO_2	Trace
Zircon	ZrSiO_4	Trace

	Applied Geology Laboratory		ID: 116226
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10575.8'
	API No.: 33025002320000	Lithology: Slightly argillaceous, calcareous siltstone	

XRD Clay Typing



Clays Identified*

Illite
Chlorite
Smectite

* The clays appear to be well-ordered.

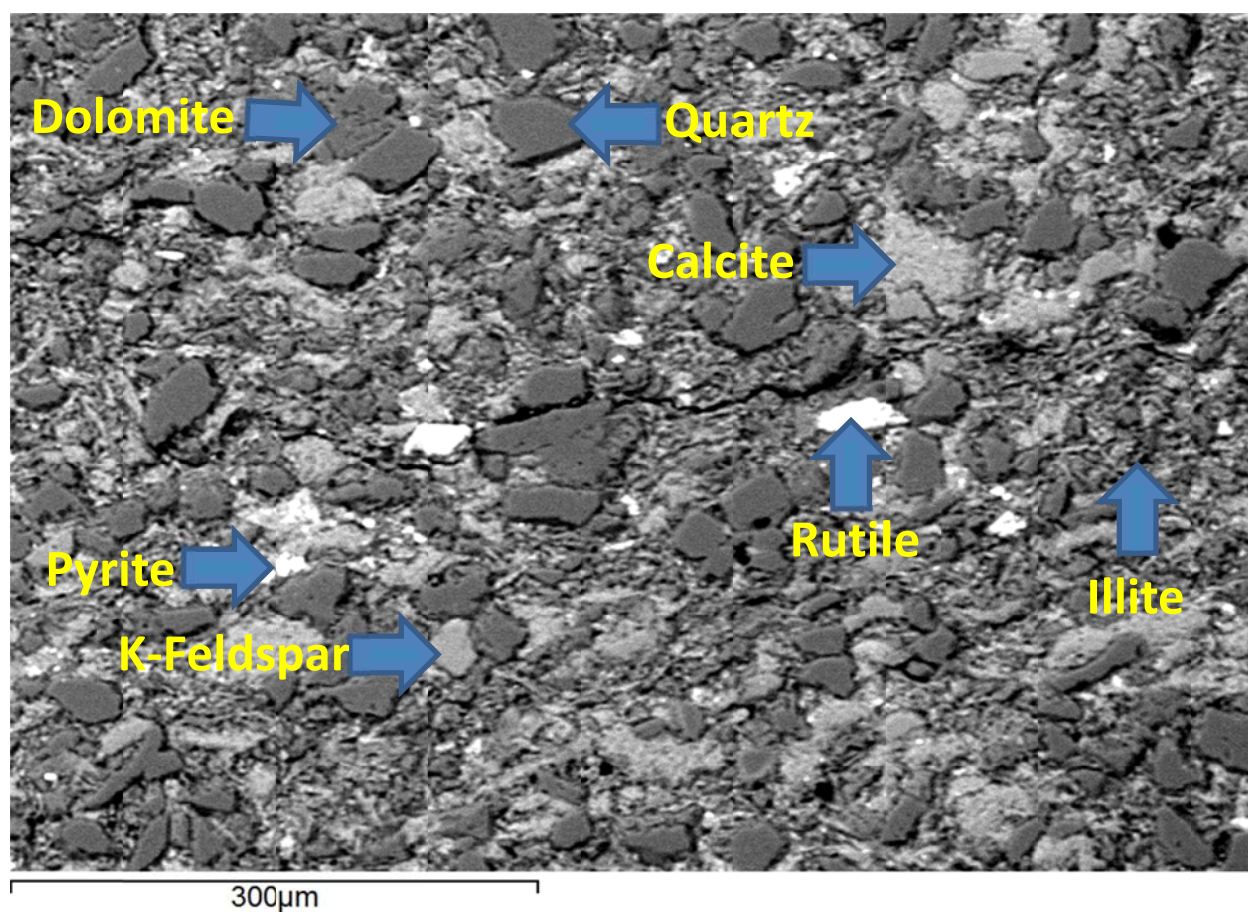
	Applied Geology Laboratory		ID: 116226
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10575.8'
	API No.: 33025002320000	Lithology: Slightly argillaceous, calcareous siltstone	

SEM

Observed Minerals

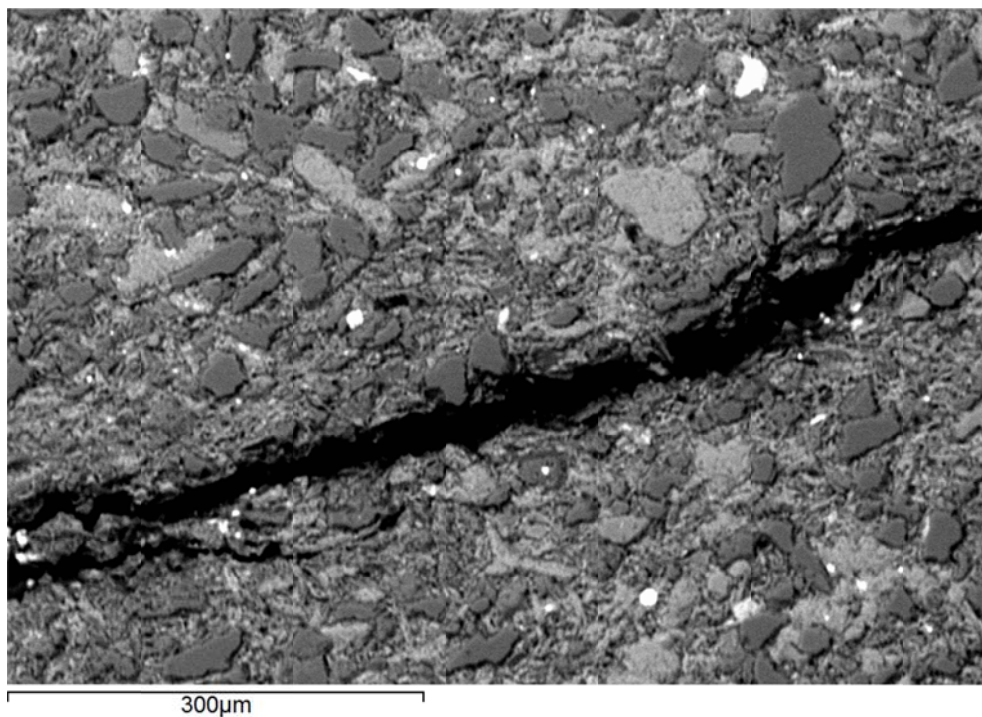
Mineral Phase	Mineral Phase
Calcite	Dolomite
Pyrite	Rutile
K-Feldspar	Apatite
Quartz	Zircon
Halite	Albite
Illite	

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified

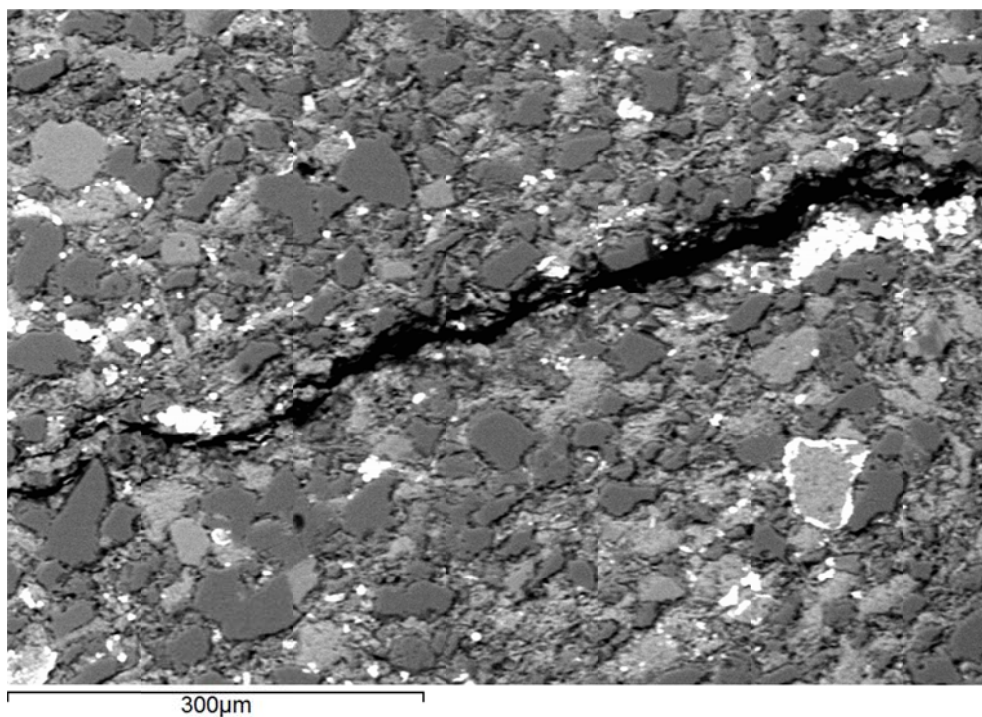


	Applied Geology Laboratory		ID: 116226
	Middle Bakken 2	NDIC Well 8709, Burbank BIA 23-8	Depth: 10575.8'
	API No.: 33025002320000	Lithology: Slightly argillaceous, calcareous siltstone	

Fracture Analysis on BSE Images



The fracture contains illite and pyrite framboids.



Illite and pyrite framboids are in and along the fracture.

	Applied Geology Laboratory		ID: 116227
	Middle Bakken 1	NDIC Well 8709, Burbank BIA 23-8	Depth: 10577.0'
	API No.: 33025002320000	Lithology: Slightly argillaceous, silty limestone	

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION



Depth 10577.0': A mottled and dense fossiliferous siltstone. Lighter areas are the result of acid testing. Markings on the upper portion of the sample are artifacts of core facing process.

PHYSICAL PROPERTIES

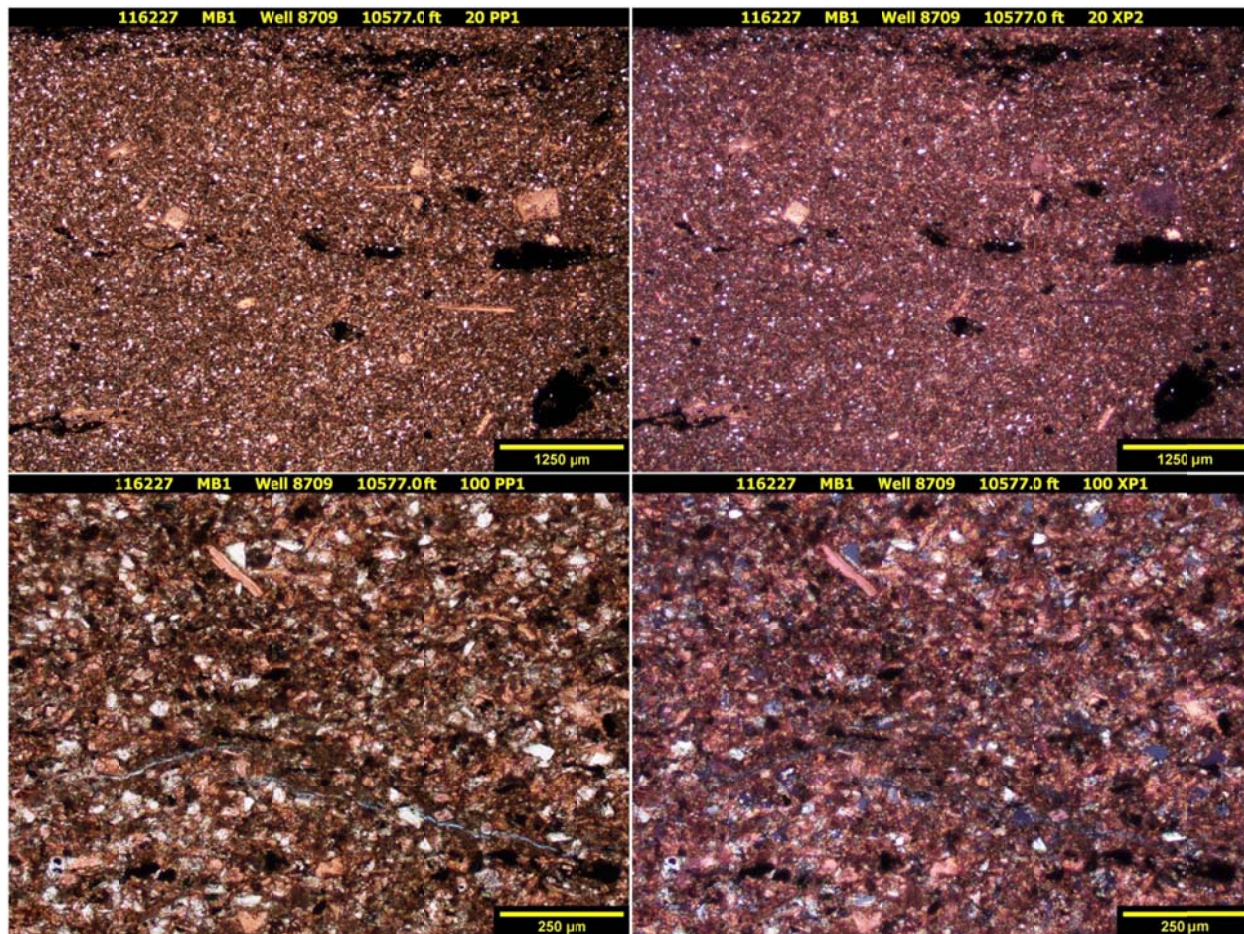
Porosity and Related Measurements Performed by MetaRock Laboratories

Pycnometer Effective Porosity, vol%	Bulk Volume, cm ³	Bulk Density, g/cm ³	Grain Volume, cm ³	Grain Density, g/cm ³
2.73	53.70	2.61	52.23	2.68

	Applied Geology Laboratory		ID: 116227
	Middle Bakken 1	NDIC Well 8709, Burbank BIA 23-8	Depth: 10577.0'
	API No.: 33025002320000	Lithology: Slightly argillaceous, silty limestone	

PHOTOMICROGRAPHS

Transmission



This sample is slightly argillaceous, silty limestone. Detrital subangular to angular monocrystalline quartz have a speckled distribution. Calcareous clasts and bioclasts abundantly occur throughout the sample. Additional detrital minerals observed at trace quantities are muscovite and feldspars. The matrix composes predominantly clay (increased zonal concentrations) and rare microcrystalline to cryptocrystalline dolomite. Common pyrite and rare anhedral dolomite skeletal and nonskeletal replacements are observed. Trace rhombohedral dolomite is present. Small organics specs are found sporadically throughout and occasionally found in larger masses. Very small, opaque, filled fractures are found largely within clay concentrations. No observed porosity is detected.

	Applied Geology Laboratory		ID: 116227
	Middle Bakken 1	NDIC Well 8709, Burbank BIA 23-8	Depth: 10577.0'
	API No.: 33025002320000	Lithology: Slightly argillaceous, silty limestone	

PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	20	Very fine grained
Calcite	55	Allochems, cement
Dolomite	10	Microcrystalline
Clay	10	
Metals	Trace	Pyrite
Muscovite	Trace	Random orientation
Organics	Trace	Globular, microfractures

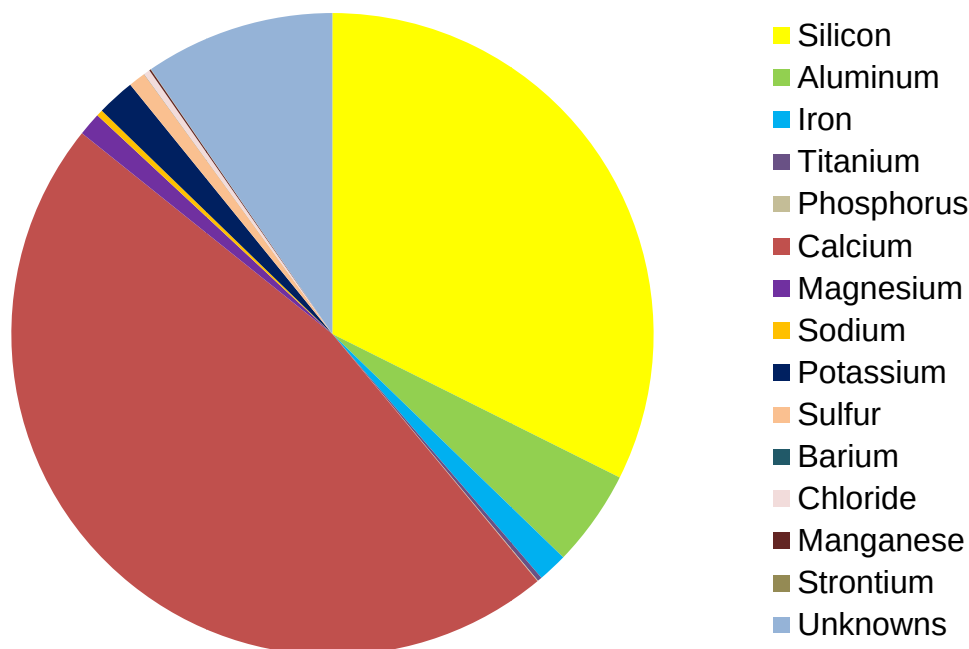
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through XRF and XRD data sets.

Detrital Texture

Category	Classification
Grain Size	Very fine
Sorting	Moderately well
Roundness	Angular to subangular

	Applied Geology Laboratory		ID: 116227
	Middle Bakken 1	NDIC Well 8709, Burbank BIA 23-8	Depth: 10577.0'
	API No.: 33025002320000	Lithology: Slightly argillaceous, silty limestone	

XRF BULK CHEMICAL COMPOSITION

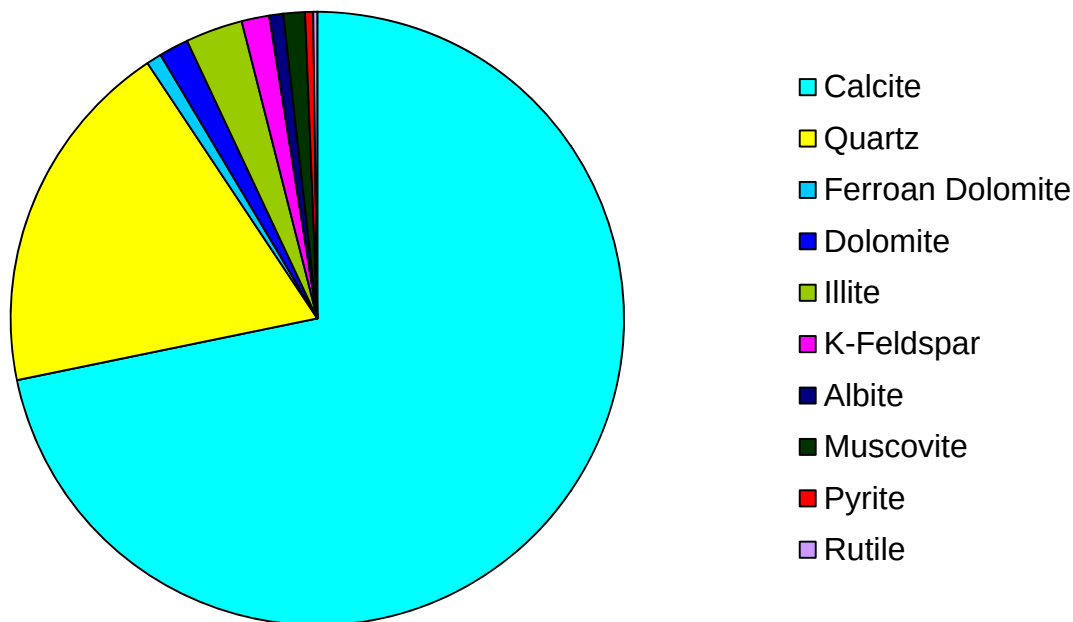


Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	32.37
Al (aluminum)	Al ₂ O ₃	4.86
Fe (iron)	Fe ₂ O ₃	1.48
Ti (titanium)	TiO ₂	0.23
P (phosphorus)	P ₂ O ₅	0.03
Ca (calcium)	CaO	46.78
Mg (magnesium)	MgO	1.17
Na (sodium)	Na ₂ O	0.32
K (potassium)	K ₂ O	1.91
S (sulfur)	SO ₃	0.86
Ba (barium)	BaO	0.01
Cl (chloride)	Cl	0.31
Mn (manganese)	MnO	0.08
Sr (strontium)	SrO	0.02
Unknowns	Due to the presence of carbonates*	9.56
Total		99.99

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

	Applied Geology Laboratory		ID: 116227
	Middle Bakken 1	NDIC Well 8709, Burbank BIA 23-8	Depth: 10577.0'
	API No.: 33025002320000	Lithology: Slightly argillaceous, silty limestone	

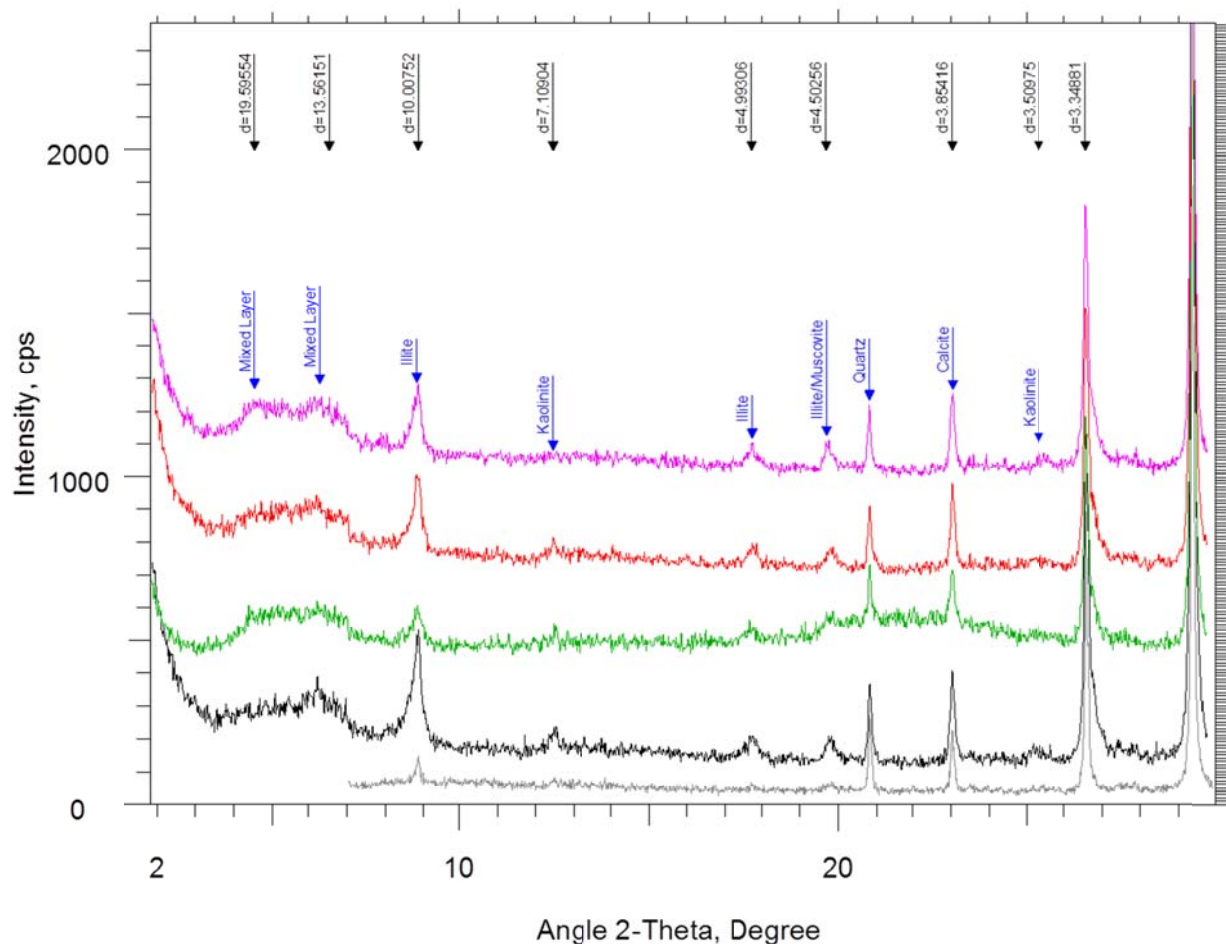
XRD MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	71.8
Quartz	SiO_2	18.9
Ferroan Dolomite	$\text{CaMg}_{0.8}\text{Fe}_{0.2}(\text{CO}_3)_2$	0.8
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	1.6
Illite	$(\text{K}, \text{H}_3\text{O})(\text{Al}, \text{Mg}, \text{Fe})_2(\text{Si}, \text{Al})_4\text{O}_{10}[(\text{OH})_2, (\text{H}_2\text{O})]$	3.0
K-Feldspar	KAlSi_3O_8	1.5
Albite	$\text{NaAlSi}_3\text{O}_8$	0.7
Muscovite	$\text{K}_{0.7}\text{Al}_2((\text{OH})_2\text{AlSi}_3\text{O}_{10})$	1.1
Pyrite	FeS_2	Trace
Rutile	TiO_2	Trace

	Applied Geology Laboratory		ID: 116227
	Middle Bakken 1	NDIC Well 8709, Burbank BIA 23-8	Depth: 10577.0'
	API No.: 33025002320000 Lithology: Slightly argillaceous, silty limestone		

XRD Clay Typing



Clays Identified

Illite

Kaolinite

Evidence of mixed-layer clays

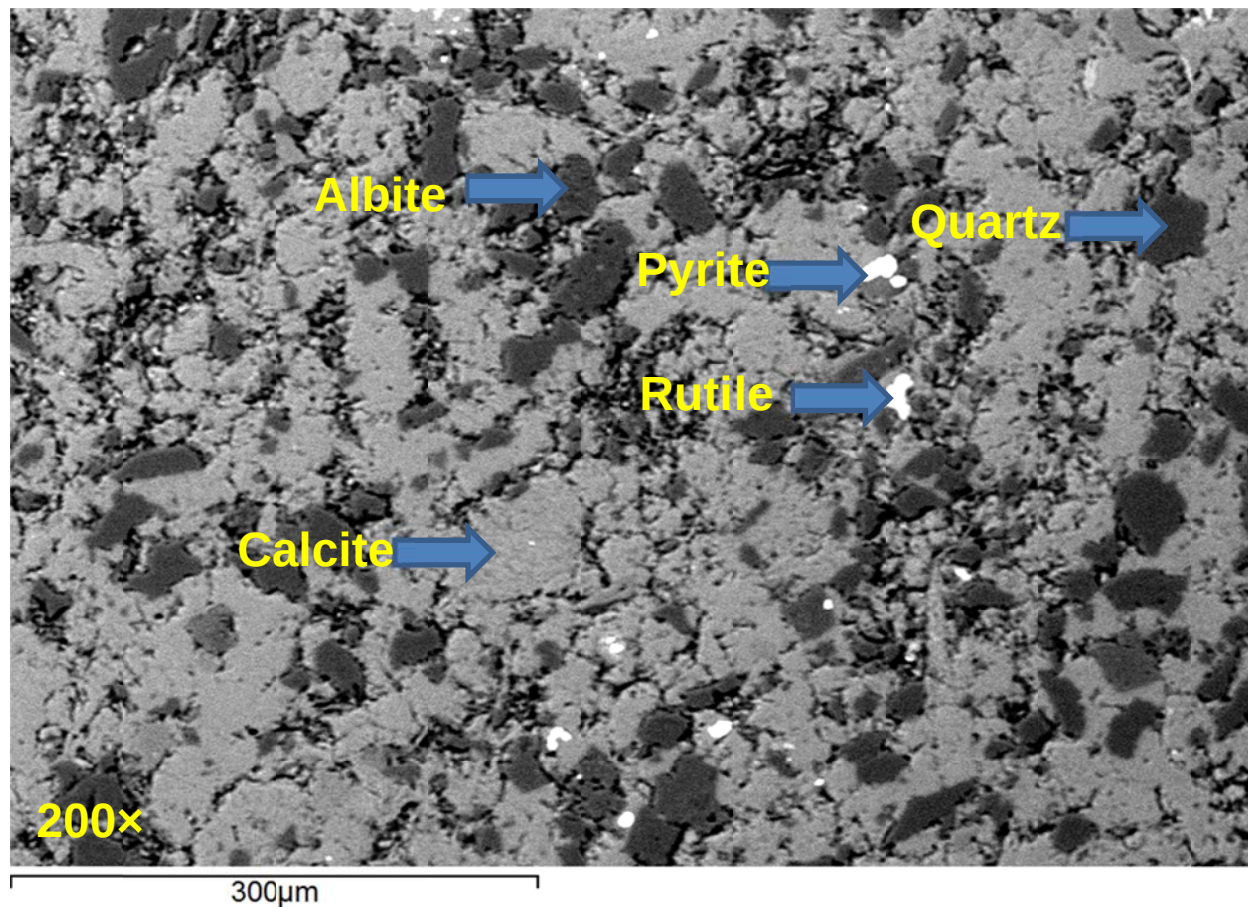
	Applied Geology Laboratory		ID: 116227
	Middle Bakken 1	NDIC Well 8709, Burbank BIA 23-8	Depth: 10577.0'
	API No.: 33025002320000	Lithology: Slightly argillaceous, silty limestone	

SEM

Observed Minerals

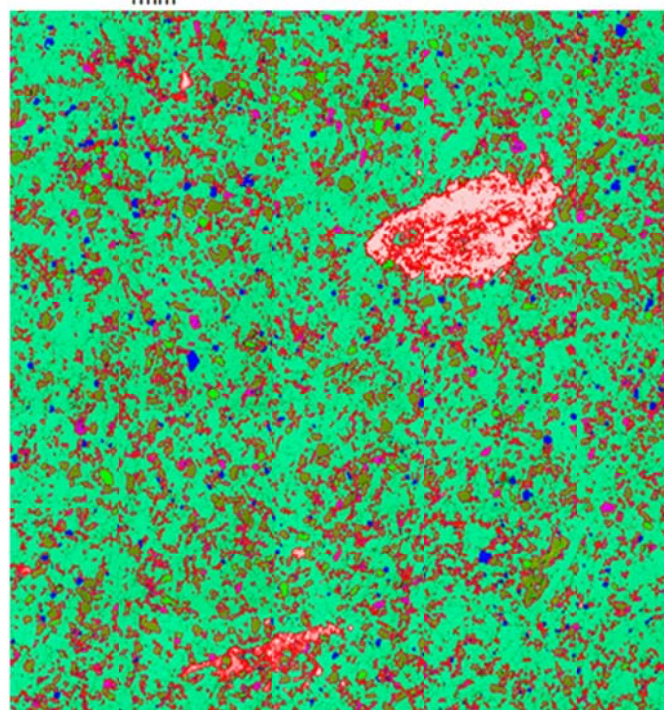
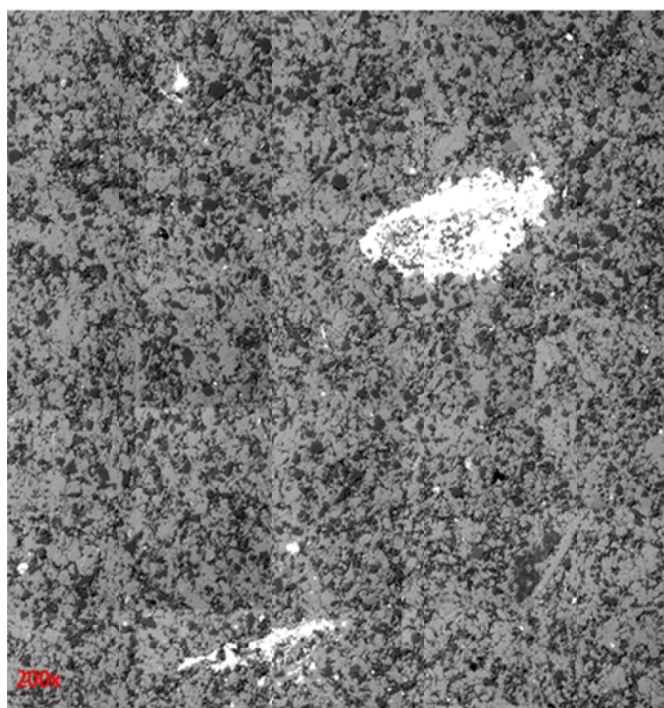
Mineral Phase	Mineral Phase
Calcite	Illite
Quartz	K-Feldspar
Pyrite	Dolomite
Albite	Zircon
Rutile	Monazite

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified



	Applied Geology Laboratory		ID: 116227
	Middle Bakken 1	NDIC Well 8709, Burbank BIA 23-8	Depth: 10577.0'
	API No.: 33025002320000	Lithology: Slightly argillaceous, silty limestone	

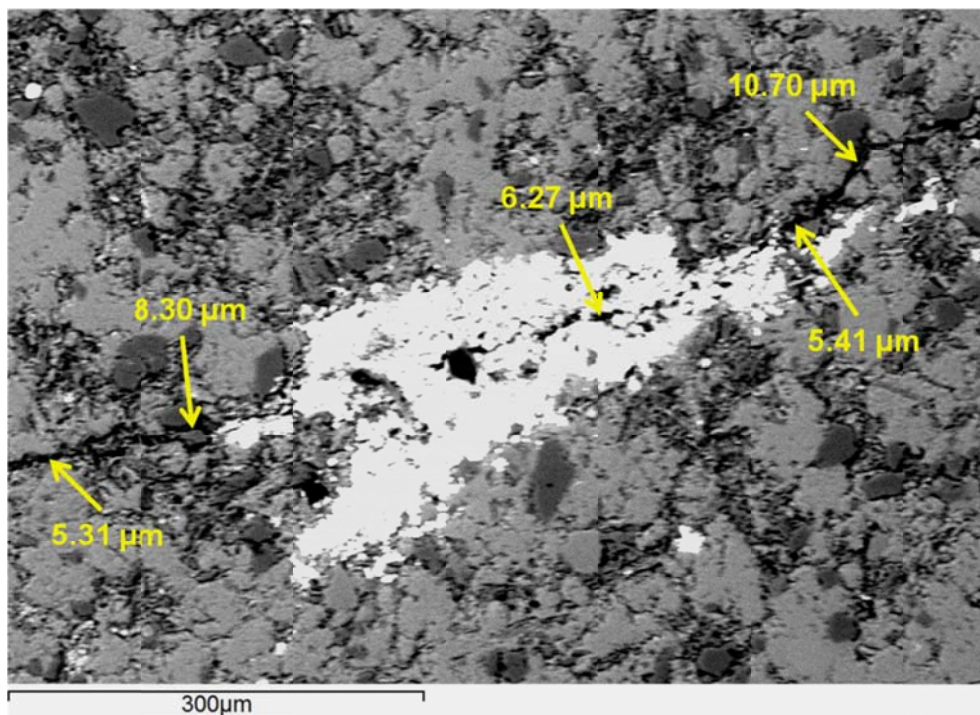
SEM BSE Image and Corresponding Digital Composite Mineral Map Image Overlaid on BSE Image with Mineral-Phase 2-D Area Percentages



	Pyrite – 2.9%
	Dolomite – 1.1%
	Calcite – 70.8%
	Albite – 1.0%
	Quartz – 5.9%
	K-Feldspar – 4.4%
	Illite – 13.9%

	Applied Geology Laboratory		ID: 116227
	Middle Bakken 1	NDIC Well 8709, Burbank BIA 23-8	Depth: 10577.0'
	API No.: 33025002320000	Lithology: Slightly argillaceous, silty limestone	

Fracture Analysis on BSE Images



The white color in the image is a pyrite deposit in the fracture.

	Applied Geology Laboratory		ID: 116227
	Middle Bakken 1	NDIC Well 8709, Burbank BIA 23-8	Depth: 10577.0'
	API No.: 33025002320000	Lithology: Slightly argillaceous, silty limestone	

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	Applied Geology Laboratory		ID: 116672
	Middle Bakken 5	NDIC Well 16766, Rogne 44-34H	Depth: 10674.0'
	API No.: 33025006640000		Lithology: Silty limestone

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION



Depth 10674.0': Massive, dense, and fractured silty limestone.

PHYSICAL PROPERTIES

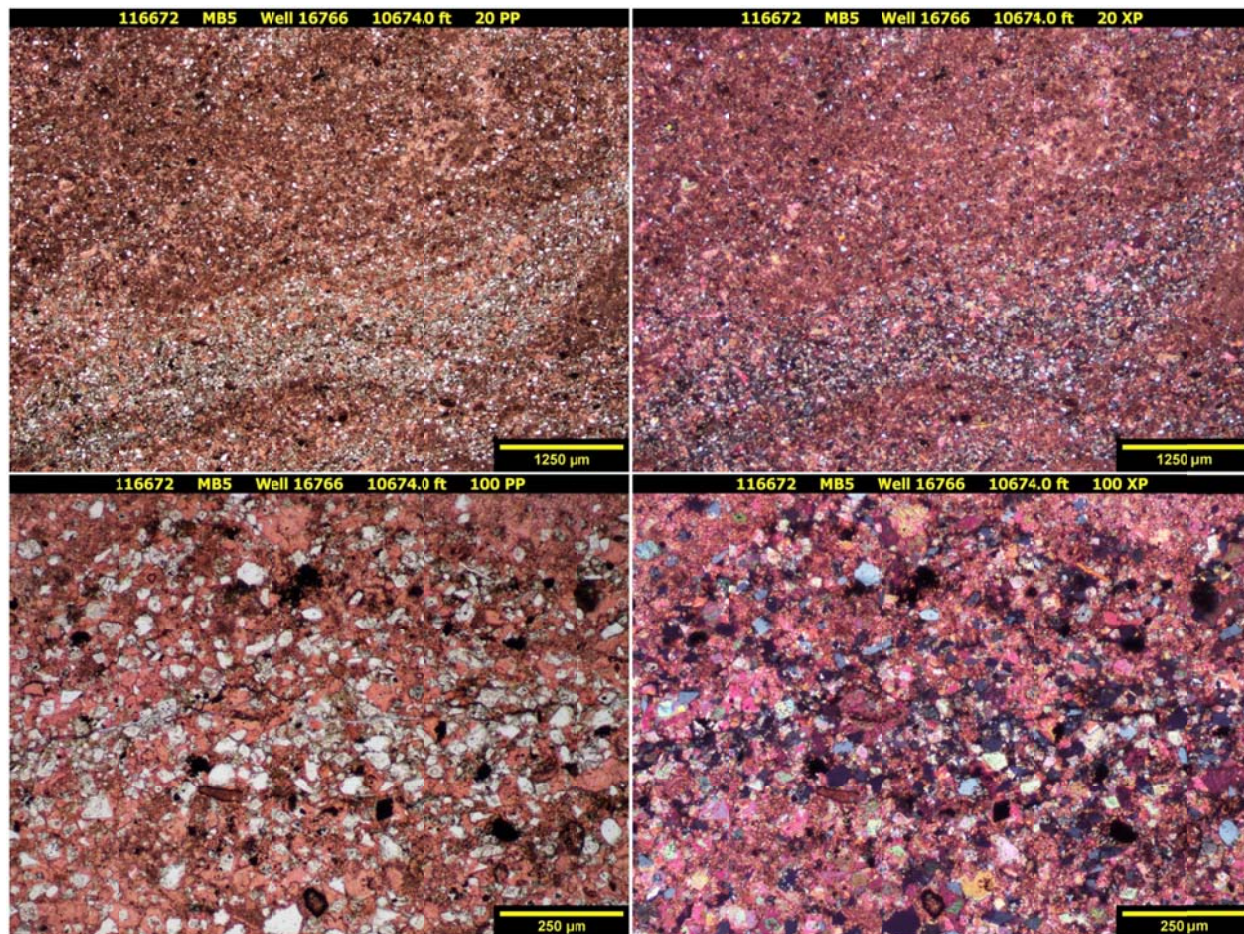
Porosity and Related Measurements Performed by MetaRock Laboratories

Pycnometer Effective Porosity, vol%	Bulk Volume, cm ³	Bulk Density, g/cm ³	Grain Volume, cm ³	Grain Density, g/cm ³
0.49	38.31	2.71	38.12	2.72

	Applied Geology Laboratory		ID: 116672
	Middle Bakken 5	NDIC Well 16766, Rogné 44-34H	Depth: 10674.0'
	API No.: 33025006640000		Lithology: Silty limestone

PHOTOMICROGRAPHS

Transmission



This sample is silty limestone. Detrital subangular to subrounded monocrystalline quartz have a speckled distribution and occasionally concentrated to form faint, burrow-like structures. Calcareous clasts and cement abundantly occur throughout the sample. Additional detrital minerals observed at trace quantities are muscovite and feldspars. The matrix composes predominantly clay, sparry calcareous cement, and rare microcrystalline to cryptocrystalline dolomite. Pyrite skeletal and nonskeletal replacement is observed. Trace rhombohedral dolomite is present. Small organic specs are found sporadically throughout and occasionally found in larger masses. No fractures or particle-based porosity are observed.

	Applied Geology Laboratory		ID: 116672
	Middle Bakken 5	NDIC Well 16766, Rogne 44-34H	Depth: 10674.0'
	API No.: 33025006640000	Lithology: Silty limestone	

PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	70	Very fine grained
Calcite	20	Cement
Dolomite	5	Few rhombs
Clay	Trace	
Metals	Trace	Pyrite
Muscovite	Trace	
Organics	Trace	Globular

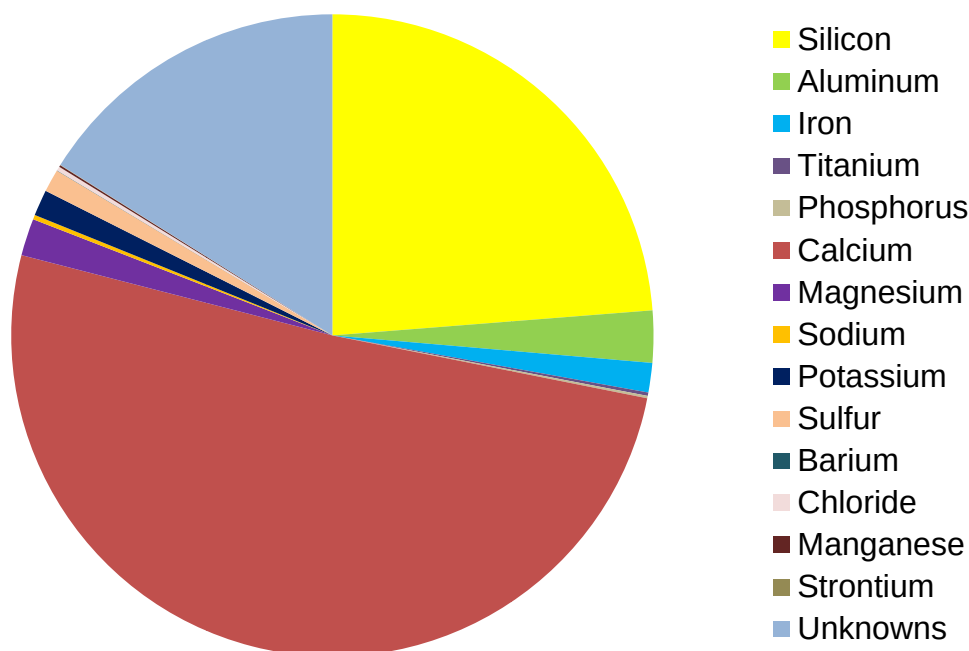
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through XRF and XRD data sets.

Detrital Texture

Category	Classification
Grain Size	Very fine grained
Sorting	Moderately sorted
Roundness	Subangular to subrounded

	Applied Geology Laboratory		ID: 116672
	Middle Bakken 5	NDIC Well 16766, Rogné 44-34H	Depth: 10674.0'
	API No.: 33025006640000	Lithology: Silty limestone	

XRF BULK CHEMICAL COMPOSITION

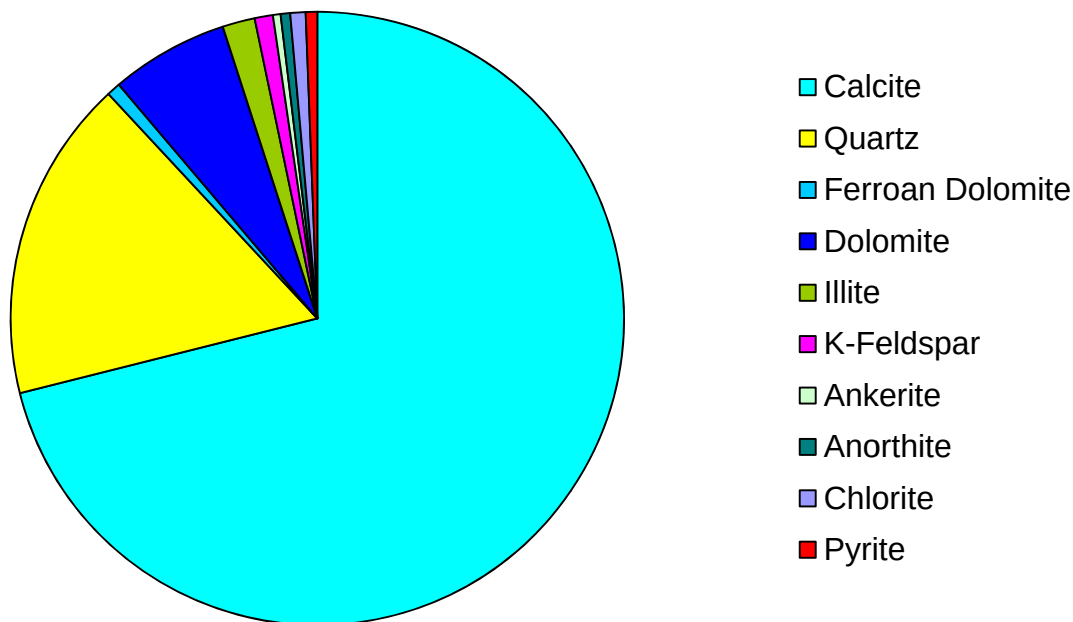


Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	23.76
Al (aluminum)	Al ₂ O ₃	2.61
Fe (iron)	Fe ₂ O ₃	1.48
Ti (titanium)	TiO ₂	0.17
P (phosphorus)	P ₂ O ₅	0.12
Ca (calcium)	CaO	50.88
Mg (magnesium)	MgO	1.87
Na (sodium)	Na ₂ O	0.23
K (potassium)	K ₂ O	1.31
S (sulfur)	SO ₃	1.14
Ba (barium)	BaO	0.02
Cl (chloride)	Cl	0.21
Mn (manganese)	MnO	0.09
Sr (strontium)	SrO	0.02
Unknowns	Due to the presence of carbonates*	16.09
Total		100.00

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

	Applied Geology Laboratory		ID: 116672
	Middle Bakken 5	NDIC Well 16766, Rogné 44-34H	Depth: 10674.0'
	API No.: 33025006640000		Lithology: Silty limestone

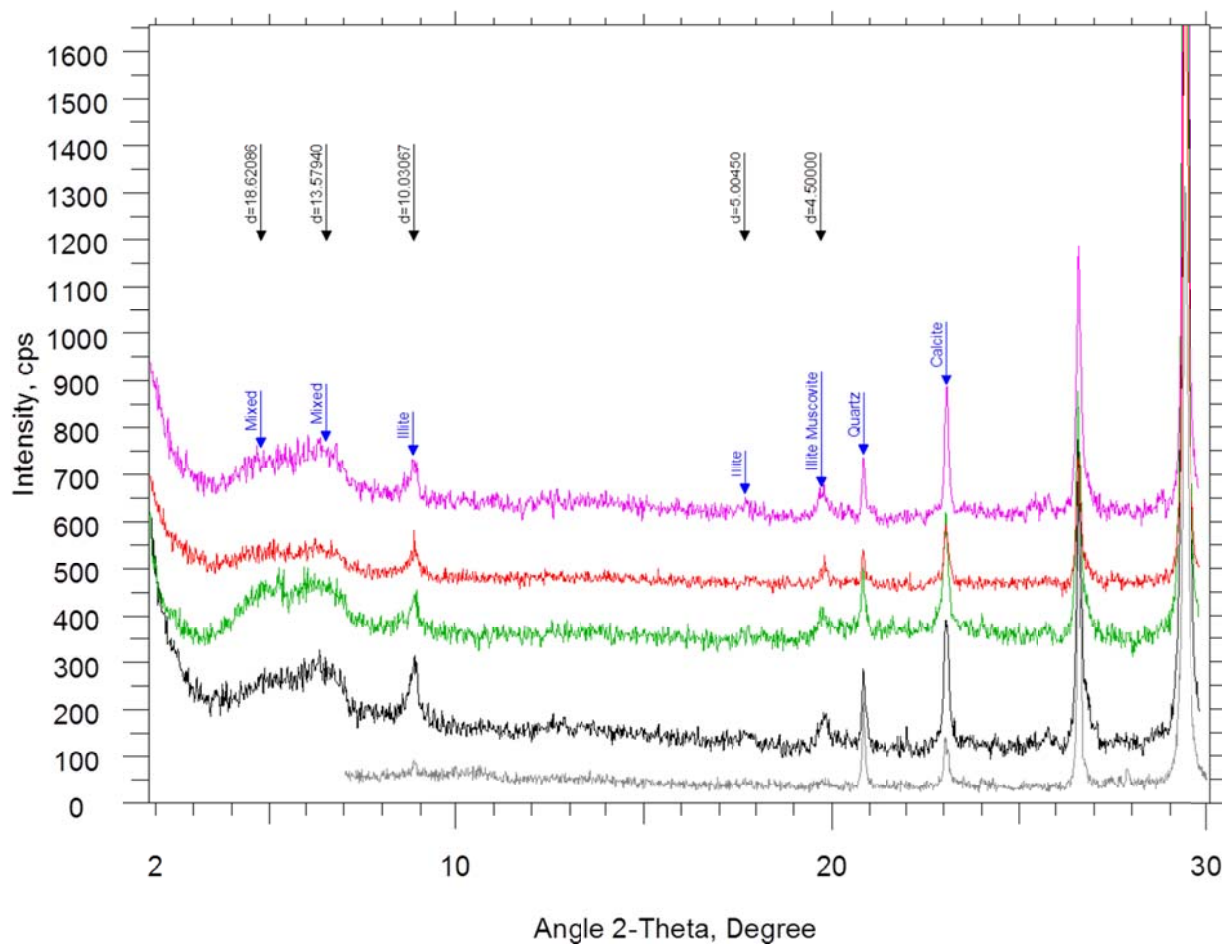
XRD MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	71.1
Quartz	SiO_2	17.0
Ferroan Dolomite	$\text{CaMg}_{0.8}\text{Fe}_{0.2}(\text{CO}_3)_2$	0.7
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	6.2
Illite	$(\text{K}, \text{H}_3\text{O})(\text{Al}, \text{Mg}, \text{Fe})_2(\text{Si}, \text{Al})_4\text{O}_{10}[(\text{OH})_2, (\text{H}_2\text{O})]$	1.7
K-Feldspar	KAlSi_3O_8	1.0
Ankerite	$\text{CaMg}_{0.45}\text{Fe}_{0.55}(\text{CO}_3)_2$	Trace
Anorthite	$\text{CaAl}_2\text{Si}_2\text{O}_4$	Trace
Chlorite	$\text{Mg}_{2.96}\text{Fe}_{1.55}\text{Fe}_{0.14}\text{Al}_{1.28}(\text{Si}_{2.62}\text{Al}_{1.38}\text{O}_{10})(\text{OH})_8$	0.8
Pyrite	FeS_2	0.6

	Applied Geology Laboratory		ID: 116672
	Middle Bakken 5	NDIC Well 16766, Rogné 44-34H	Depth: 10674.0'
	API No.: 33025006640000 Lithology: Silty limestone		

XRD Clay Typing



Clays Identified

Illite

Mixed-layer clay

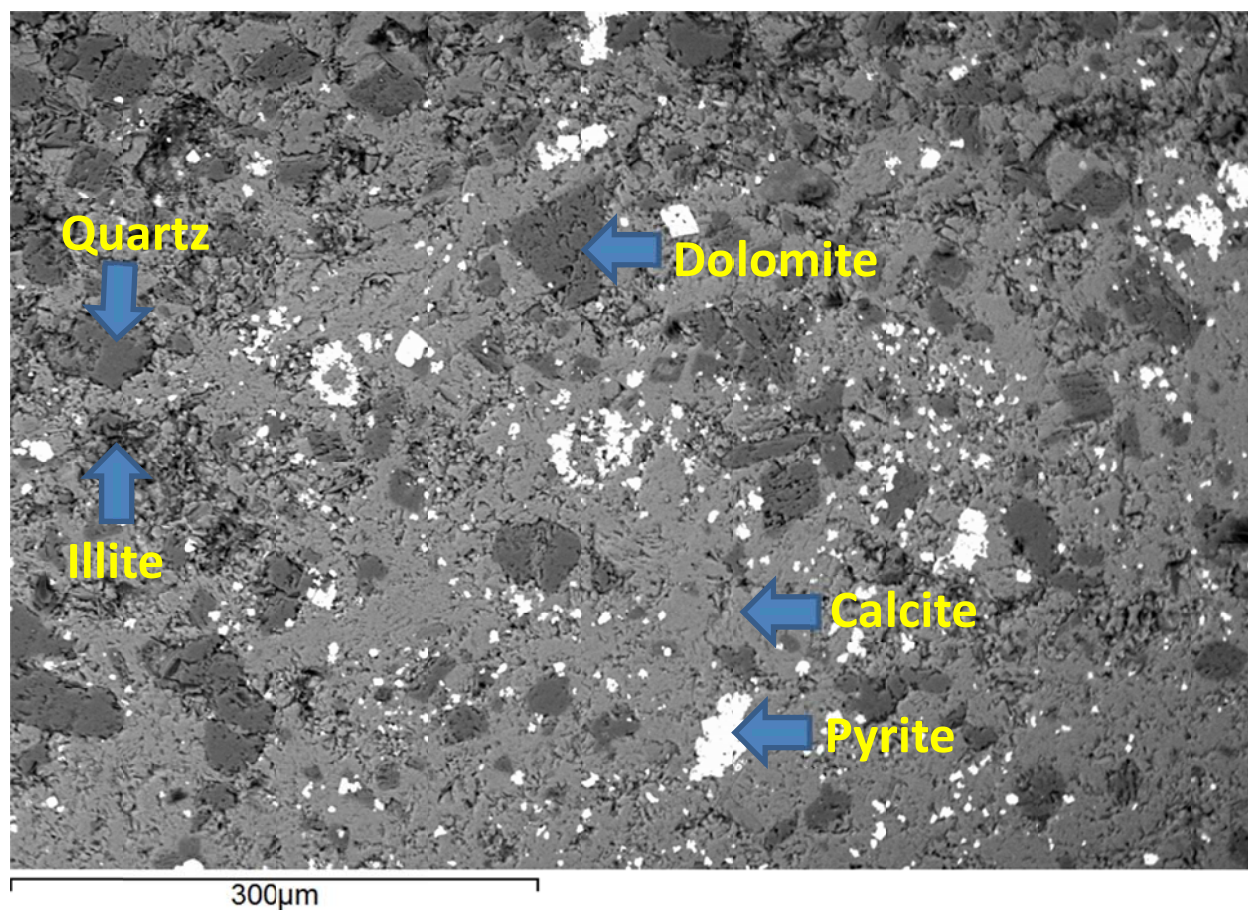
	Applied Geology Laboratory		ID: 116672
	Middle Bakken 5	NDIC Well 16766, Rogné 44-34H	Depth: 10674.0'
	API No.: 33025006640000		Lithology: Silty limestone

SEM

Observed Minerals

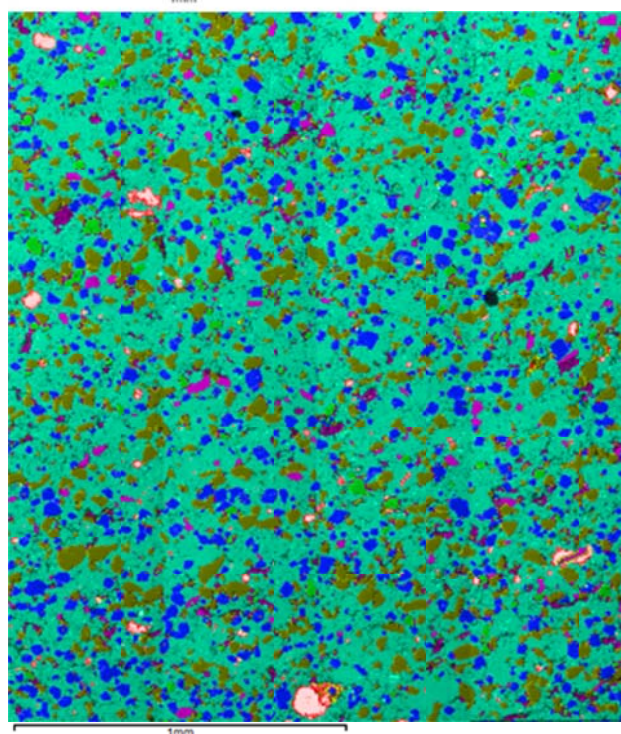
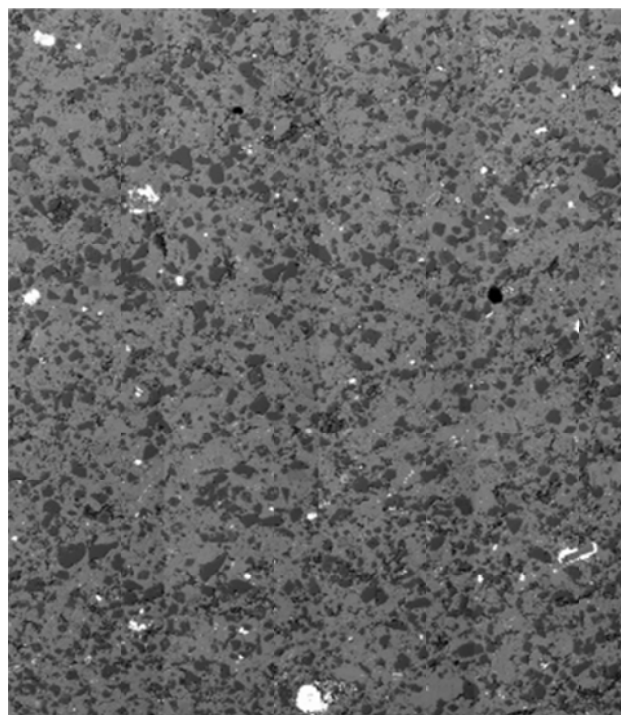
Mineral Phase	Mineral Phase
Calcite	Illite
Dolomite	K-Feldspar
Quartz	Rutile
Pyrite	Cuprite
Halite	Hematite
Apatite	

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified



	Applied Geology Laboratory		ID: 116672
	Middle Bakken 5	NDIC Well 16766, Rogne 44-34H	Depth: 10674.0'
	API No.: 33025006640000		Lithology: Silty limestone

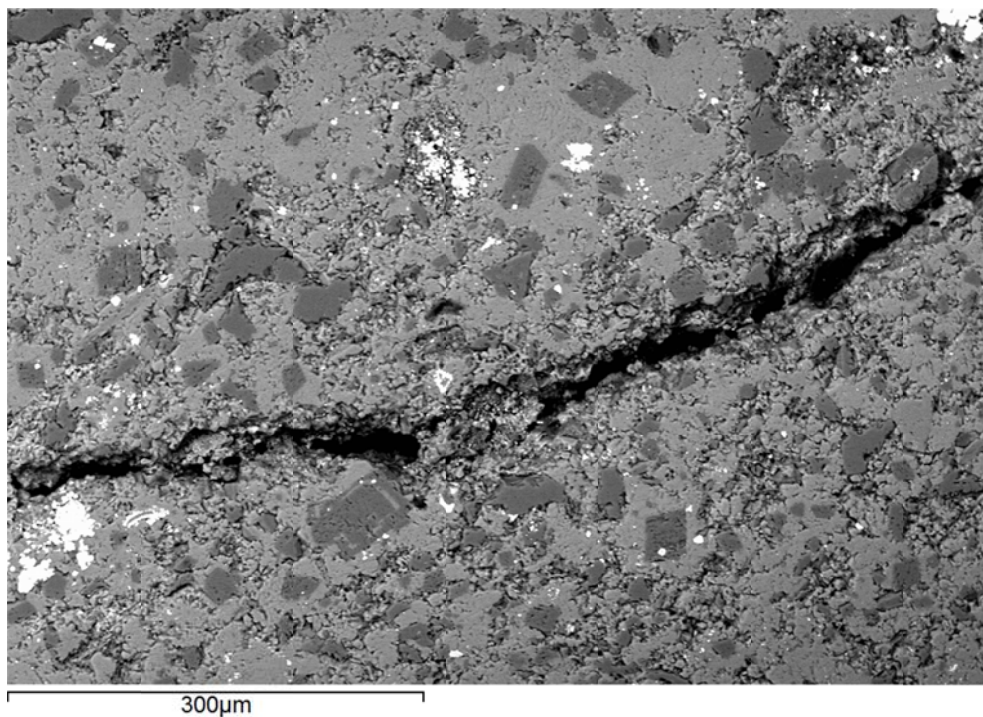
SEM BSE Image and Corresponding Digital Composite Mineral Map Image Overlaid on BSE Image with Mineral-Phase 2-D Area Percentages



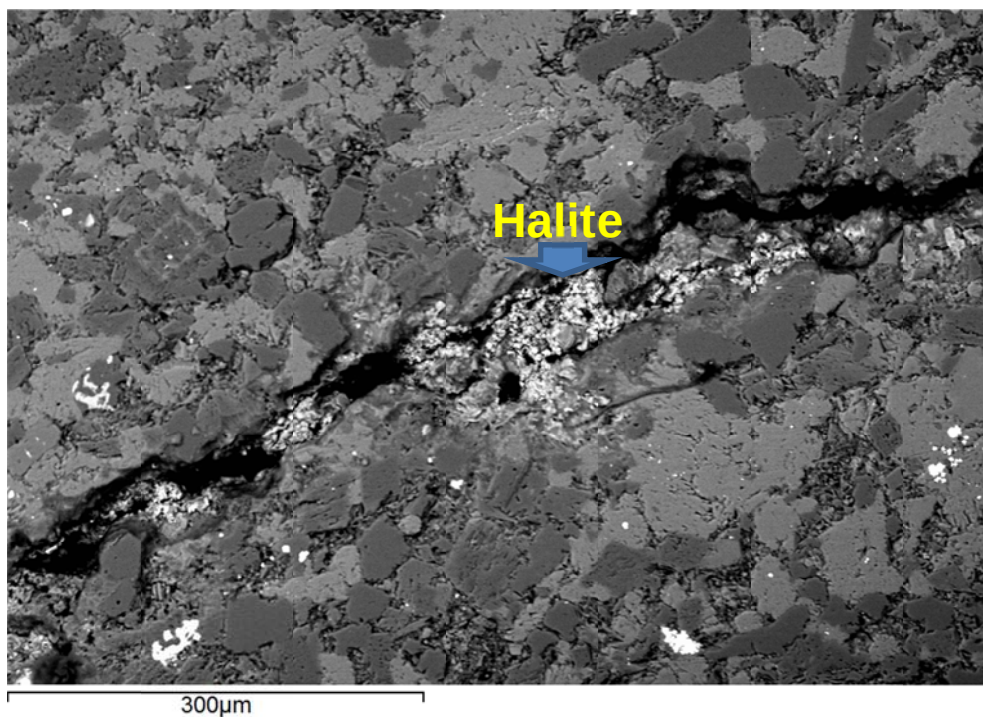
	Pyrite – 2.2%
	Dolomite – 9.6%
	Albite – 1.8%
	Quartz – 12.2%
	Calcite – 62.2%
	K-Feldspar – 4.8%
	Illite – 7.1%

	Applied Geology Laboratory		ID: 116672
	Middle Bakken 5	NDIC Well 16766, Rogné 44-34H	Depth: 10674.0'
	API No.: 33025006640000		Lithology: Silty limestone

Fracture Analysis on BSE Images



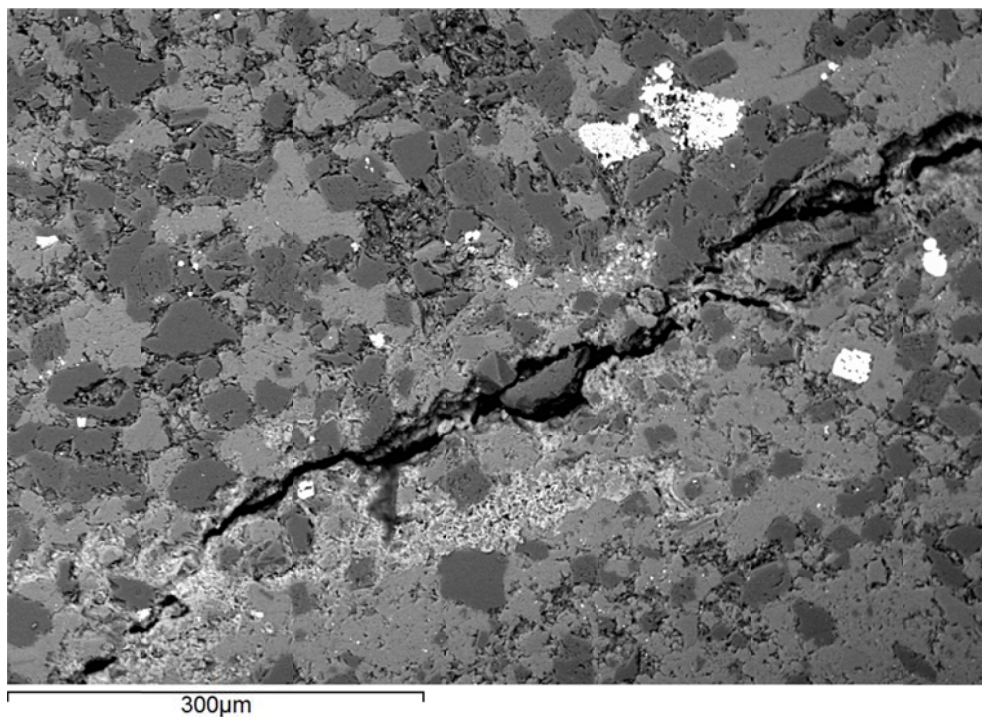
The fracture is partially filled with illite.



Halite is noted in the fracture.

	Applied Geology Laboratory		ID: 116672
	Middle Bakken 5	NDIC Well 16766, Rogne 44-34H	Depth: 10674.0'
	API No.: 33025006640000		Lithology: Silty limestone

Additional Fracture Analysis on BSE Images



There is a halite coating along the fracture.

	Applied Geology Laboratory		ID: 116228
	Middle Bakken 4	NDIC Well 16766, Rogné 44-34H	Depth: 10675.2'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION



Depth 10675.2': A coarser, massive packstone. Open and cemented fractures are observed.

PHYSICAL PROPERTIES

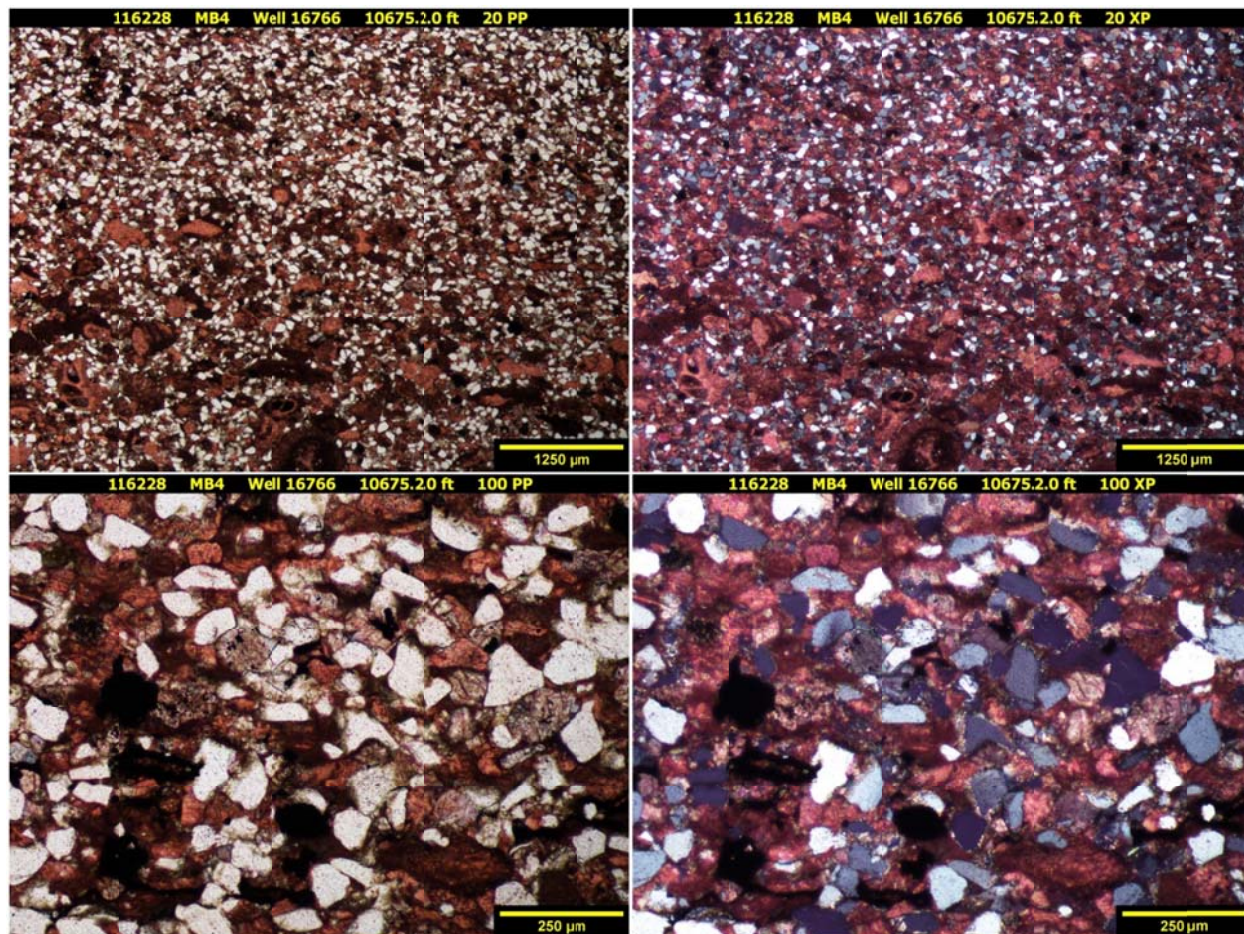
Porosity and Related Measurements Performed by MetaRock Laboratories

Pycnometer Effective Porosity, vol%	Bulk Volume, cm ³	Bulk Density, g/cm ³	Grain Volume, cm ³	Grain Density, g/cm ³
0.28	45.54	2.68	45.41	2.69

	Applied Geology Laboratory		ID: 116228
	Middle Bakken 4	NDIC Well 16766, Rogné 44-34H	Depth: 10675.2'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

PHOTOMICROGRAPHS

Transmission



This sample represents silty, oolitic packstone. Dispersed and, at times clustered, subrounded to subangular monocrystalline quartz is a common detrital mineral. Trace levels of feldspars and clays and no muscovite are observed. Nonskeletal, calcareous clasts are the more abundant allochem. Commonly occurring ooids, peloids, and skeletal grains are heavily fragmented (making fossil identification difficult) and scattered throughout. Evidence of micritization exists on both skeletal and nonskeletal grains. Pyrite and gypsum replacements are present at minor levels. Rare zones of clay mixed with microcrystalline to cryptocrystalline dolomite are present. Evidence of minor levels of compaction is noted by immature, small stylolites. Pore-filling, sparry calcite cement eliminates any observed porosity through traditional optical techniques. Although three horizontal fractures are noted, it is likely that these are an artifact of sampling.

	Applied Geology Laboratory		ID: 116228
	Middle Bakken 4	NDIC Well 16766, Rogne 44-34H	Depth: 10675.2'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	20	Fine grained
Calcite	75	Allochems, cement
Dolomite	Trace	Microcrystalline
Clay	Trace	
Metals	Trace	Pyrite
Muscovite	Trace	
Organics	Trace	Globular, micro-styolites

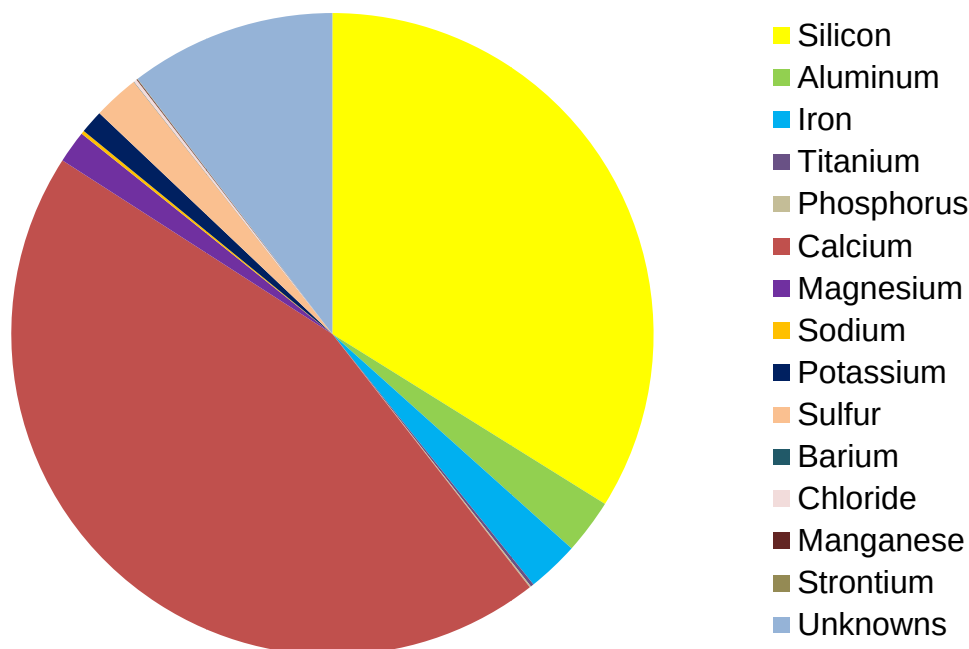
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through XRF and XRD data sets.

Detrital Texture

Category	Classification
Grain Size	Fine
Sorting	Moderately
Roundness	Subangular to subrounded

	Applied Geology Laboratory		ID: 116228
	Middle Bakken 4	NDIC Well 16766, Rogné 44-34H	Depth: 10675.2'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

XRF BULK CHEMICAL COMPOSITION

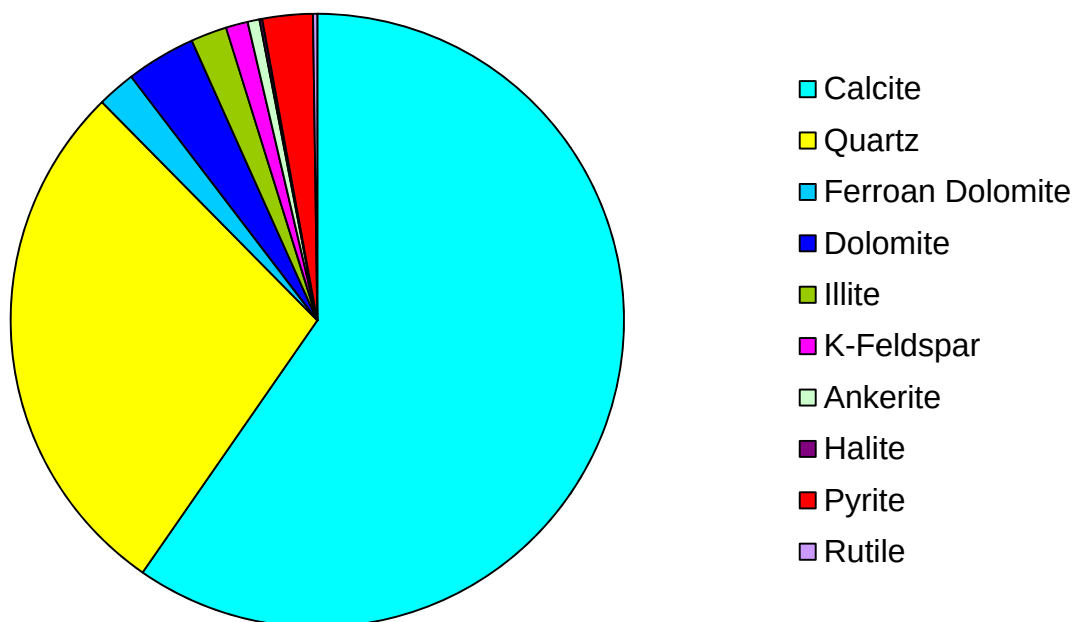


Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	33.87
Al (aluminum)	Al ₂ O ₃	2.76
Fe (iron)	Fe ₂ O ₃	2.60
Ti (titanium)	TiO ₂	0.16
P (phosphorus)	P ₂ O ₅	0.07
Ca (calcium)	CaO	44.64
Mg (magnesium)	MgO	1.63
Na (sodium)	Na ₂ O	0.17
K (potassium)	K ₂ O	1.17
S (sulfur)	SO ₃	2.31
Ba (barium)	BaO	0.02
Cl (chloride)	Cl	0.16
Mn (manganese)	MnO	0.04
Sr (strontium)	SrO	0.03
Unknowns	Due to the presence of carbonates*	10.37
Total		100.00

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

	Applied Geology Laboratory		ID: 116228
	Middle Bakken 4	NDIC Well 16766, Rogn 44-34H	Depth: 10675.2'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

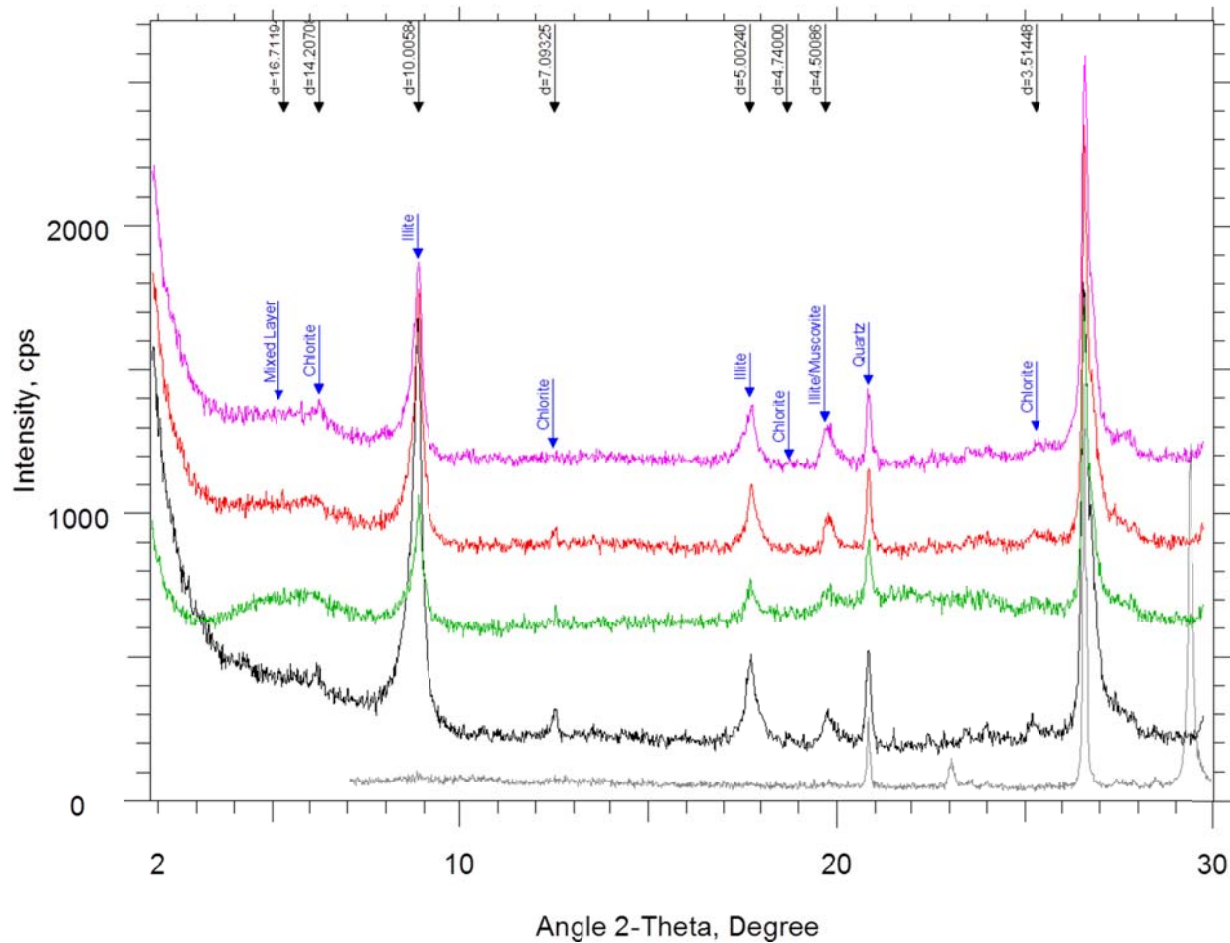
XRD MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	60.0
Quartz	SiO_2	28.0
Ferroan Dolomite	$\text{CaMg}_{0.8}\text{Fe}_{0.2}(\text{CO}_3)_2$	2.0
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	3.7
Illite	$(\text{K}, \text{H}_3\text{O})(\text{Al}, \text{Mg}, \text{Fe})_2(\text{Si}, \text{Al})_4\text{O}_{10}[(\text{OH})_2, (\text{H}_2\text{O})]$	1.9
K-Feldspar	KAlSi_3O_8	1.2
Ankerite	$\text{CaMg}_{0.45}\text{Fe}_{0.55}(\text{CO}_3)_2$	0.6
Halite	NaCl	Trace
Pyrite	FeS_2	2.7
Rutile	TiO_2	Trace

	Applied Geology Laboratory		ID: 116228
	Middle Bakken 4	NDIC Well 16766, Rogn 44-34H	Depth: 10675.2'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

XRD Clay Typing



Clays Identified

Illite
Chlorite
Evidence of mixed-layer clays

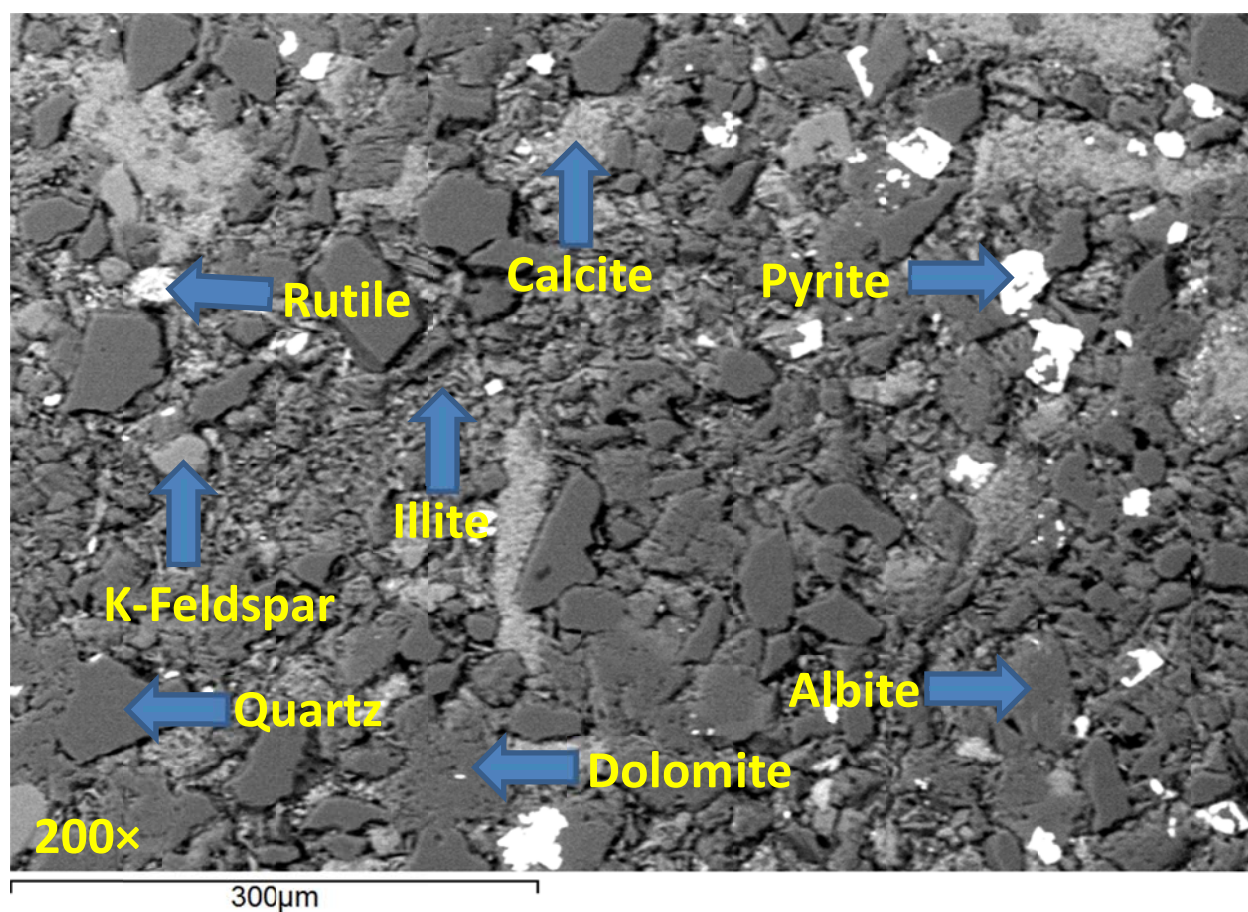
	Applied Geology Laboratory		ID: 116228
	Middle Bakken 4	NDIC Well 16766, Rogné 44-34H	Depth: 10675.2'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

SEM

Observed Minerals

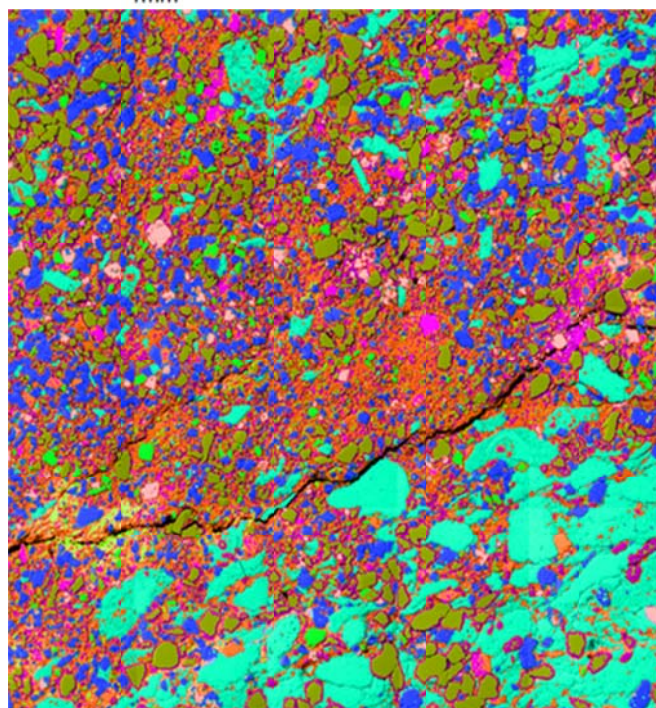
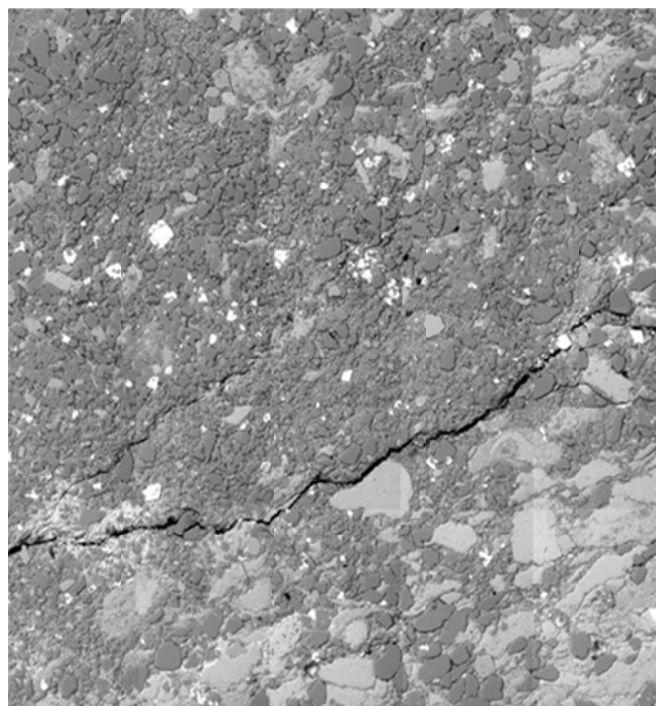
Mineral Phase	Mineral Phase
Calcite	K-Feldspar
Quartz	Zircon
Pyrite	Apatite
Dolomite	Albite
Rutile	Halite
Illite	

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified



	Applied Geology Laboratory		ID: 116228
	Middle Bakken 4	NDIC Well 16766, Rogne 44-34H	Depth: 10675.2'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

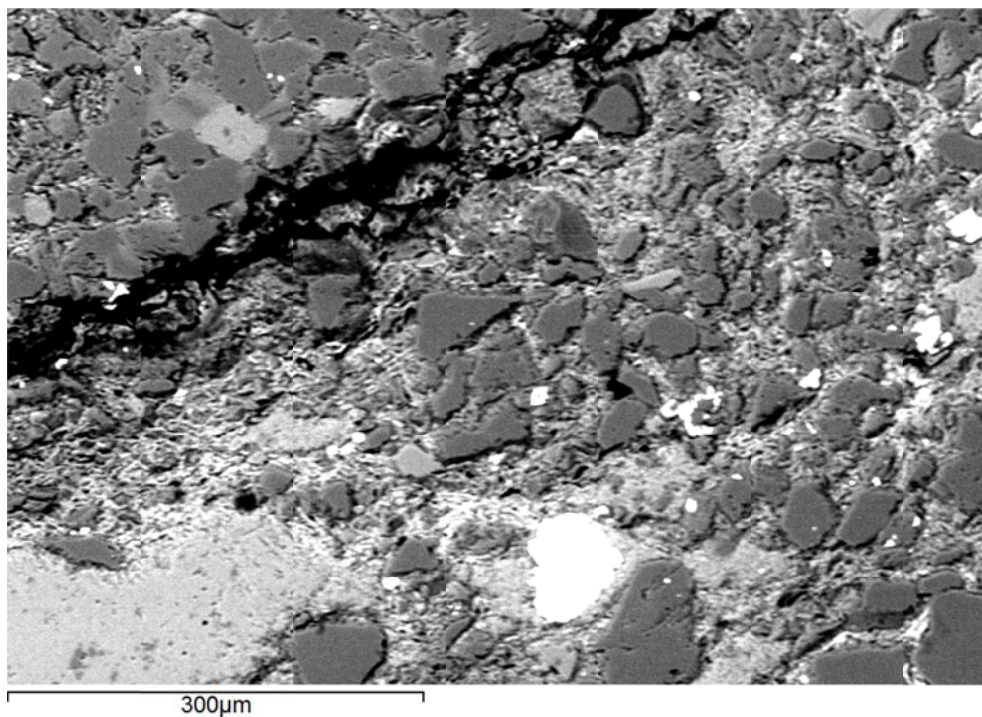
SEM BSE Image and Corresponding Digital Composite Mineral Map Image Overlaid on BSE Image with Mineral-Phase 2-D Area Percentages



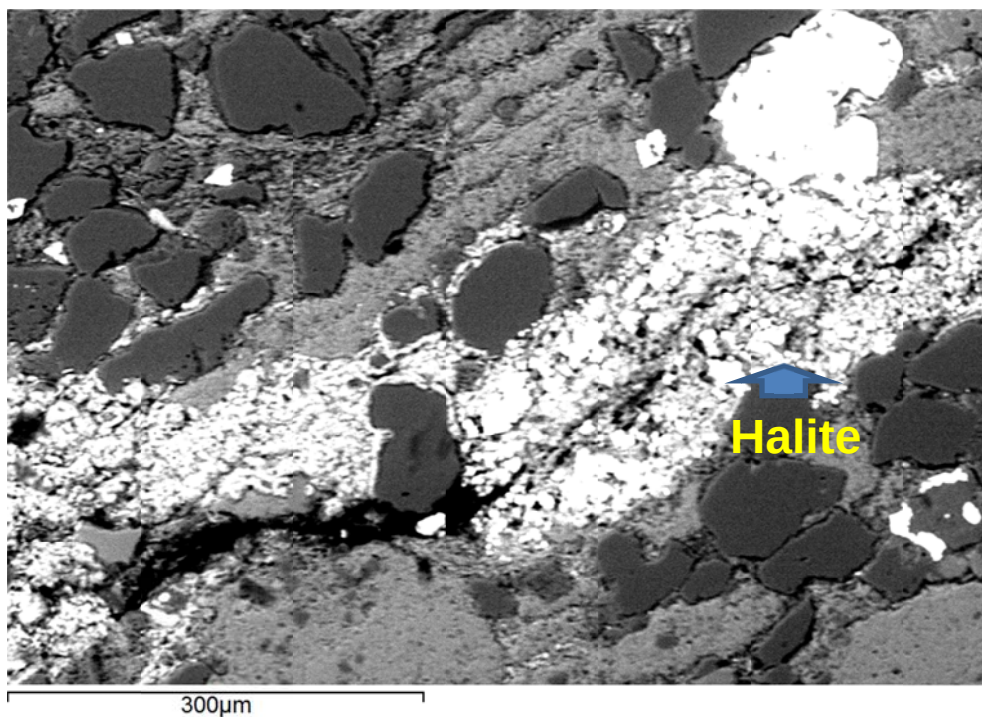
	Pyrite – 1.8%
	Dolomite – 14.9%
	Calcite – 18.0%
	Albite – 1.8%
	Quartz – 19.2%
	K-Feldspar – 17.7%
	Illite – 25.0%
	Apatite – 0.1%
	Halite – 1.6%

	Applied Geology Laboratory		ID: 116228
	Middle Bakken 4	NDIC Well 16766, Rogne 44-34H	Depth: 10675.2'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

Fracture Analysis on BSE Images



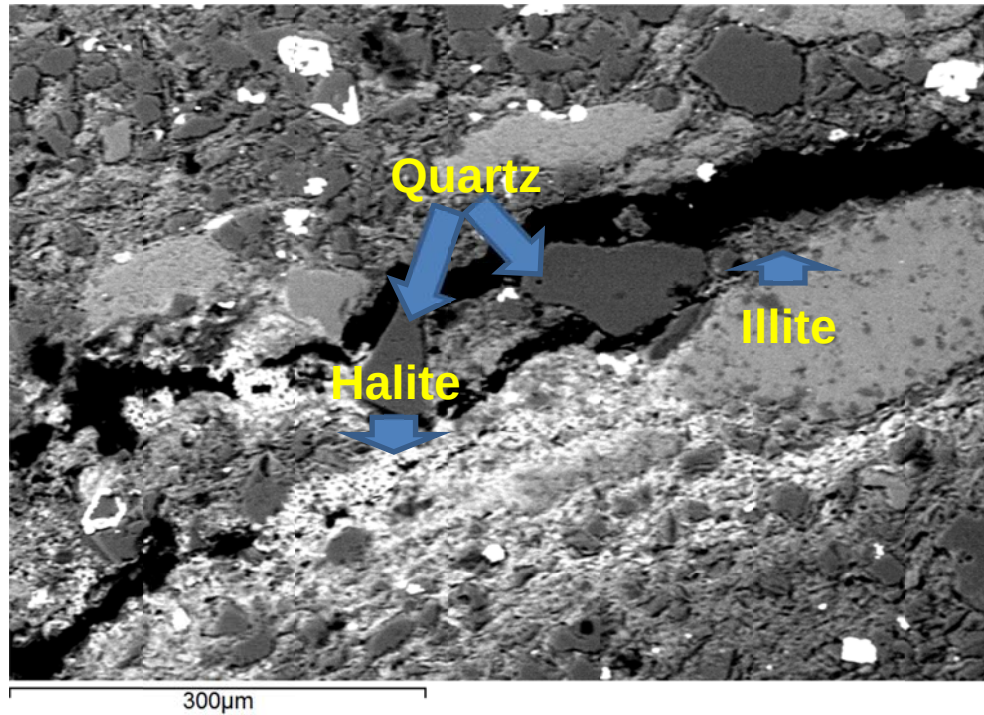
Halite and illite partially fill the fracture.



Large halite deposits along the fracture nearly fill it.

	Applied Geology Laboratory		ID: 116228
	Middle Bakken 4	NDIC Well 16766, Rogné 44-34H	Depth: 10675.2'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

Additional Fracture Analysis on BSE Images



Illite lines the fracture, halite is found in and along the fracture, and a few quartz grains survived the fracture event.

	Applied Geology Laboratory		ID: 116233
	Middle Bakken 4	NDIC Well 16766, Rogne 44-34H	Depth: 10675.6'
	API No.: 33025006640000		Lithology: Silty, oolitic limestone

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION

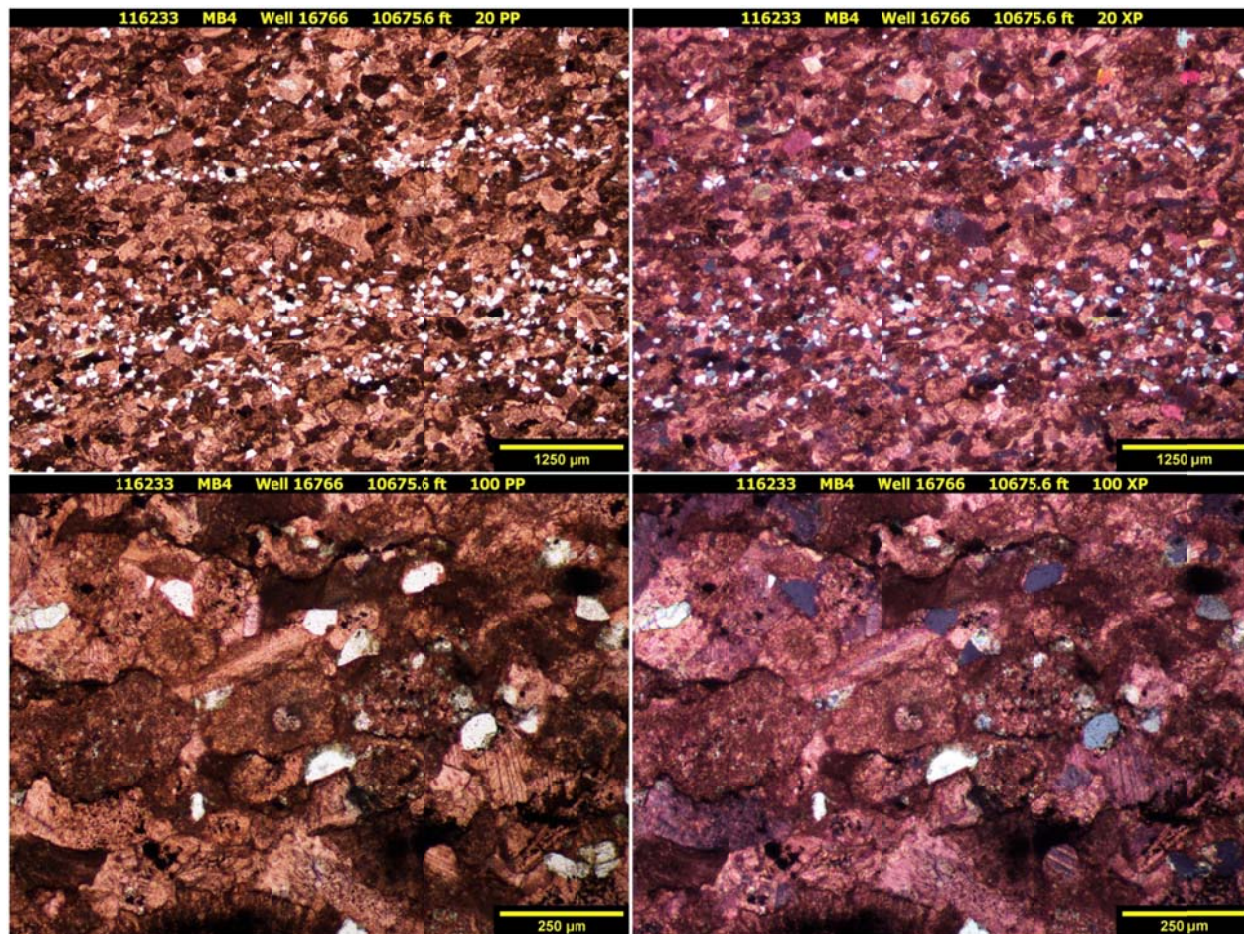


Depth 10675.6': A coarser, massive packstone. Open and cemented fractures are observed.

	Applied Geology Laboratory		ID: 116233
	Middle Bakken 4	NDIC Well 16766, Rogne 44-34H	Depth: 10675.6'
	API No.: 33025006640000		Lithology: Silty, oolitic limestone

PHOTOMICROGRAPHS

Transmission



This sample represents silty, oolitic packstone. Angular to subangular monocrystalline quartz is dispersed and in the form of multiple faint laminations. No feldspars, muscovite, or clays are observed. Lithic calcareous clasts are abundant. Ooids, peloids, and skeletal grains are scattered throughout. Many of the oolids, peloids, and fossils are fragmented. Evidence of micritization, dolomitization, and iron oxide coating are observed on both skeletal and nonskeletal grains. Pyrite partial allochem replacement and globular growth are present at minor levels. Evidence of minor levels of compaction is noted by immature, grain-sized stylolites. Pore-filling, sparry calcite eliminates any observed particle-based porosity in the thin section. Organics are noted as small dispersed globs, and no fractures are detected.

	Applied Geology Laboratory		ID: 116233
	Middle Bakken 4	NDIC Well 16766, Rogne 44-34H	Depth: 10675.6'
	API No.: 33025006640000		Lithology: Silty, oolitic limestone

PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	15	Fine grained
Calcite	85	Allochems, cement
Dolomite	Trace	Replacement
Clay	0	Not observed
Metals	Trace	Pyrite
Muscovite	0	Not observed
Organics	Trace	Globular

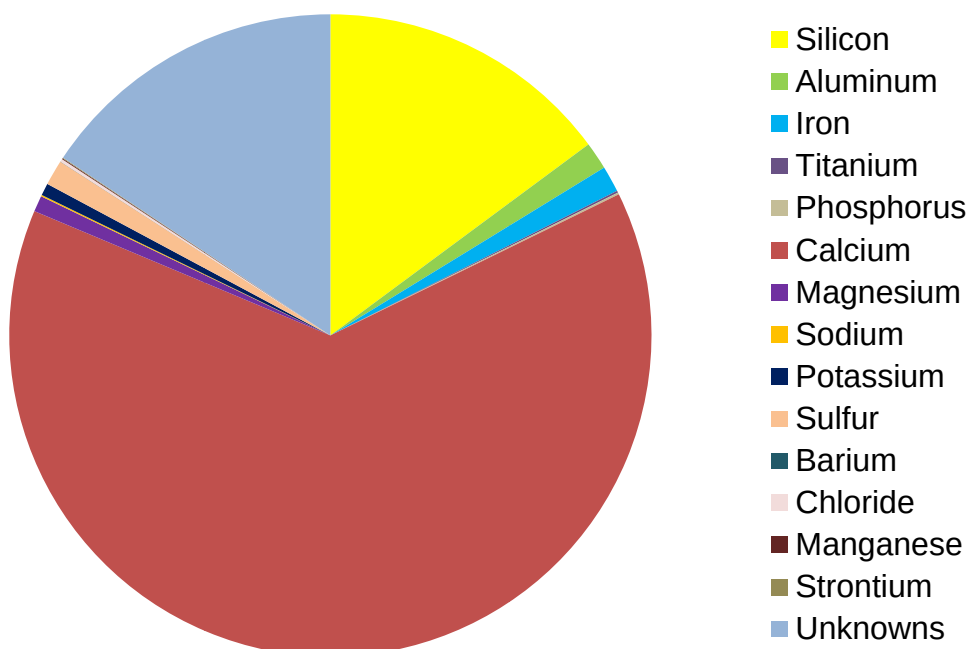
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through XRF and XRD data sets.

Texture

Category	Classification
Grain Size	Fine
Sorting	Moderately well
Roundness	Angular to subangular

	Applied Geology Laboratory		ID: 116233
	Middle Bakken 4	NDIC Well 16766, Rogné 44-34H	Depth: 10675.6'
	API No.: 33025006640000		Lithology: Silty, oolitic limestone

XRF BULK CHEMICAL COMPOSITION

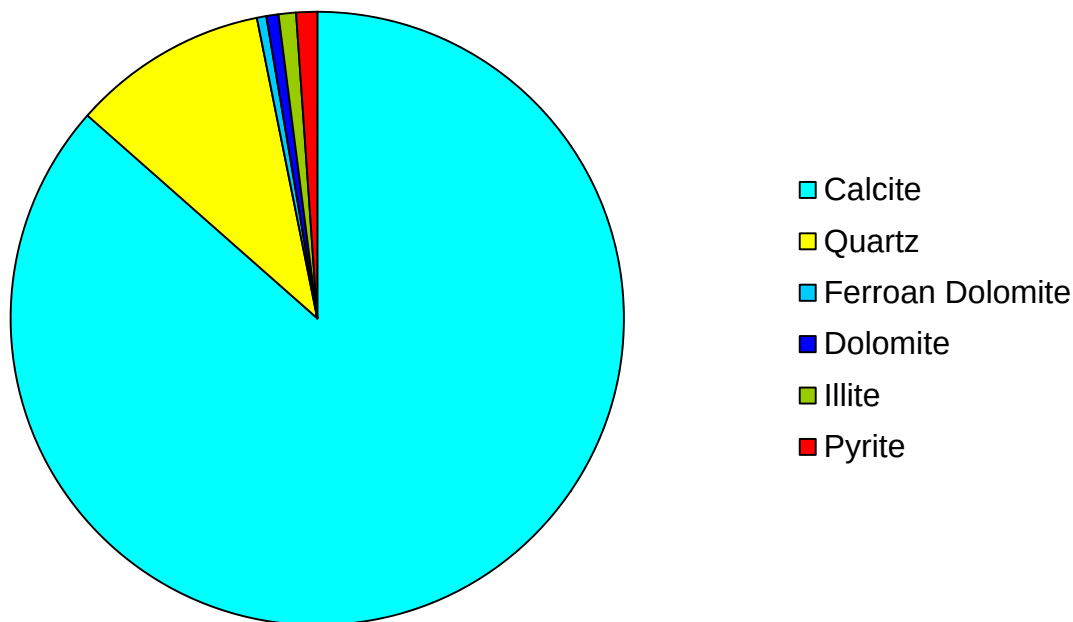


Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	14.86
Al (aluminum)	Al ₂ O ₃	1.39
Fe (iron)	Fe ₂ O ₃	1.32
Ti (titanium)	TiO ₂	0.10
P (phosphorus)	P ₂ O ₅	0.09
Ca (calcium)	CaO	63.57
Mg (magnesium)	MgO	0.81
Na (sodium)	Na ₂ O	0.07
K (potassium)	K ₂ O	0.61
S (sulfur)	SO ₃	1.28
Ba (barium)	BaO	0.01
Cl (chloride)	Cl	0.14
Mn (manganese)	MnO	0.05
Sr (strontium)	SrO	0.04
Unknowns	Due to the presence of carbonates*	15.67
Total		100.01

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

	Applied Geology Laboratory		ID: 116233
	Middle Bakken 4	NDIC Well 16766, Rogné 44-34H	Depth: 10675.6'
	API No.: 33025006640000		Lithology: Silty, oolitic limestone

XRD MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	86.5
Quartz	SiO_2	10.3
Ferroan Dolomite	$\text{CaMg}_{0.8}\text{Fe}_{0.2}(\text{CO}_3)_2$	Trace
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	0.6
Illite	$(\text{K}, \text{H}_3\text{O})(\text{Al}, \text{Mg}, \text{Fe})_2(\text{Si}, \text{Al})_4\text{O}_{10}[(\text{OH})_2, (\text{H}_2\text{O})]$	0.9
Pyrite	FeS_2	1.1

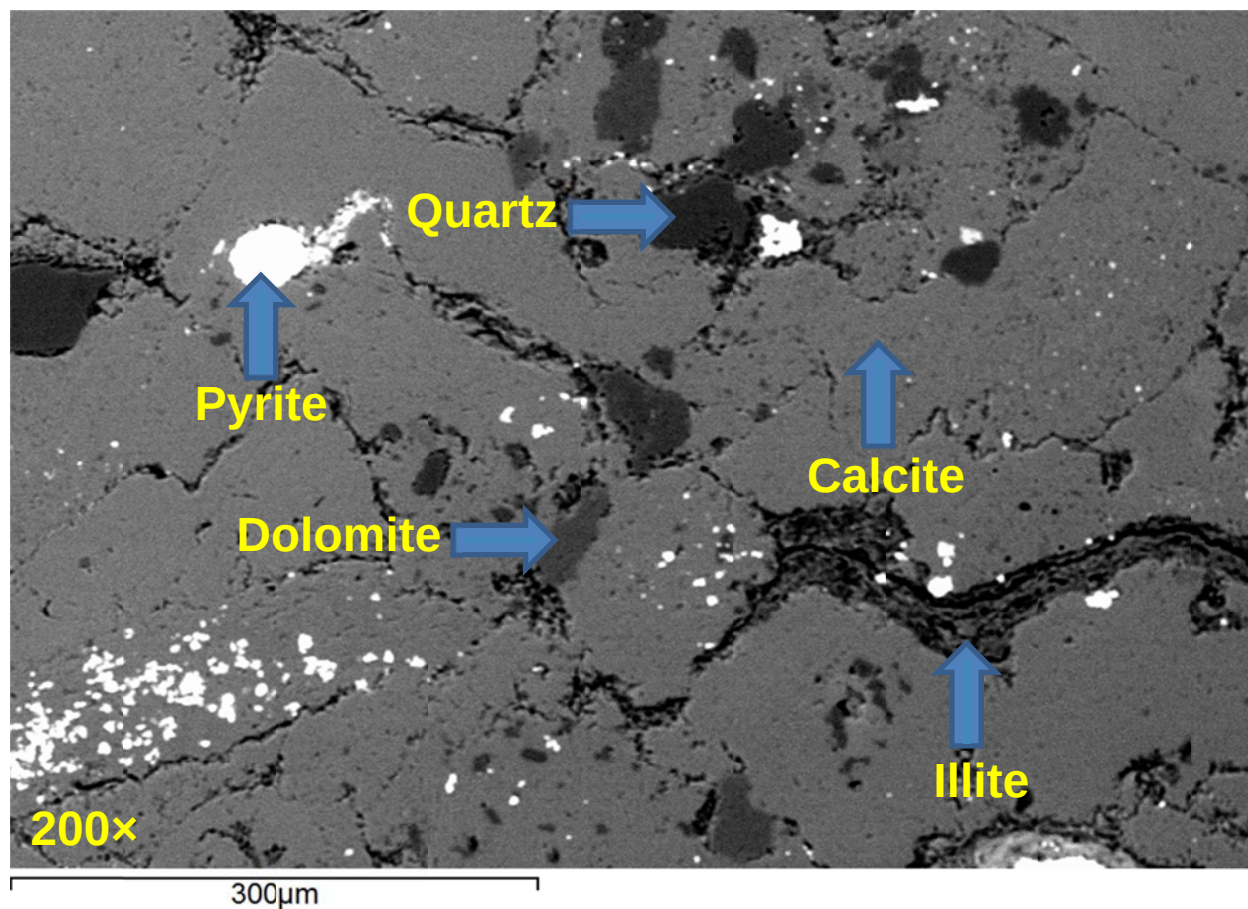
	Applied Geology Laboratory		ID: 116233
	Middle Bakken 4	NDIC Well 16766, Rogne 44-34H	Depth: 10675.6'
	API No.: 33025006640000		Lithology: Silty, oolitic limestone

SEM

Observed Minerals

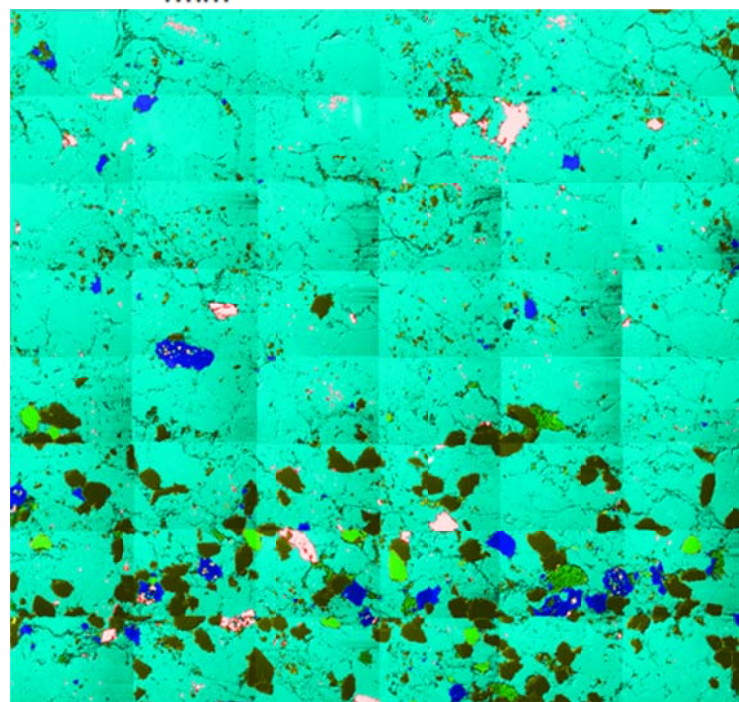
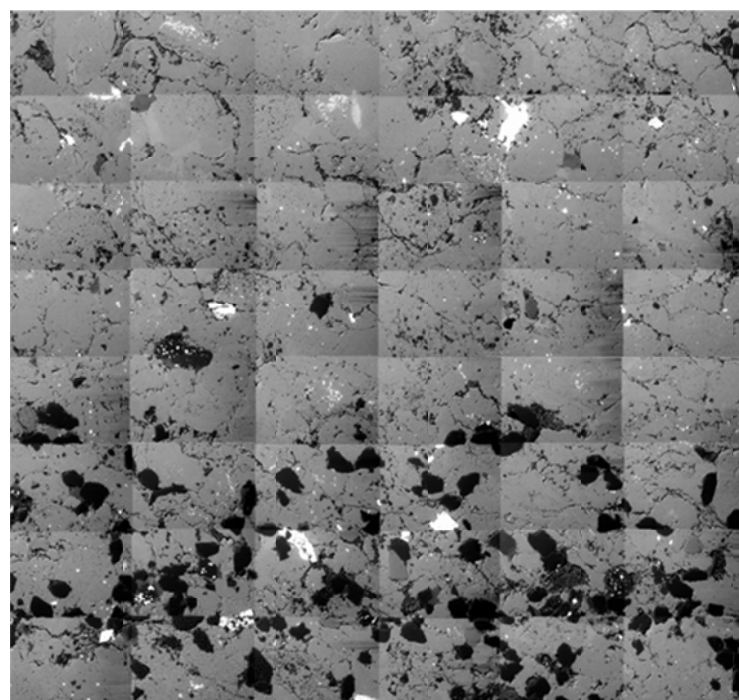
Mineral Phase	Mineral Phase
Calcite	Fluorapatite
Dolomite	Quartz
Pyrite	Illite

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified



	Applied Geology Laboratory		ID: 116233
	Middle Bakken 4	NDIC Well 16766, Rogne 44-34H	Depth: 10675.6'
	API No.: 33025006640000		Lithology: Silty, oolitic limestone

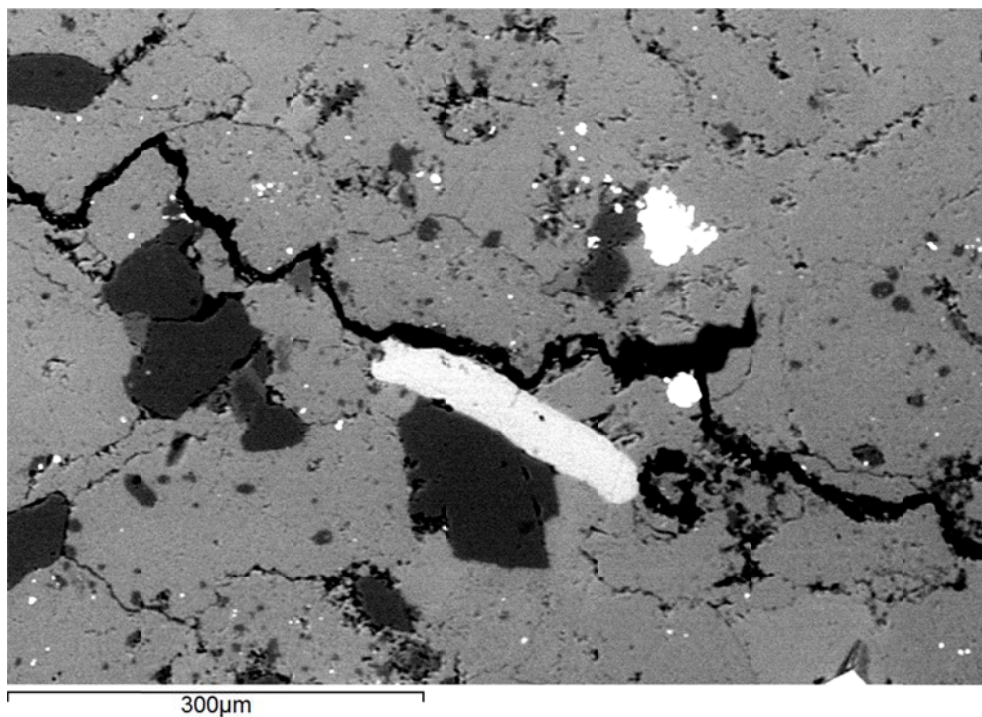
SEM BSE Image and Corresponding Digital Composite Mineral Map Image Overlaid on BSE Image with Mineral-Phase 2-D Area Percentages



	Pyrite – 1.9%
	Dolomite – 1.9%
	Albite – 1.2%
	Quartz – 7.5%
	Calcite – 87.6%

	Applied Geology Laboratory		ID: 116233
	Middle Bakken 4	NDIC Well 16766, Rogne 44-34H	Depth: 10675.6'
	API No.: 33025006640000		Lithology: Silty, oolitic limestone

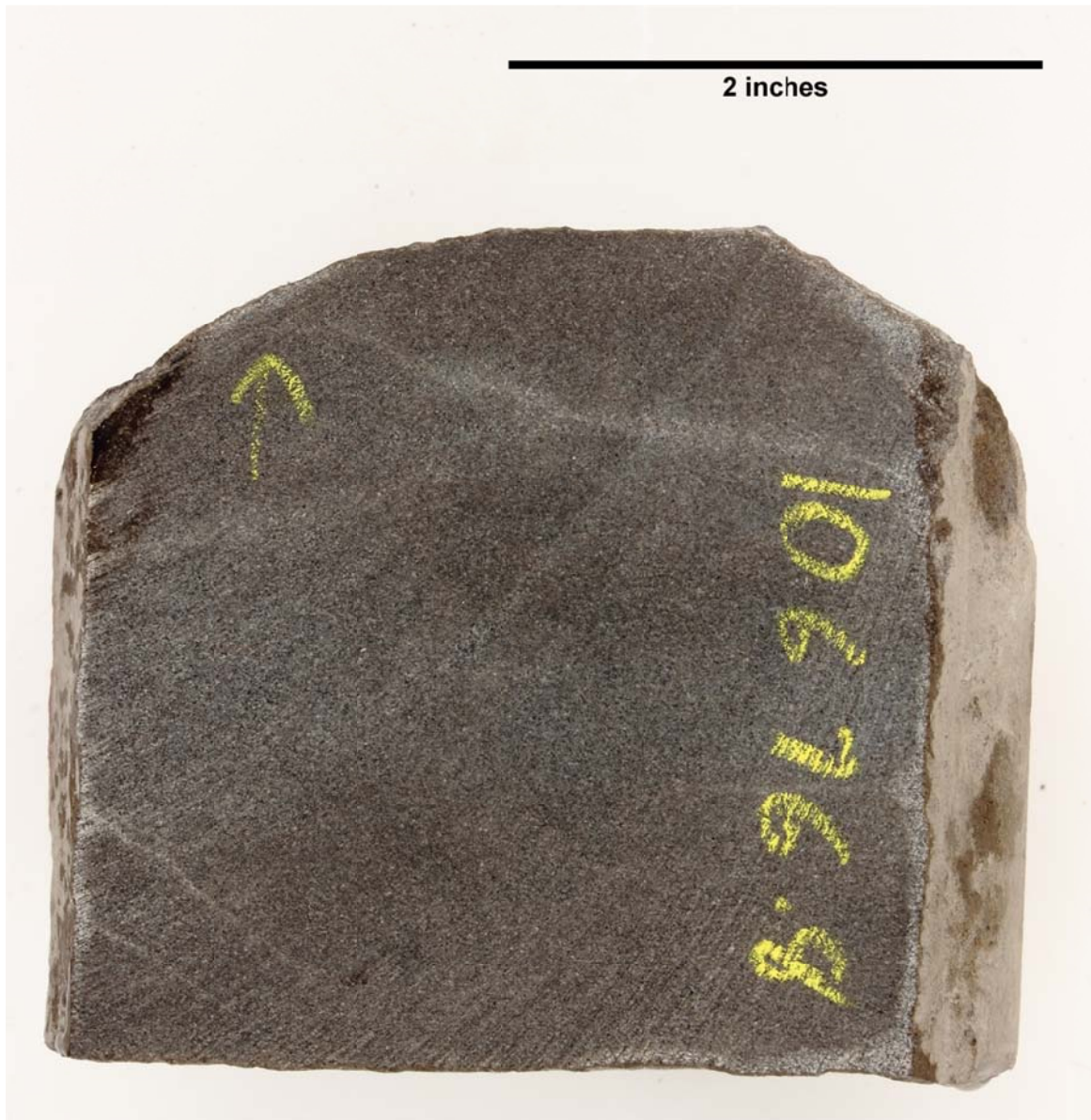
Fracture Analysis on BSE Images



This fracture contains very little material and may not be natural.

	Applied Geology Laboratory		ID: 116234
	Middle Bakken 4	NDIC Well 16766, Rogne 44-34H	Depth: 10676.8'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION

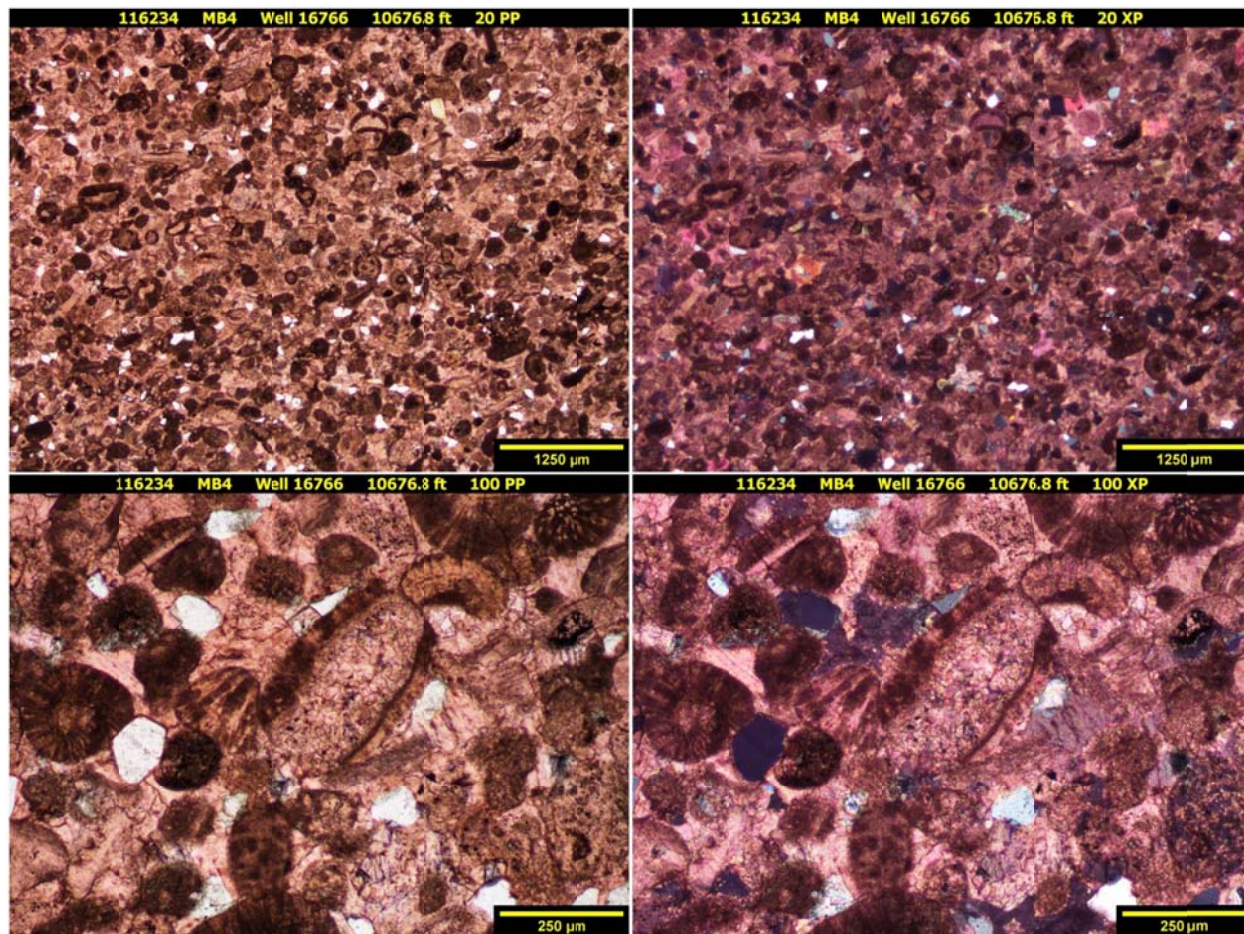


Depth 10676.8': A coarser, massive packstone. Cemented fractures are observed.

	Applied Geology Laboratory		ID: 116234
	Middle Bakken 4	NDIC Well 16766, Rogne 44-34H	Depth: 10676.8'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

PHOTOMICROGRAPHS

Transmission



This sample represents silty, oolitic packstone. Subangular to subrounded monocrystalline quartz is disseminated throughout the sample. Trace amounts of rutile and no muscovite, feldspars, or clays are observed. Nonskeletal and skeletal allochems are abundant. Ooids, peloids, calcareous clast fragments, and skeletal grains are dispersed throughout. Evidence of micritization exists on both skeletal and nonskeletal grains. Pyrite and dolomitization replacement are present at minor levels. Conversely to other samples from this lithofacie, no evidence of immature, small stylolites as a result of compaction is noted. Pore-filling, sparry calcite cement eliminates any observable interparticle-based porosity in the thin section. Trace amounts of small organic globes are noted throughout. One horizontal fracture is observed across most of the face of the sample. It is likely that this is an artifact of sampling.

	Applied Geology Laboratory		ID: 116234
	Middle Bakken 4	NDIC Well 16766, Rogne 44-34H	Depth: 10676.8'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	10	Fine grained
Calcite	90	Allochems, cement
Dolomite	0	Not observed
Clay	0	Not observed
Metals	Trace	Pyrite
Muscovite	0	Not observed
Organics	Trace	Globular

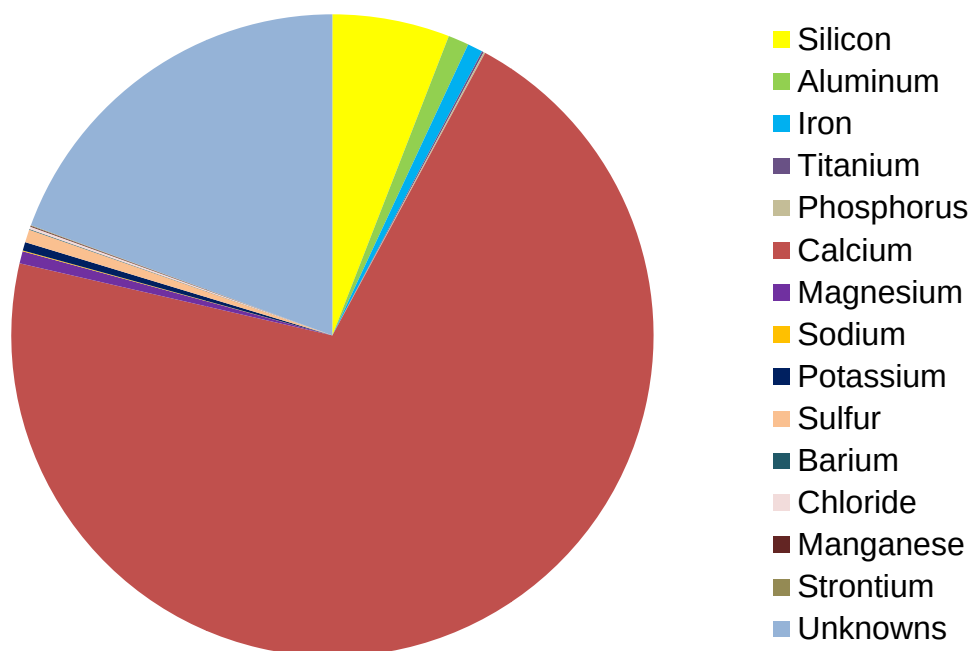
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through XRF and XRD data sets.

Detrital Texture

Category	Classification
Grain Size	Fine
Sorting	Poorly
Roundness	Subangular to subrounded

	Applied Geology Laboratory		ID: 116234
	Middle Bakken 4	NDIC Well 16766, Rogne 44-34H	Depth: 10676.8'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

XRF BULK CHEMICAL COMPOSITION

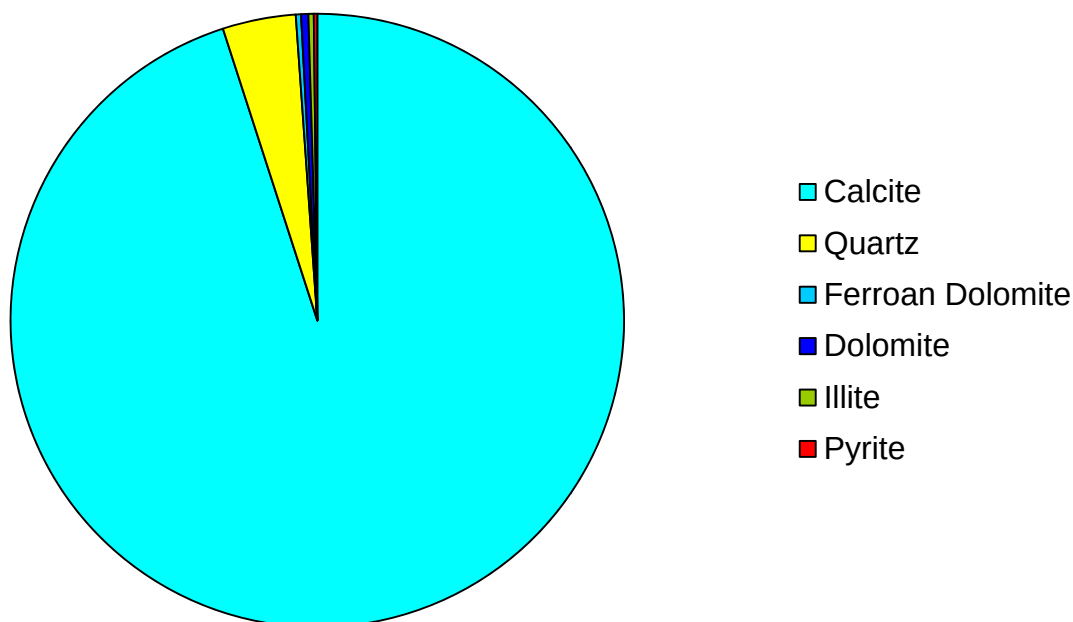


Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	5.90
Al (aluminum)	Al ₂ O ₃	1.05
Fe (iron)	Fe ₂ O ₃	0.77
Ti (titanium)	TiO ₂	0.09
P (phosphorus)	P ₂ O ₅	0.08
Ca (calcium)	CaO	70.71
Mg (magnesium)	MgO	0.61
Na (sodium)	Na ₂ O	0.04
K (potassium)	K ₂ O	0.43
S (sulfur)	SO ₃	0.65
Ba (barium)	BaO	0.03
Cl (chloride)	Cl	0.13
Mn (manganese)	MnO	0.04
Sr (strontium)	SrO	0.04
Unknowns	Due to the presence of carbonates*	19.42
Total		99.99

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

	Applied Geology Laboratory		ID: 116234
	Middle Bakken 4	NDIC Well 16766, Rogné 44-34H	Depth: 10676.8'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

XRD MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	95.0
Quartz	SiO_2	3.9
Ferroan Dolomite	$\text{CaMg}_{0.8}\text{Fe}_{0.2}(\text{CO}_3)_2$	Trace
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	Trace
Illite	$(\text{K}, \text{H}_3\text{O})(\text{Al}, \text{Mg}, \text{Fe})_2(\text{Si}, \text{Al})_4\text{O}_{10}[(\text{OH})_2, (\text{H}_2\text{O})]$	Trace
Pyrite	FeS_2	Trace

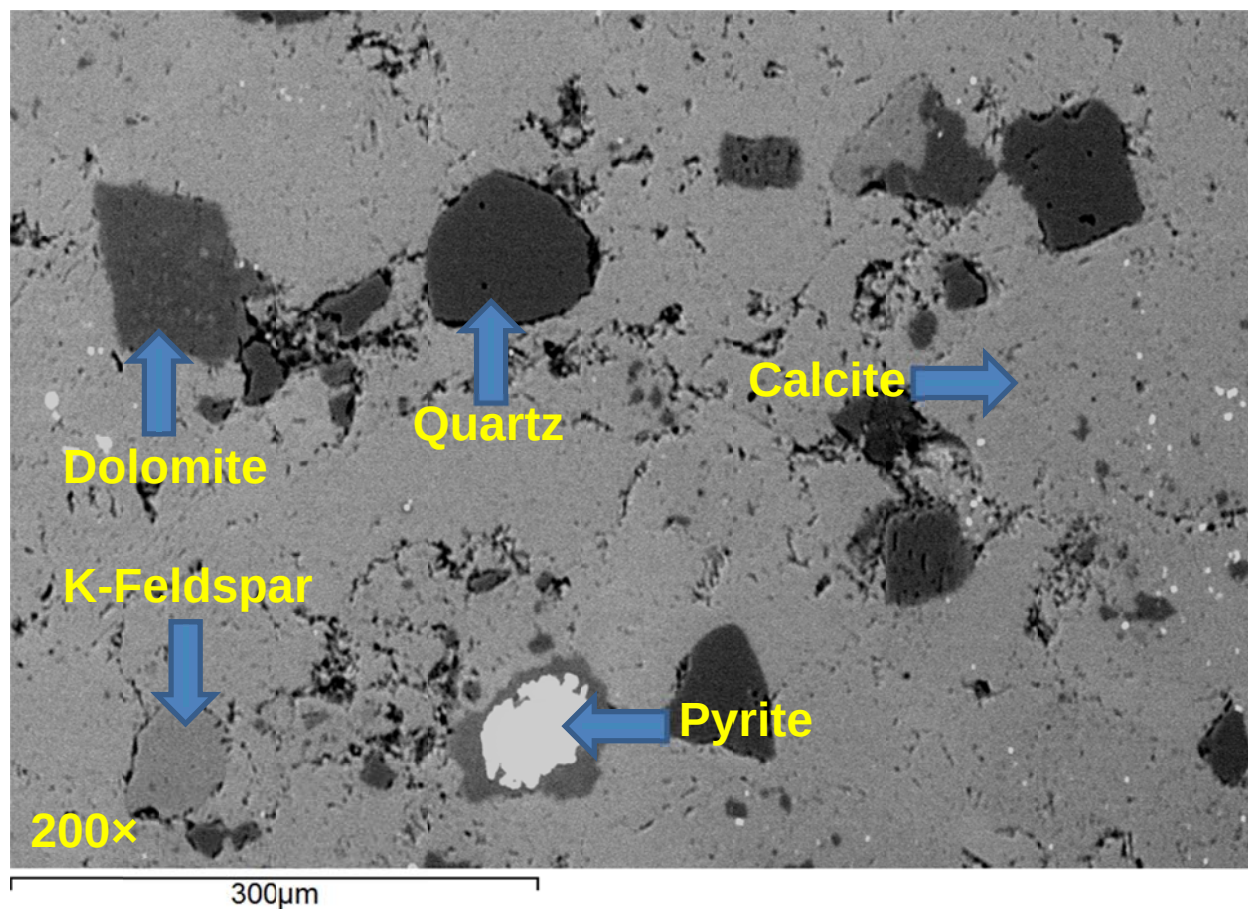
	Applied Geology Laboratory		ID: 116234
	Middle Bakken 4	NDIC Well 16766, Rogné 44-34H	Depth: 10676.8'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

SEM

Observed Minerals

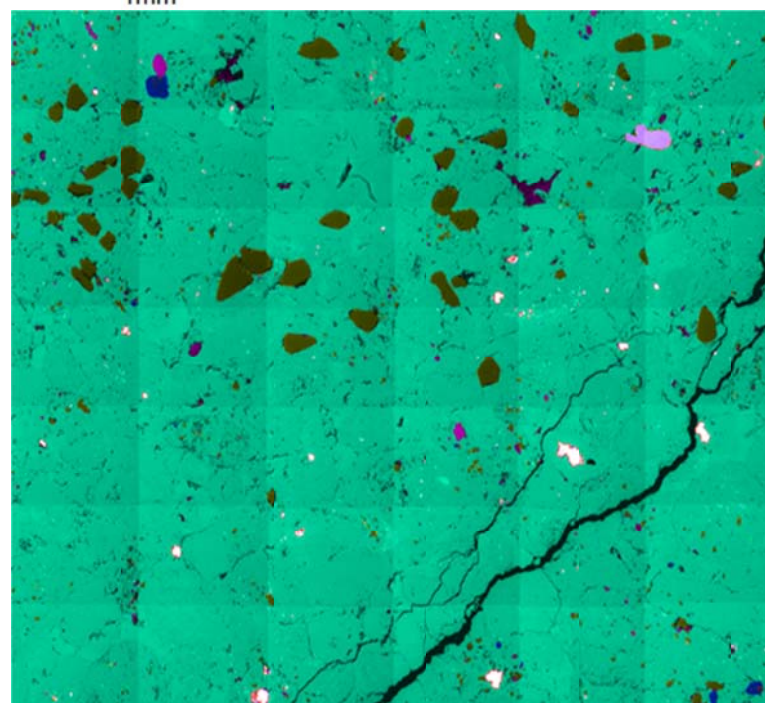
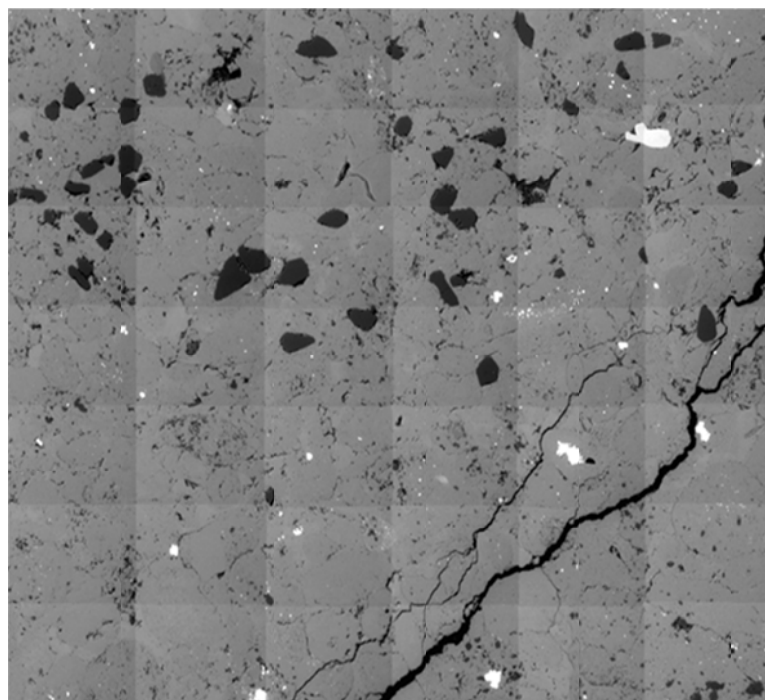
Mineral Phase	Mineral Phase
Calcite	Pyrite
Quartz	K-Feldspar
Dolomite	Apatite
Illite	

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified



	Applied Geology Laboratory		ID: 116234
	Middle Bakken 4	NDIC Well 16766, Rogne 44-34H	Depth: 10676.8'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

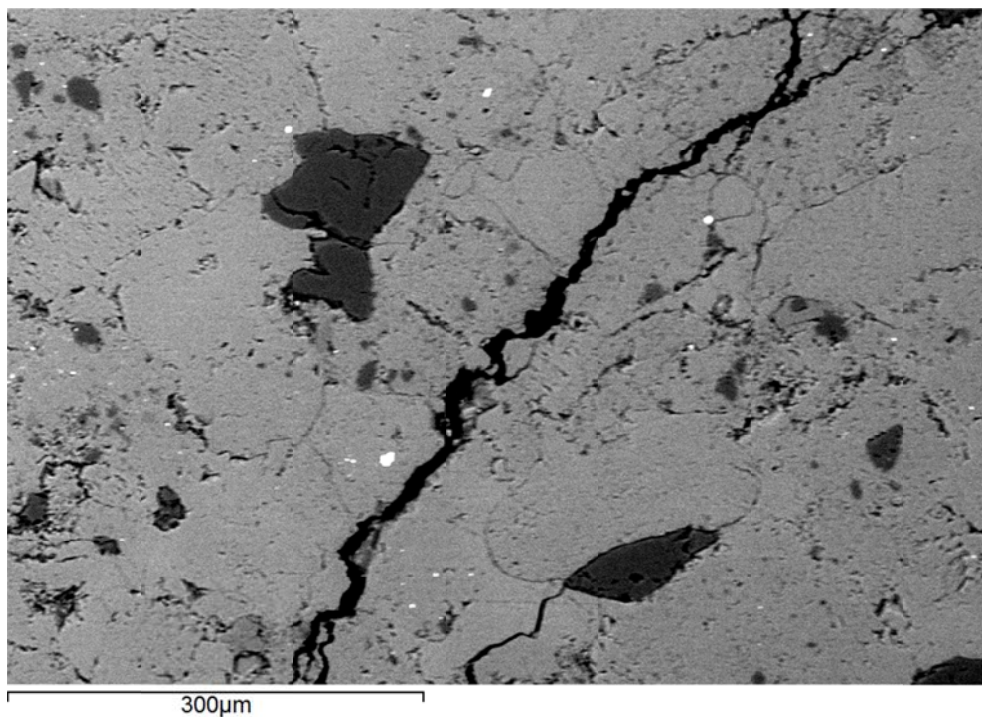
SEM BSE Image and Corresponding Digital Composite Mineral Map Image Overlaid on BSE Image with Mineral-Phase 2-D Area Percentages



	Pyrite – 0.4%
	Dolomite – 0.3%
	Calcite – 93.6%
	Apatite – 1.1%
	Quartz – 3.7%
	K-Feldspar – 0.9%

	Applied Geology Laboratory		ID: 116234
	Middle Bakken 4	NDIC Well 16766, Rogne 44-34H	Depth: 10676.8'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

Fracture Analysis on BSE Images



The observed fractures do not contain any material and may be induced.

	Applied Geology Laboratory		ID: 116229
	Middle Bakken 4	NDIC Well 16766, Rogne 44-34H	Depth: 10677.8'
	API No.: 33025006640000		Lithology: Oolitic packstone

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION



Depth 10677.8': A coarser, massive packstone. Open and cemented fractures are observed.

PHYSICAL PROPERTIES

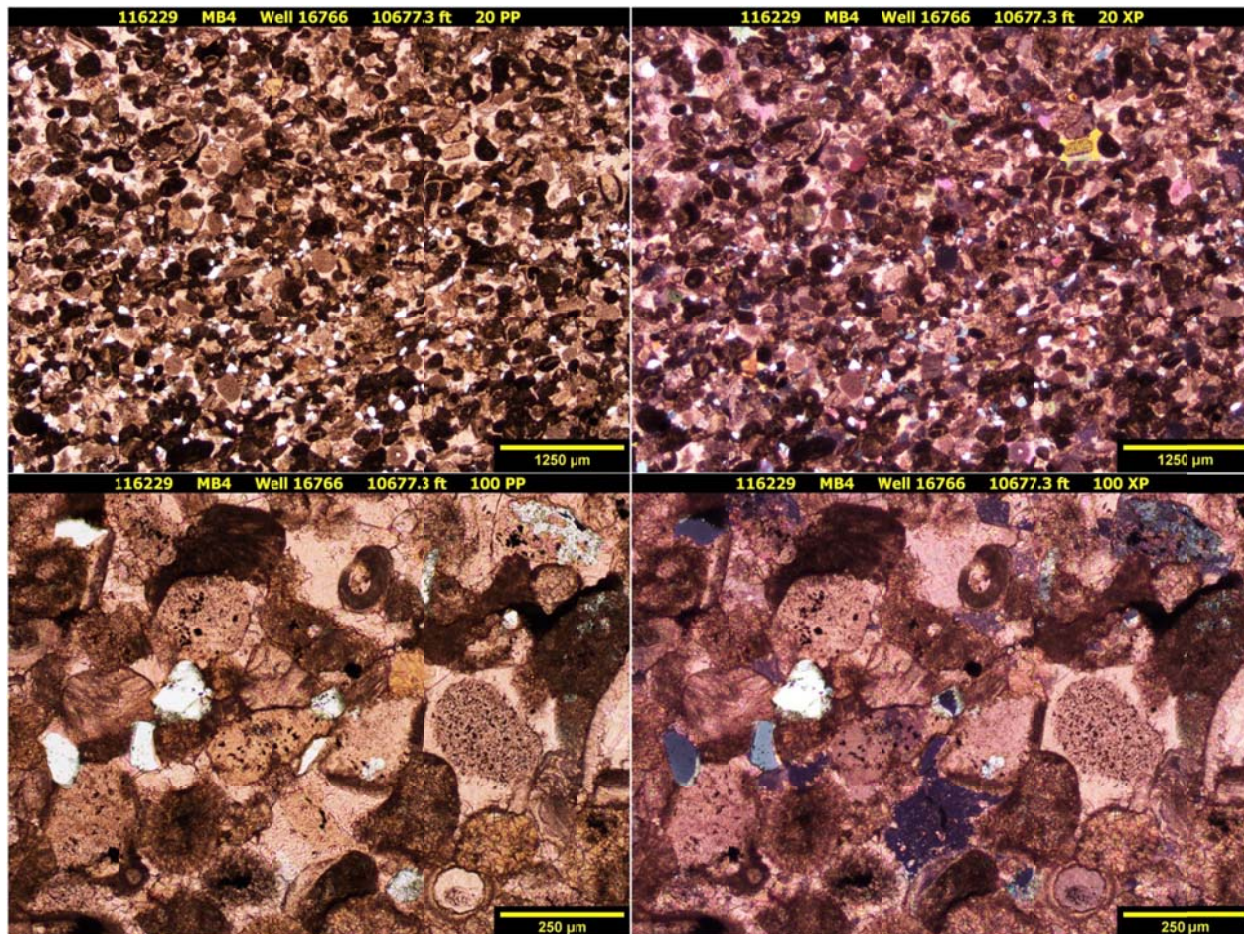
Porosity and Related Measurements Performed by MetaRock Laboratories

Pycnometer Effective Porosity, vol%	Bulk Volume, cm ³	Bulk Density, g/cm ³	Grain Volume, cm ³	Grain Density, g/cm ³
1.41	26.77	2.65	26.39	2.69

	Applied Geology Laboratory		ID: 116229
	Middle Bakken 4	NDIC Well 16766, Rogné 44-34H	Depth: 10677.8'
	API No.: 33025006640000		Lithology: Oolitic packstone

PHOTOMICROGRAPHS

Transmission



This sample represents oolitic packstone. Subangular to subrounded monocrystalline quartz is a minor detrital mineral. No feldspars, muscovite, or clays are observed. Allochems are abundant. Ooids, peloids, calcareous clast fragments, and skeletal grains (likely bryozoans, brachiopods, and echinoderms) are scattered throughout. Evidence of micritization and iron oxide coating are observed on both skeletal and nonskeletal grains. Pyrite grain replacement and globular growth are present at minor levels. Evidence of minor levels of compaction is noted by immature, grain-sized stylolites. The combination of common pore-filling, sparry calcite cement with rare gypsum eliminates any observed particle-based porosity in the thin section. One horizontal fracture is observed across the entire face of the sample. It is likely that this is an artifact of sampling.

	Applied Geology Laboratory		ID: 116229
	Middle Bakken 4	NDIC Well 16766, Rogne 44-34H	Depth: 10677.8'
	API No.: 33025006640000		Lithology: Oolitic packstone

PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	10	Fine grained
Calcite	90	Allochems, cement
Dolomite	0	Not observed
Clay	0	Not observed
Metals	Trace	Pyrite
Muscovite	Trace	
Organics	Trace	Globular

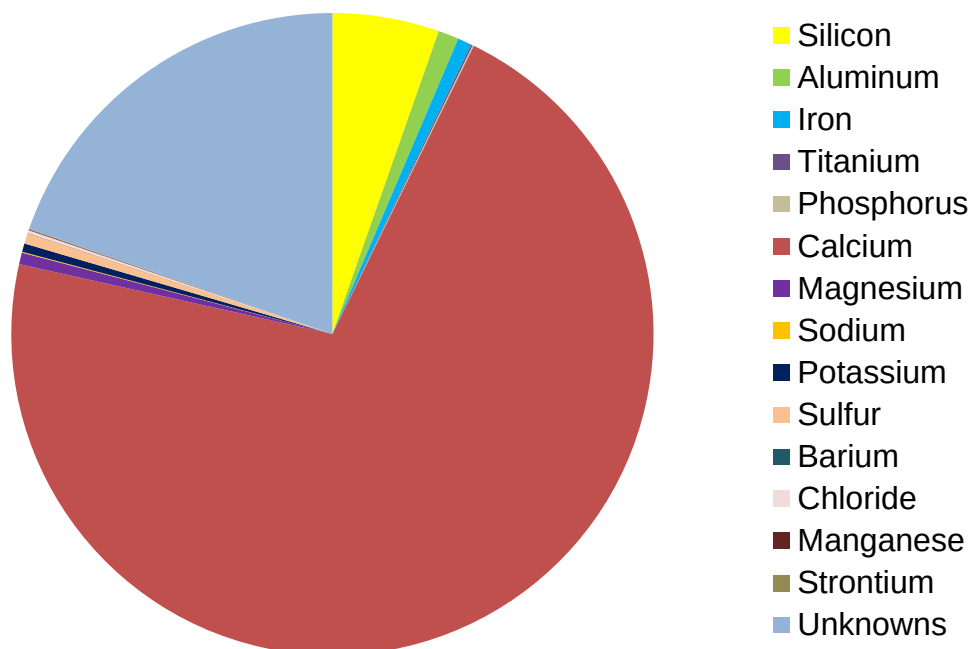
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through XRF and XRD data sets.

Detrital Texture

Category	Classification
Grain Size	Fine
Sorting	Poorly
Roundness	Subangular to subrounded

	Applied Geology Laboratory		ID: 116229
	Middle Bakken 4	NDIC Well 16766, Rogné 44-34H	Depth: 10677.8'
	API No.: 33025006640000		Lithology: Oolitic packstone

XRF BULK CHEMICAL COMPOSITION



Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	5.37
Al (aluminum)	Al ₂ O ₃	1.04
Fe (iron)	Fe ₂ O ₃	0.70
Ti (titanium)	TiO ₂	0.09
P (phosphorus)	P ₂ O ₅	0.07
Ca (calcium)	CaO	71.24
Mg (magnesium)	MgO	0.59
Na (sodium)	Na ₂ O	0.04
K (potassium)	K ₂ O	0.43
S (sulfur)	SO ₃	0.53
Ba (barium)	BaO	0.02
Cl (chloride)	Cl	0.14
Mn (manganese)	MnO	0.04
Sr (strontium)	SrO	0.04
Unknowns	Due to the presence of carbonates*	19.68
Total		100.02

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

	Applied Geology Laboratory		ID: 116229
	Middle Bakken 4	NDIC Well 16766, Rogné 44-34H	Depth: 10677.8'
	API No.: 33025006640000		Lithology: Oolitic packstone

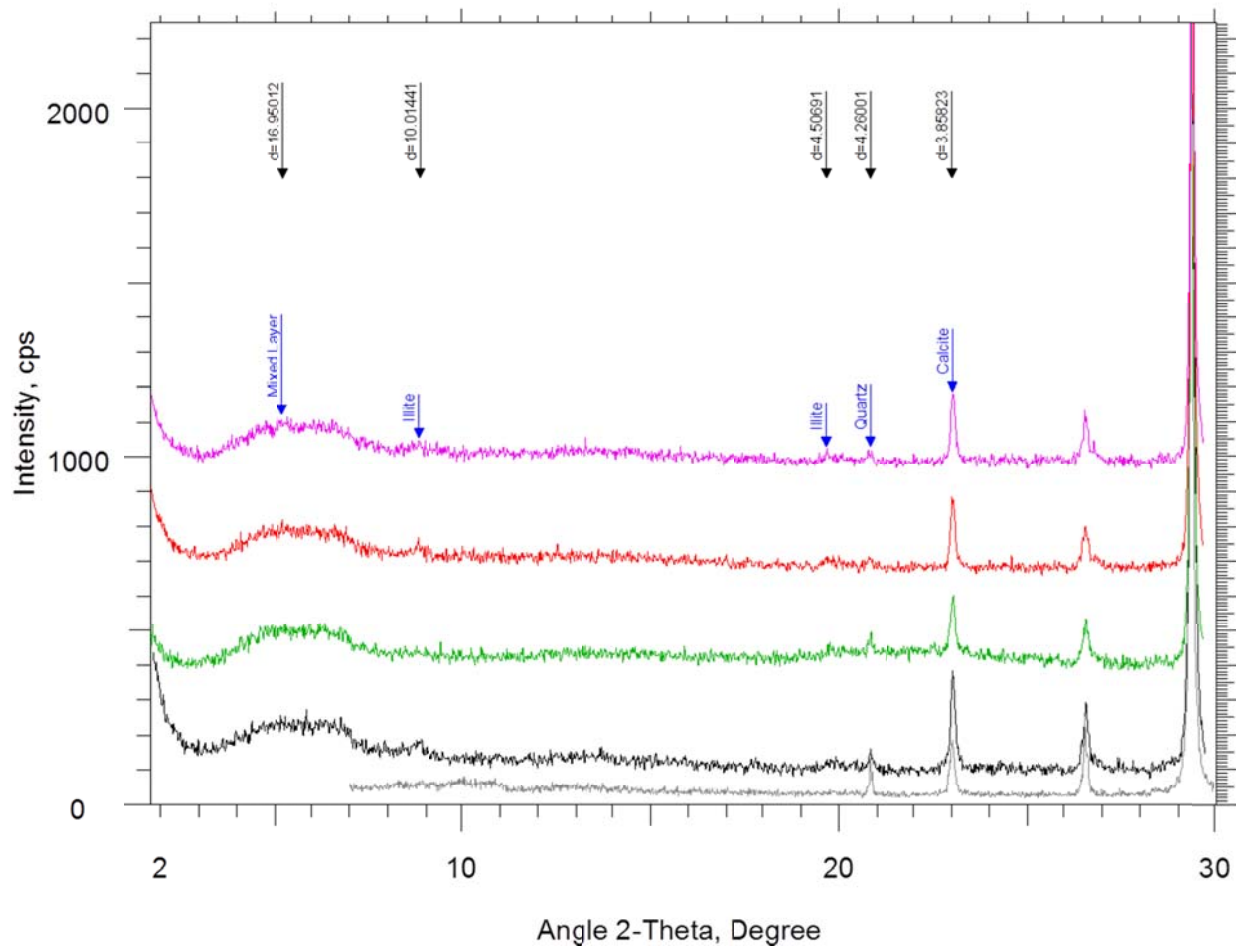
XRD MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	93.8
Quartz	SiO_2	5.2
Ferroan Dolomite	$\text{CaMg}_{0.8}\text{Fe}_{0.2}(\text{CO}_3)_2$	Trace
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	Trace
Chlorite	$\text{Mg}_{2.96}\text{Fe}_{1.55}\text{Fe}_{0.14}\text{Al}_{1.28}(\text{Si}_{2.62}\text{Al}_{1.38}\text{O}_{10})(\text{OH})_8$	Trace
Pyrite	FeS_2	Trace
Zircon	ZrSiO_4	Trace

	Applied Geology Laboratory		ID: 116229
	Middle Bakken 4	NDIC Well 16766, Rogné 44-34H	Depth: 10677.8'
	API No.: 33025006640000		Lithology: Oolitic packstone

XRD Clay Typing



Clays Identified

Illite

Mixed-layer clays

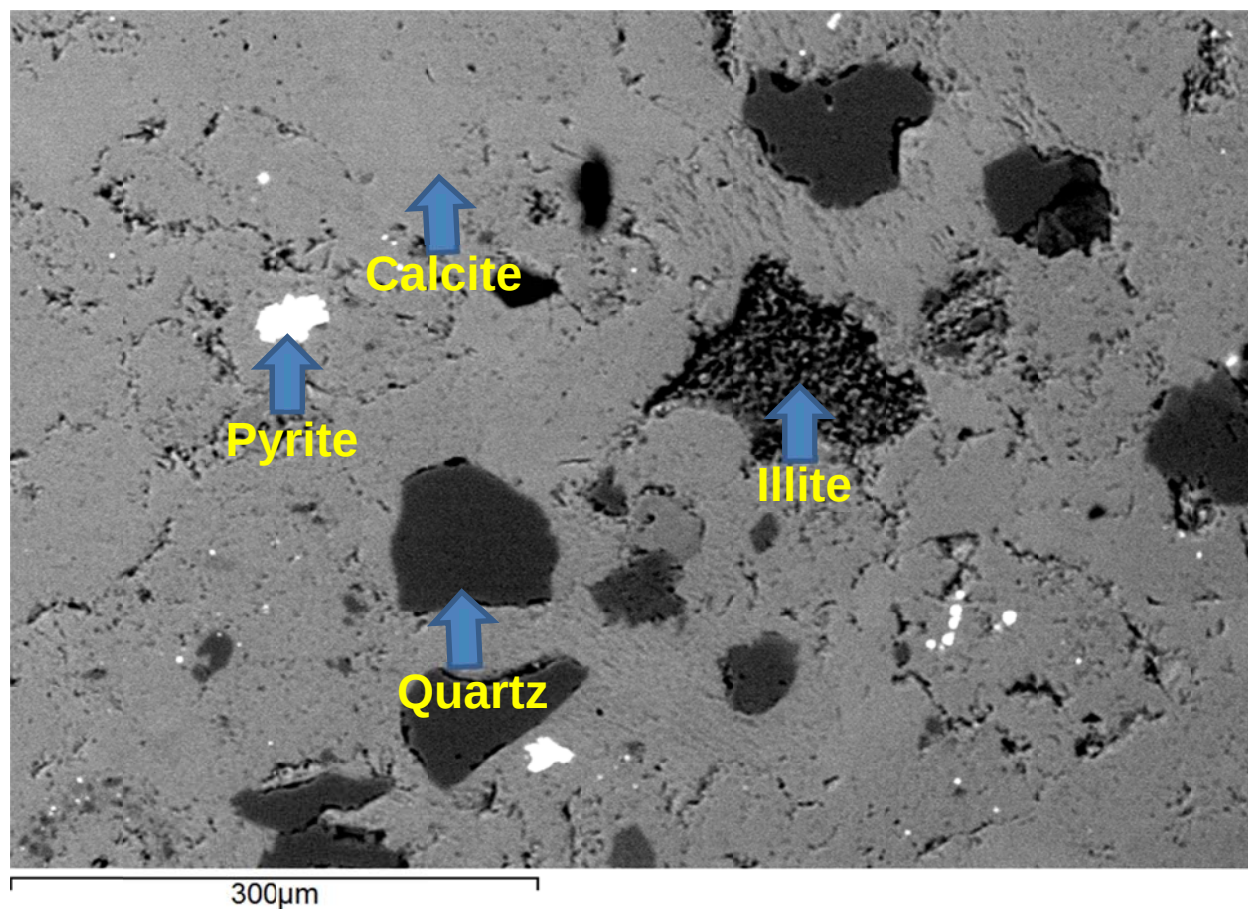
	Applied Geology Laboratory		ID: 116229
	Middle Bakken 4	NDIC Well 16766, Rogné 44-34H	Depth: 10677.8'
	API No.: 33025006640000		Lithology: Oolitic packstone

SEM

Observed Minerals

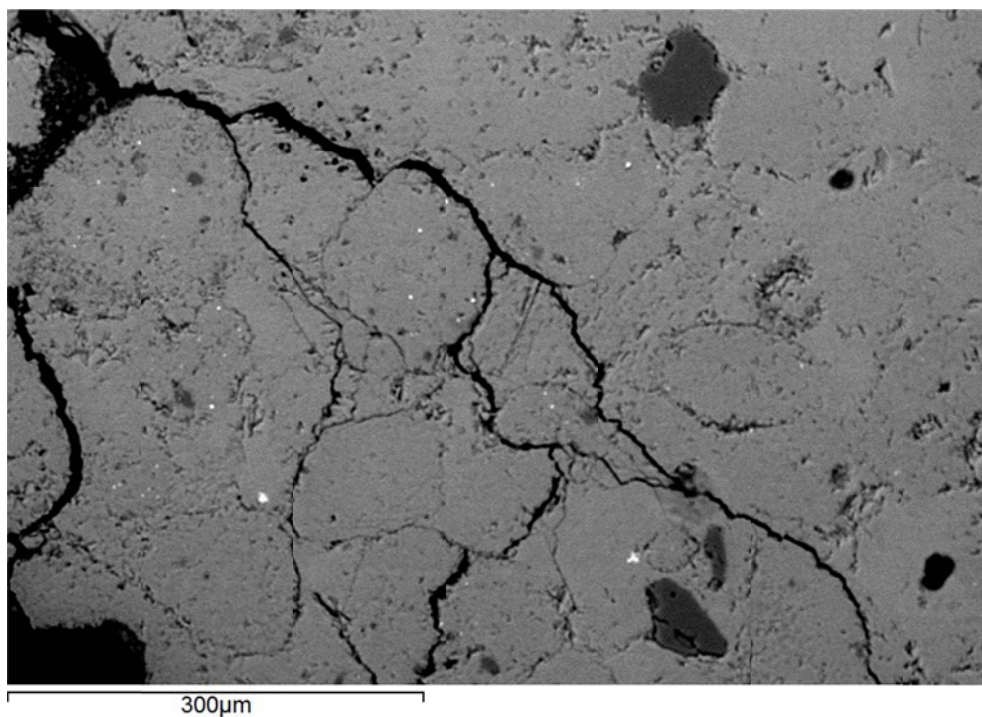
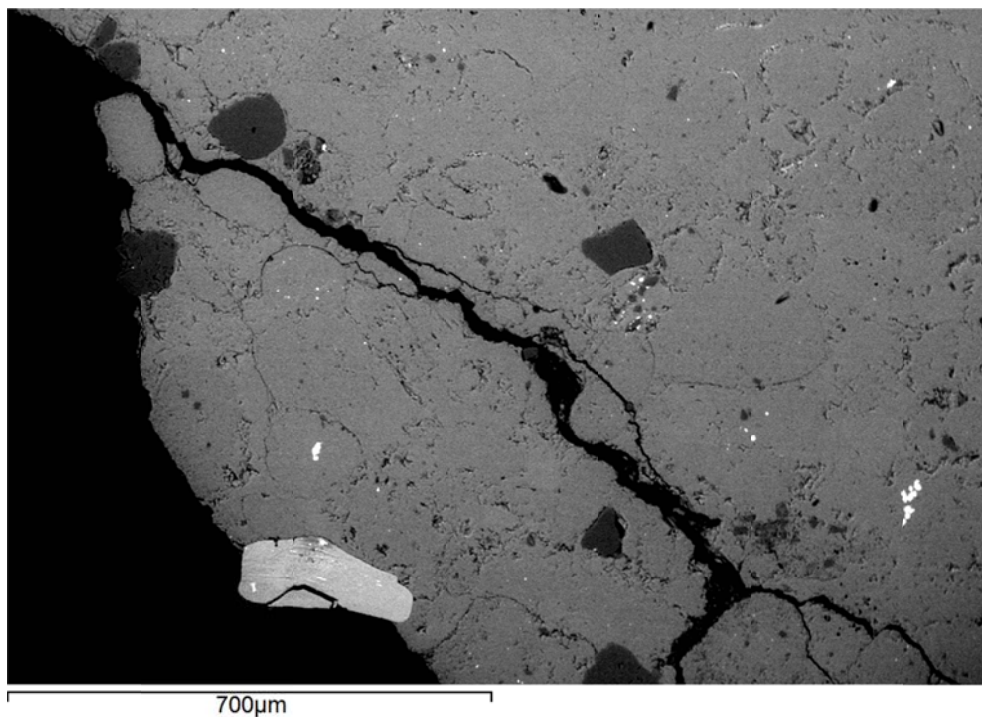
Mineral Phase	Mineral Phase
Calcite	K-Feldspar
Pyrite	Fluorapatite
Illite	Zircon
Quartz	Dolomite

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified



	Applied Geology Laboratory		ID: 116229
	Middle Bakken 4	NDIC Well 16766, Rogne 44-34H	Depth: 10677.8'
	API No.: 33025006640000		Lithology: Oolitic packstone

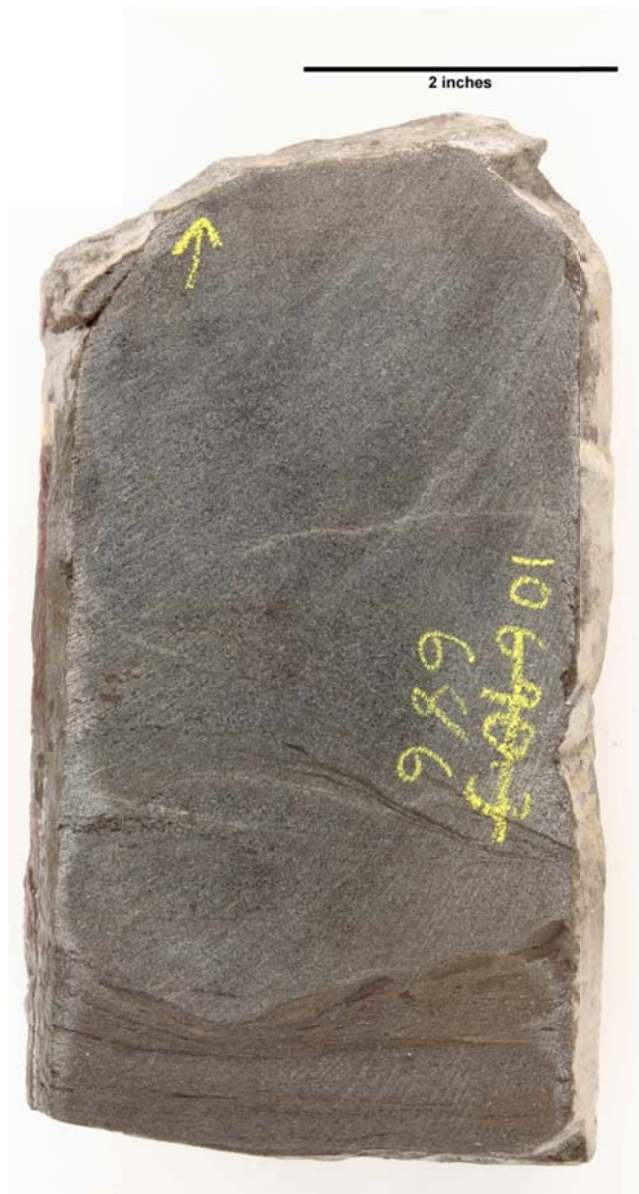
Fracture Analysis on BSE Images



The fracture network extending from the top slide to the bottom slide appears to consist induced fractures because no fill material is present.

	Applied Geology Laboratory		ID: 116235
	Middle Bakken 3	NDIC Well 16766, Rogne 44-34H	Depth: 10686.0'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION

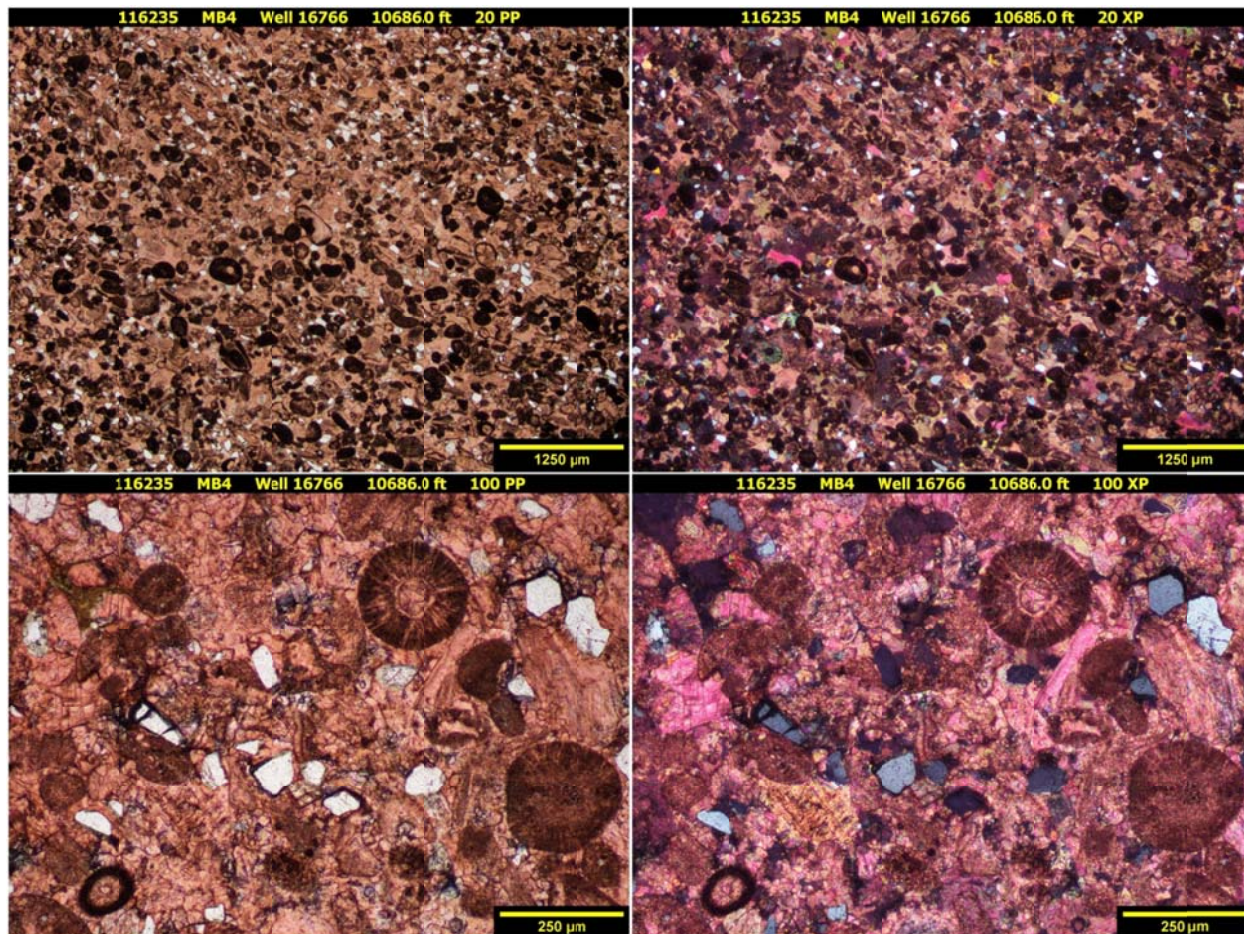


Depth 10686.0': A coarser, massive packstone. Cemented fractures are observed.

	Applied Geology Laboratory		ID: 116235
	Middle Bakken 3	NDIC Well 16766, Rogné 44-34H	Depth: 10686.0'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

PHOTOMICROGRAPHS

Transmission



This sample represents silty, oolitic packstone. Subangular to subrounded monocrystalline quartz is disseminated throughout the sample and grouped to form faint, weak laminations. No muscovite, feldspars, or clays are observed. Nonskeletal and skeletal allochems are common but less abundant than other samples from this lithofacie. Ooids, peloids, calcareous clast fragments, and skeletal grains are dispersed throughout. Evidence of micritization exists on both skeletal and nonskeletal grains. Pyrite and dolomitization allochem replacement are present at trace levels. No evidence of immature, small stylolites as a result of compaction is noted. Pore-filling, sparry calcite cement is prevalent and eliminates any observable interparticle-based porosity in the thin section. No indication of organics is witnessed.

	Applied Geology Laboratory		ID: 116235
	Middle Bakken 3	NDIC Well 16766, Rogné 44-34H	Depth: 10686.0'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	10	Very fine grained
Calcite	90	Allochems, cement
Dolomite	Trace	Allochem replacement
Clay	0	Not observed
Metals	Trace	Pyrite
Muscovite	0	Not observed
Organics	0	Not observed

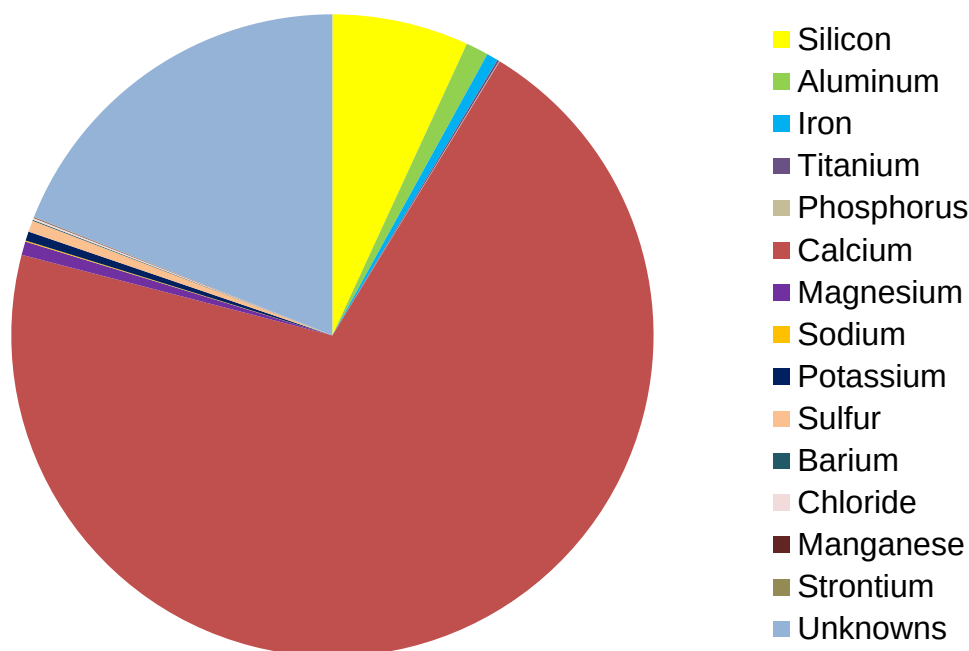
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through XRF and XRD data sets.

Detrital Texture

Category	Classification
Grain Size	Fine
Sorting	Poorly
Roundness	Subangular to subrounded

	Applied Geology Laboratory		ID: 116235
	Middle Bakken 3	NDIC Well 16766, Rogné 44-34H	Depth: 10686.0'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

XRF BULK CHEMICAL COMPOSITION

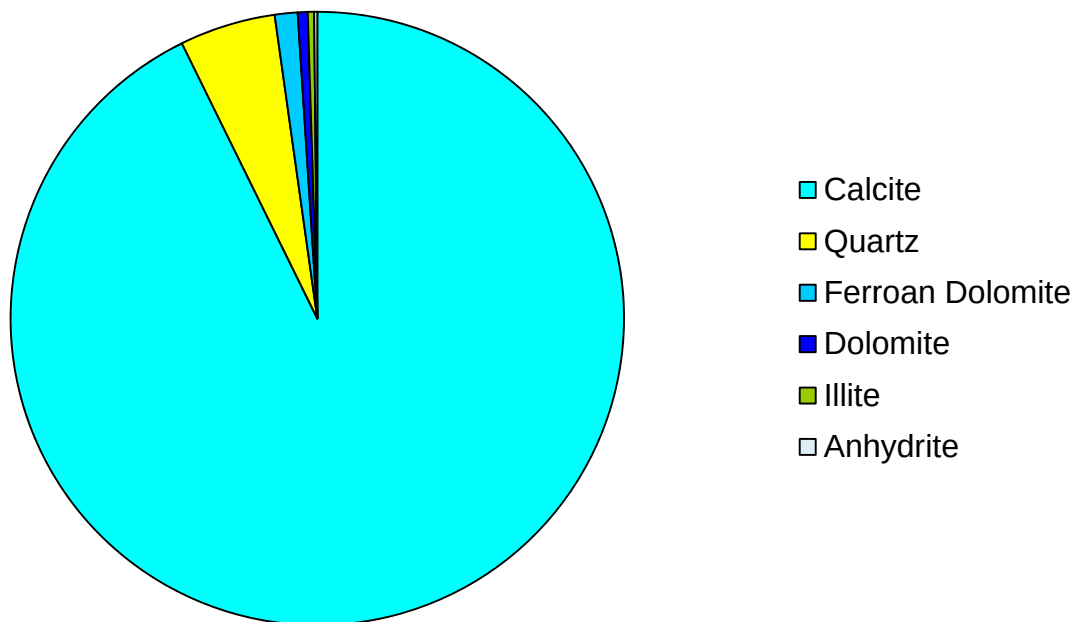


Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	6.88
Al (aluminum)	Al ₂ O ₃	1.14
Fe (iron)	Fe ₂ O ₃	0.57
Ti (titanium)	TiO ₂	0.10
P (phosphorus)	P ₂ O ₅	0.03
Ca (calcium)	CaO	70.31
Mg (magnesium)	MgO	0.68
Na (sodium)	Na ₂ O	0.05
K (potassium)	K ₂ O	0.47
S (sulfur)	SO ₃	0.57
Ba (barium)	BaO	0.05
Cl (chloride)	Cl	0.10
Mn (manganese)	MnO	0.03
Sr (strontium)	SrO	0.03
Unknowns	Due to the presence of carbonates*	18.98
Total		99.99

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

	Applied Geology Laboratory		ID: 116235
	Middle Bakken 3	NDIC Well 16766, Rogné 44-34H	Depth: 10686.0'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

XRD MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	92.7
Quartz	SiO_2	5.1
Ferroan Dolomite	$\text{CaMg}_{0.8}\text{Fe}_{0.2}(\text{CO}_3)_2$	1.2
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	Trace
Illite	$(\text{K}, \text{H}_3\text{O})(\text{Al}, \text{Mg}, \text{Fe})_2(\text{Si}, \text{Al})_4\text{O}_{10}[(\text{OH})_2, (\text{H}_2\text{O})]$	Trace
Anhydrite	CaSO_4	Trace

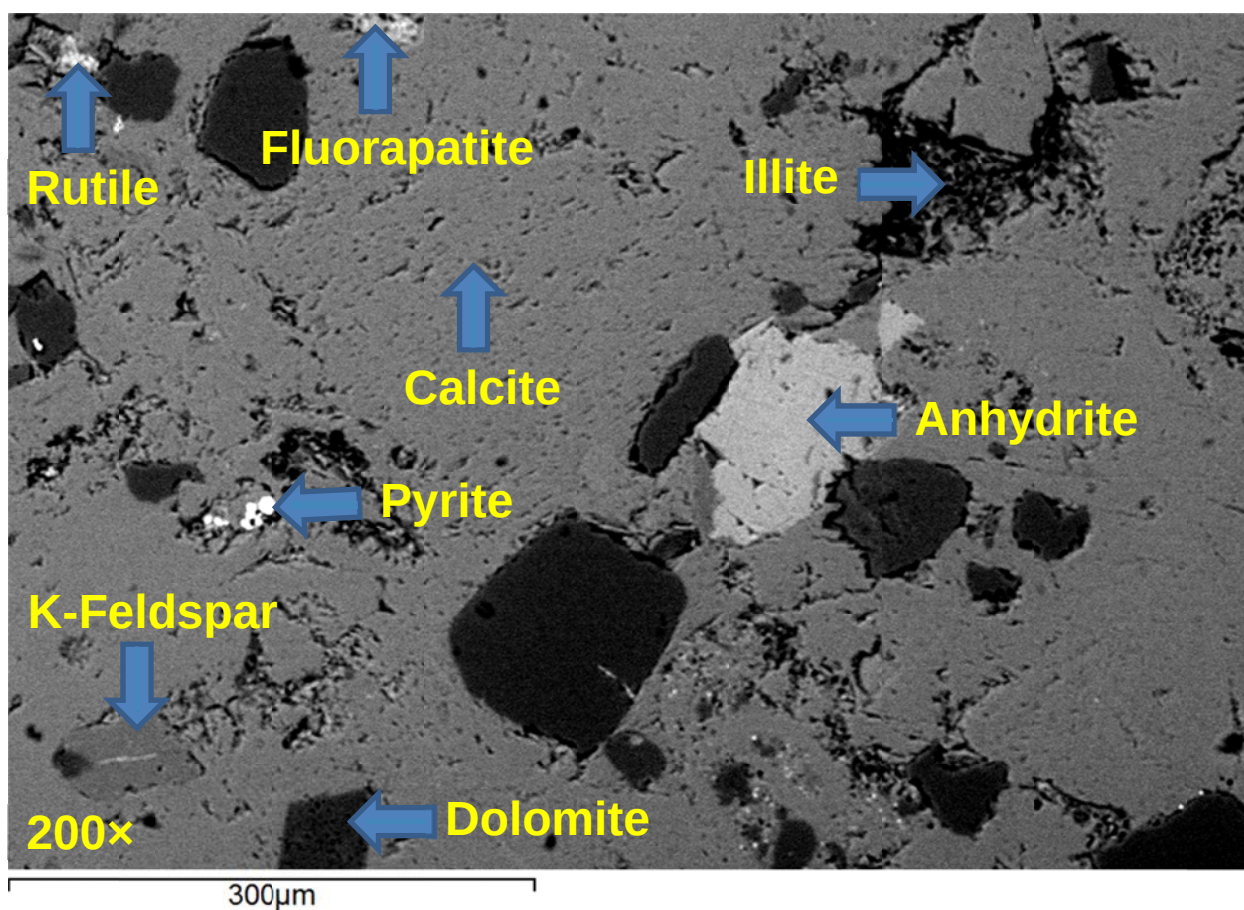
	Applied Geology Laboratory		ID: 116235
	Middle Bakken 3	NDIC Well 16766, Rogné 44-34H	Depth: 10686.0'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

SEM

Observed Minerals

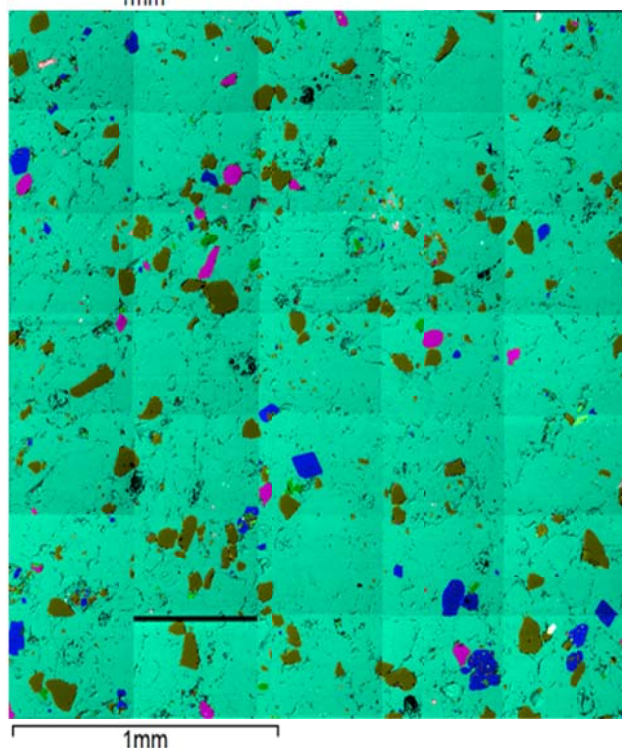
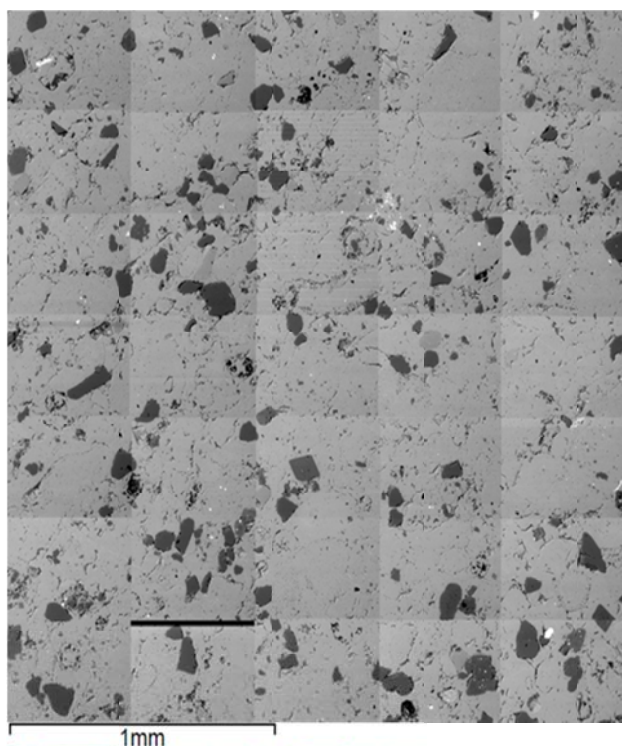
Mineral Phase	Mineral Phase
Calcite	Zircon
Quartz	Albite
Dolomite	Rutile
Fluorapatite	Illite
Monazite	K-Feldspar
Pyrite	Anhydrite

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified



	Applied Geology Laboratory		ID: 116235
	Middle Bakken 3	NDIC Well 16766, Rogne 44-34H	Depth: 10686.0'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

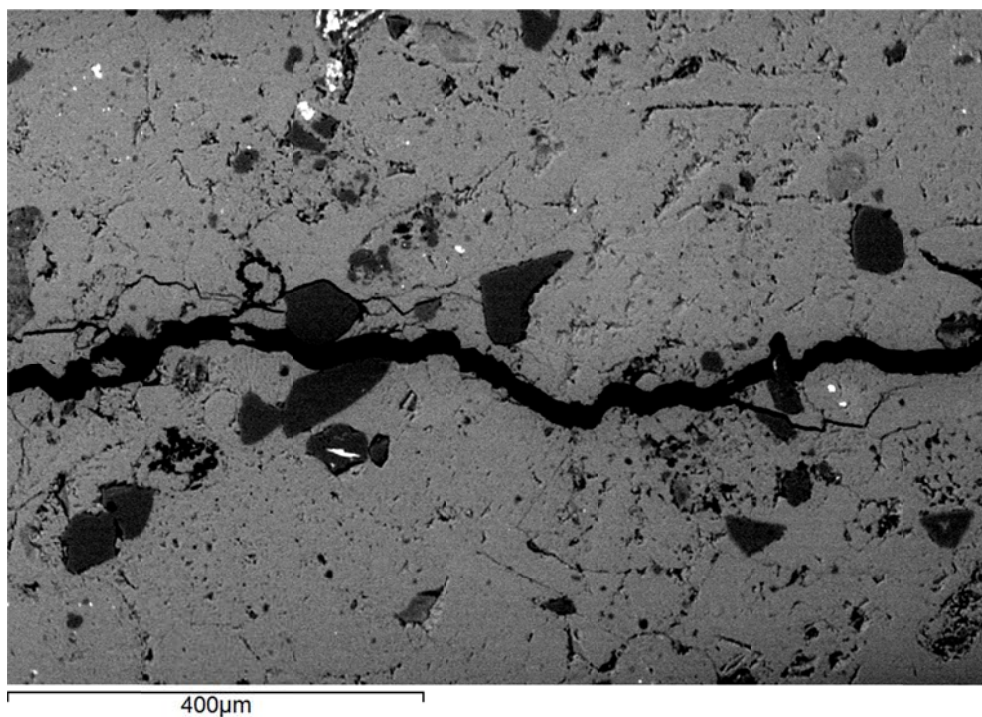
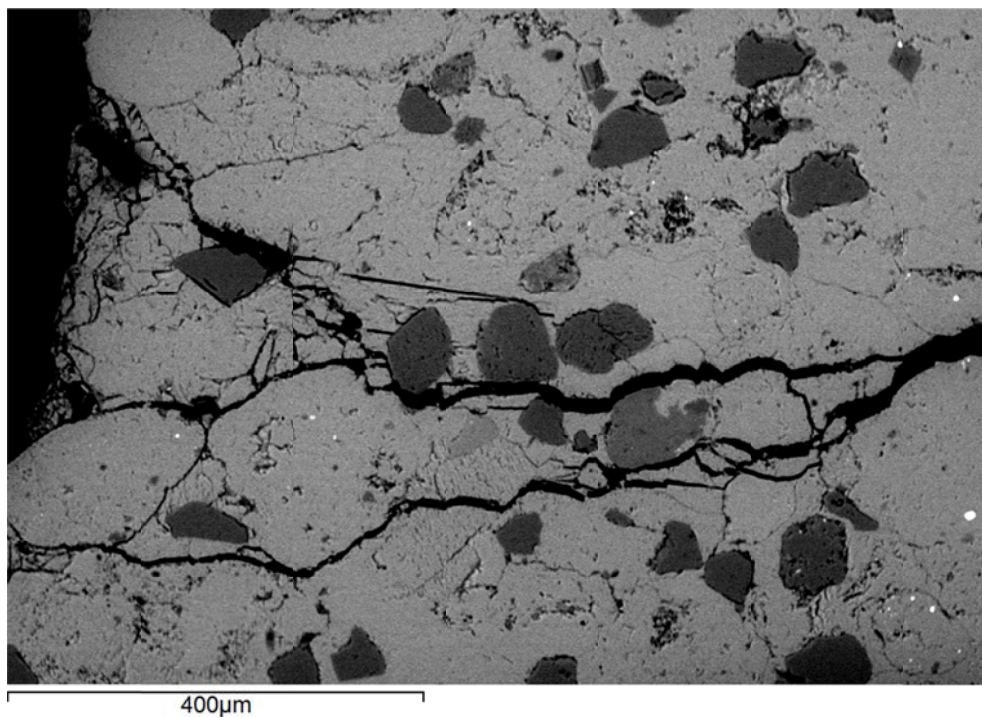
SEM BSE Image and Corresponding Digital Composite Mineral Map Image Overlaid on BSE Image with Mineral-Phase 2-D Area Percentages



	Pyrite – 0.1%
	Dolomite – 1.4%
	Calcite – 90.5%
	Albite – 0.6%
	Quartz – 6.7%
	K-Feldspar – 0.7%

	Applied Geology Laboratory		ID: 116235
	Middle Bakken 3	NDIC Well 16766, Rogne 44-34H	Depth: 10686.0'
	API No.: 33025006640000		Lithology: Silty, oolitic packstone

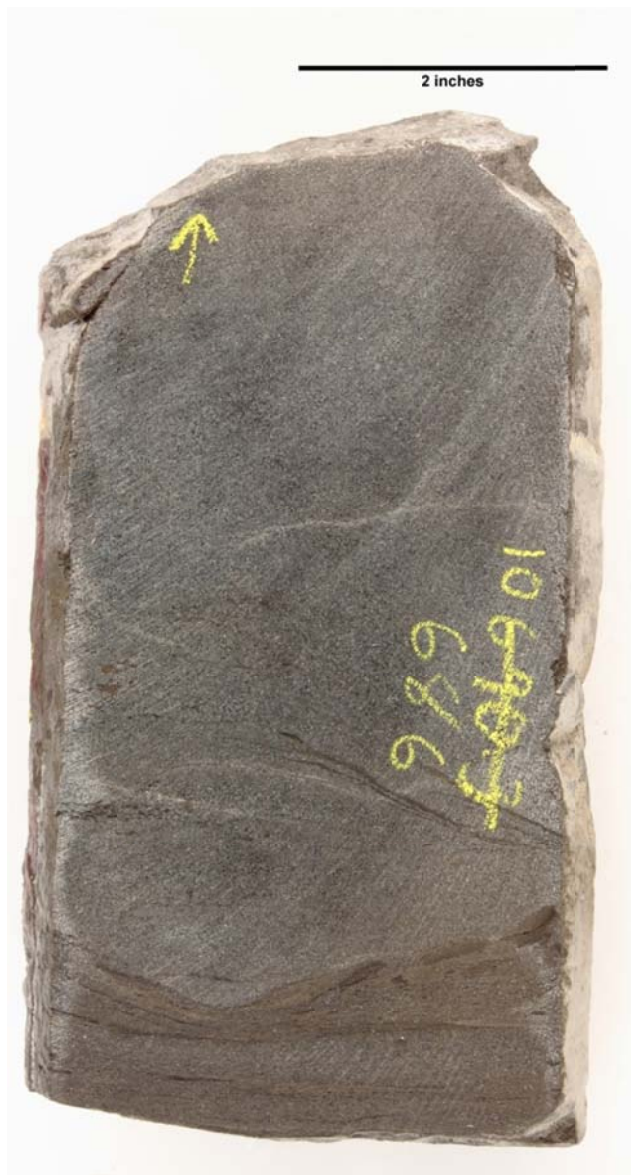
Fracture Analysis on BSE Images



The fracture network in the two images may be induced, as the fracture contain no material.

	Applied Geology Laboratory		ID: 116230
	Middle Bakken 3	NDIC Well 16766, Rogné 44-34H	Depth: 10686.3'
	API No.: 33025006640000	Lithology: Silty, oolitic limestone	

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION



Depth 10686.3': A coarser, massive packstone. Cemented fractures are observed.

PHYSICAL PROPERTIES

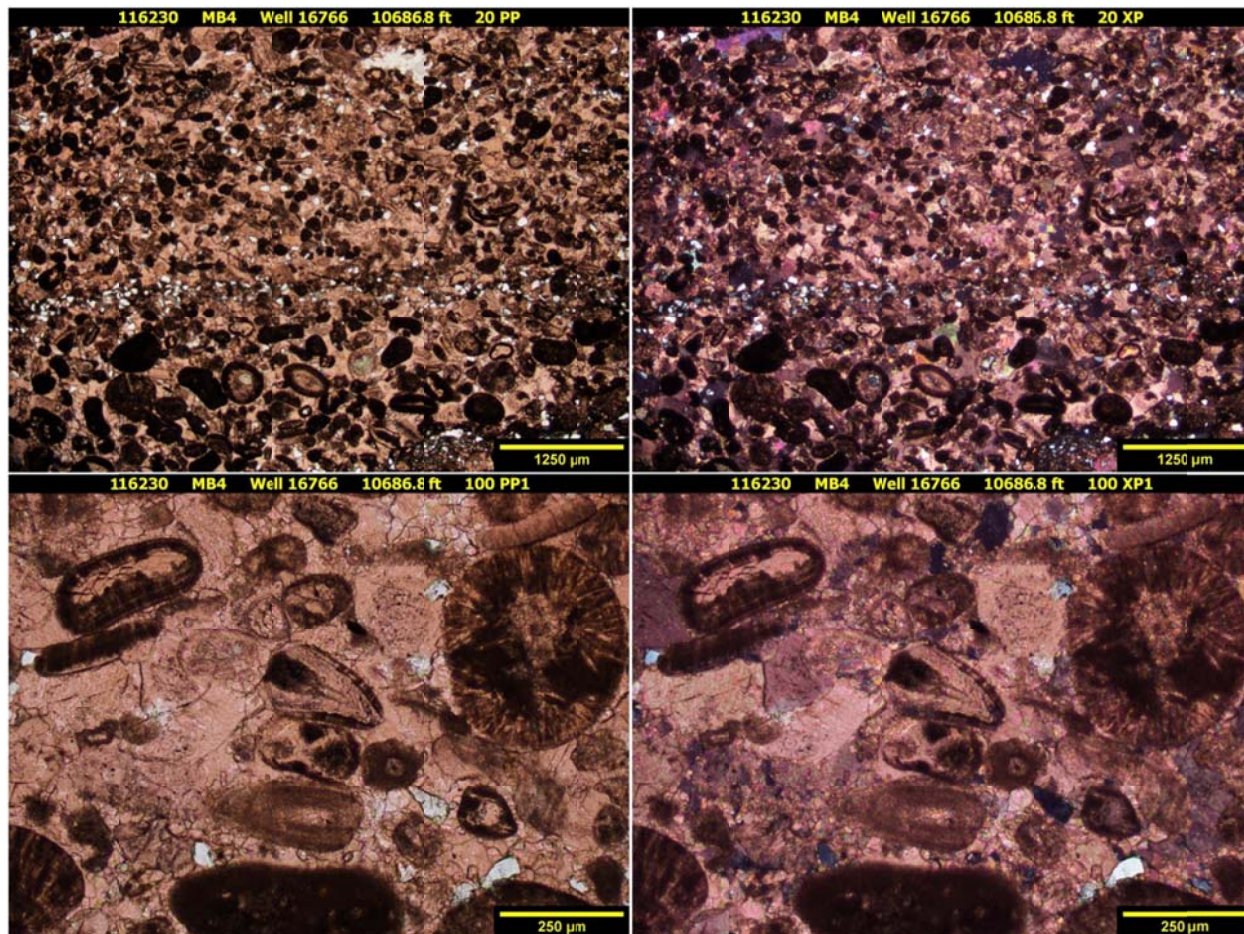
Porosity and Related Measurements Performed by MetaRock Laboratories

Pycnometer Effective Porosity, vol%	Bulk Volume, cm ³	Bulk Density, g/cm ³	Grain Volume, cm ³	Grain Density, g/cm ³
2.11	50.18	2.63	49.12	2.68

	Applied Geology Laboratory		ID: 116230
	Middle Bakken 3	NDIC Well 16766, Rogné 44-34H	Depth: 10686.3'
	API No.: 33025006640000		Lithology: Silty, oolitic limestone

PHOTOMICROGRAPHS

Transmission



This sample represents silty, oolitic packstone. Subrounded monocrystalline quartz is a common detrital mineral. Trace levels of feldspars and no muscovite are observed. Nonskeletal and skeletal allochems are abundant. Ooids, peloids, grapestones, calcareous clast fragments, and skeletal grains (likely bryozoans, trilobites, and echinoderms) are scattered throughout. Evidence of micritization exists on both skeletal and nonskeletal grains. Pyrite, anhydrite, and gypsum replacement are present at minor levels. Rare zones of clay mixed with rhombohedral to cryptocrystalline dolomite are present. Evidence of minor levels of compaction is noted by immature, small stylolites. The combination of common pore-filling, sparry calcite cement along with salt eliminates any observed interparticle-based porosity in the thin section. Intraparticle porosity as the result of dissolution does exist at trace levels. One horizontal fracture is observed across most of the face of the sample. It is likely that this is an artifact of sampling.

	Applied Geology Laboratory		ID: 116230
	Middle Bakken 3	NDIC Well 16766, Rogne 44-34H	Depth: 10686.3'
	API No.: 33025006640000		Lithology: Silty, oolitic limestone

PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	10	Very fine grained
Calcite	55	Allochems, cement
Dolomite	Trace	Microcrystalline, few rhombs
Clay	Trace	Allochem replacement
Salts	Trace	Anhydrite, gypsum
Metals	Trace	Pyrite
Muscovite	Trace	
Organics	Trace	Globular, microfractures

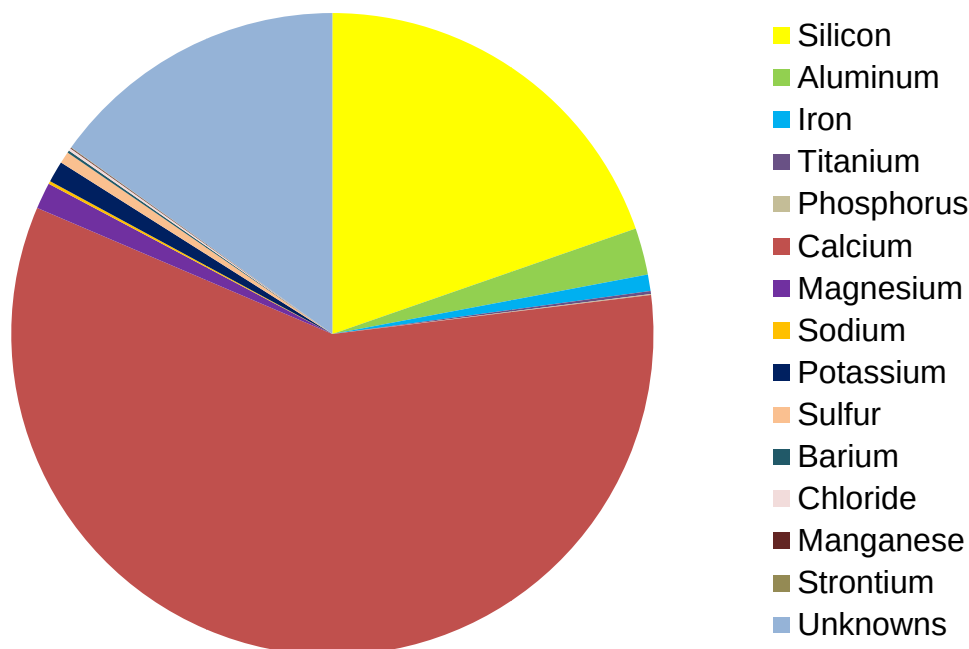
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through XRF and XRD data sets.

Detrital Texture

Category	Classification
Grain Size	Fine
Sorting	Poorly
Roundness	Subrounded

	Applied Geology Laboratory		ID: 116230
	Middle Bakken 3	NDIC Well 16766, Rogne 44-34H	Depth: 10686.3'
	API No.: 33025006640000		Lithology: Silty, oolitic limestone

XRF BULK CHEMICAL COMPOSITION

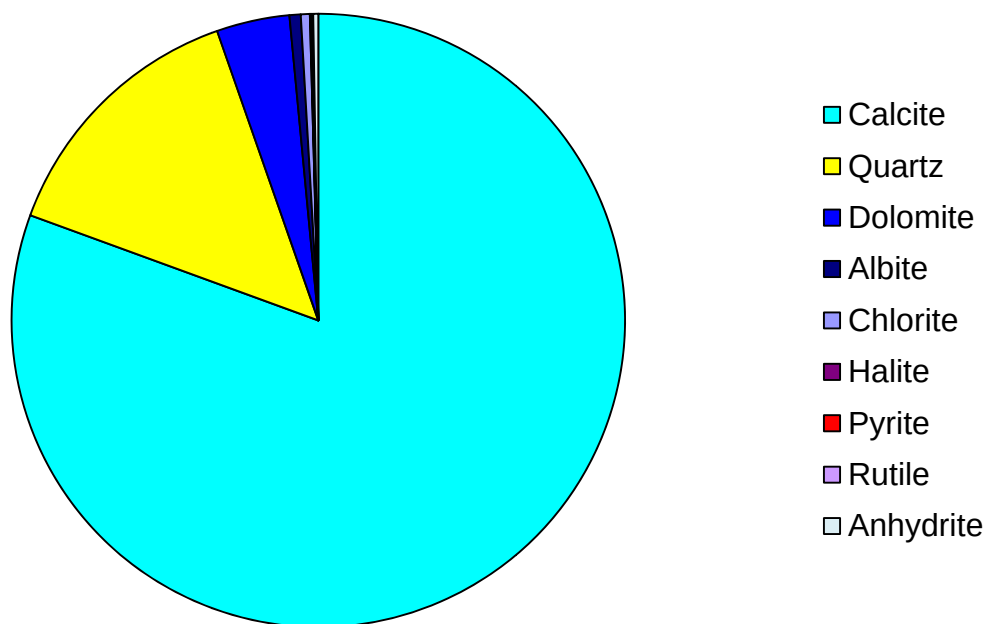


Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	19.67
Al (aluminum)	Al ₂ O ₃	2.36
Fe (iron)	Fe ₂ O ₃	0.83
Ti (titanium)	TiO ₂	0.15
P (phosphorus)	P ₂ O ₅	0.05
Ca (calcium)	CaO	58.37
Mg (magnesium)	MgO	1.32
Na (sodium)	Na ₂ O	0.15
K (potassium)	K ₂ O	1.07
S (sulfur)	SO ₃	0.59
Ba (barium)	BaO	0.12
Cl (chloride)	Cl	0.13
Mn (manganese)	MnO	0.04
Sr (strontium)	SrO	0.03
Unknowns	Due to the presence of carbonates*	15.12
Total		100.00

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

	Applied Geology Laboratory		ID: 116230
	Middle Bakken 3	NDIC Well 16766, Rogné 44-34H	Depth: 10686.3'
	API No.: 33025006640000		Lithology: Silty, oolitic limestone

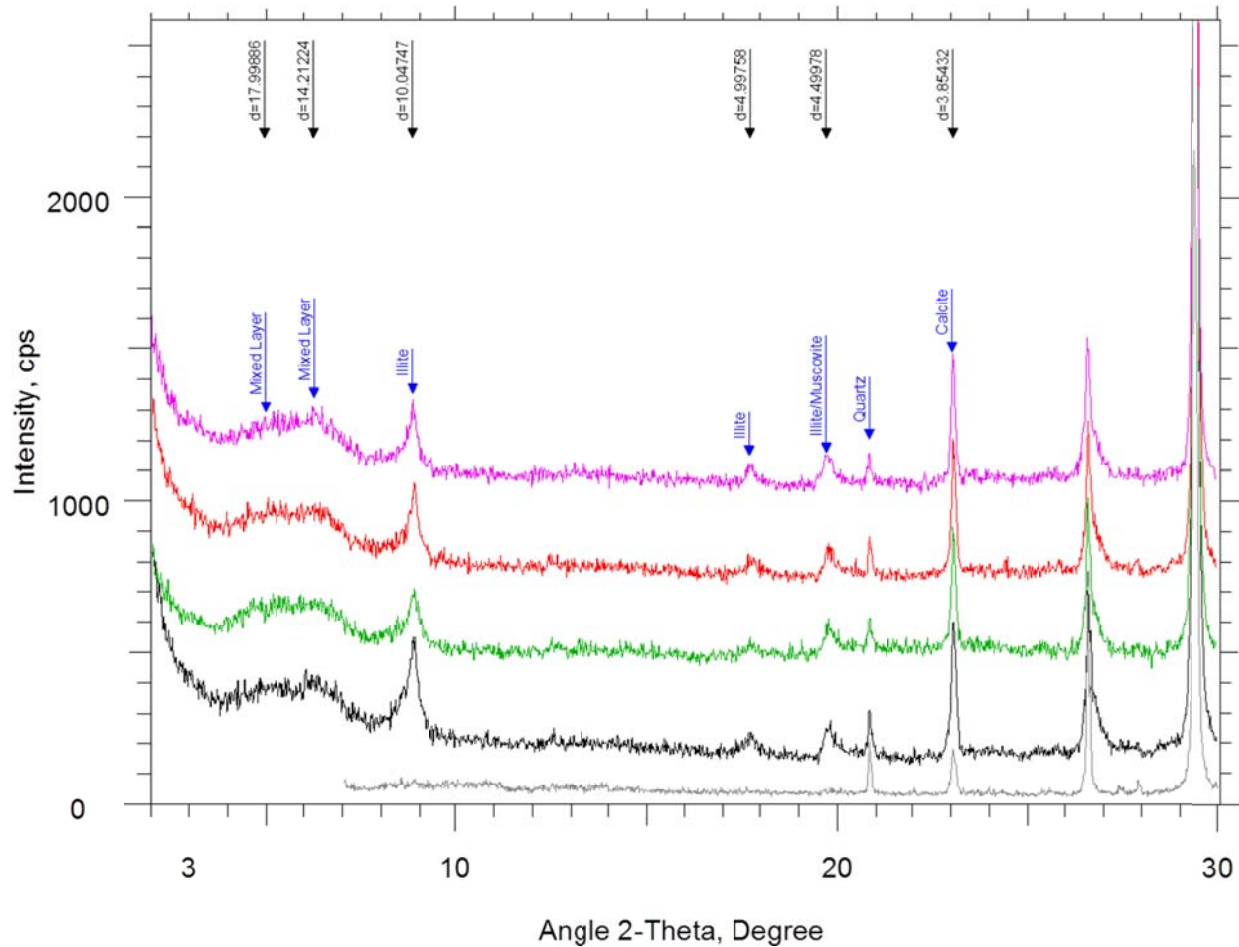
XRD MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	80.6
Quartz	SiO_2	14.1
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	3.8
Albite	$\text{NaAlSi}_3\text{O}_8$	0.6
Chlorite	$\text{Mg}_{2.96}\text{Fe}_{1.55}\text{Fe}_{0.14}\text{Al}_{1.28}(\text{Si}_{2.62}\text{Al}_{1.38}\text{O}_{10})(\text{OH})_8$	Trace
Halite	NaCl	Trace
Pyrite	FeS_2	Trace
Rutile	TiO_2	Trace
Anhydrite	CaSO_4	Trace

	Applied Geology Laboratory		ID: 116230
	Middle Bakken 3	NDIC Well 16766, Rogné 44-34H	Depth: 10686.3'
	API No.: 33025006640000		Lithology: Silty, oolitic limestone

XRD Clay Typing



Clays Identified

Illite

Mixed-layer clays

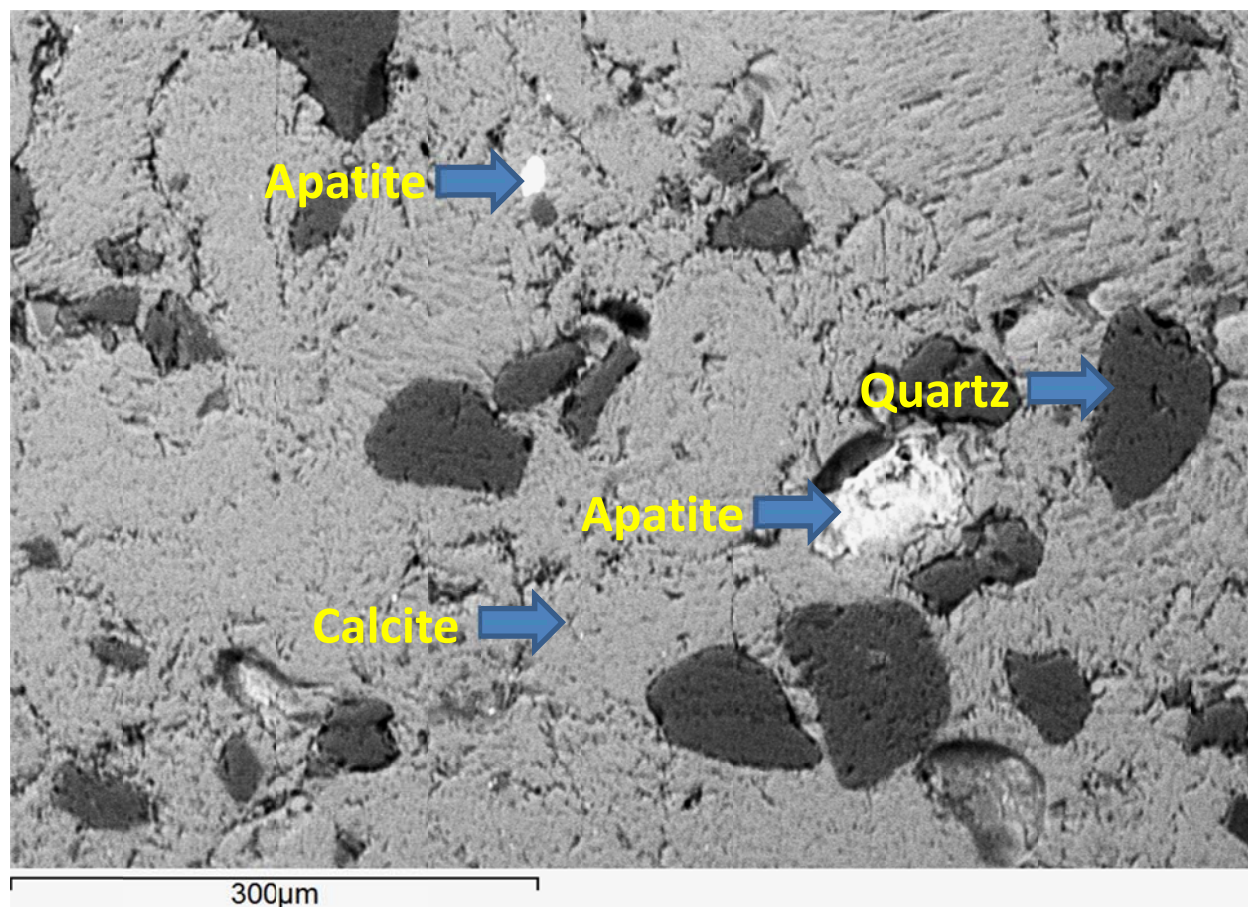
	Applied Geology Laboratory		ID: 116230
	Middle Bakken 3	NDIC Well 16766, Rogné 44-34H	Depth: 10686.3'
	API No.: 33025006640000		Lithology: Silty, oolitic limestone

SEM

Observed Minerals

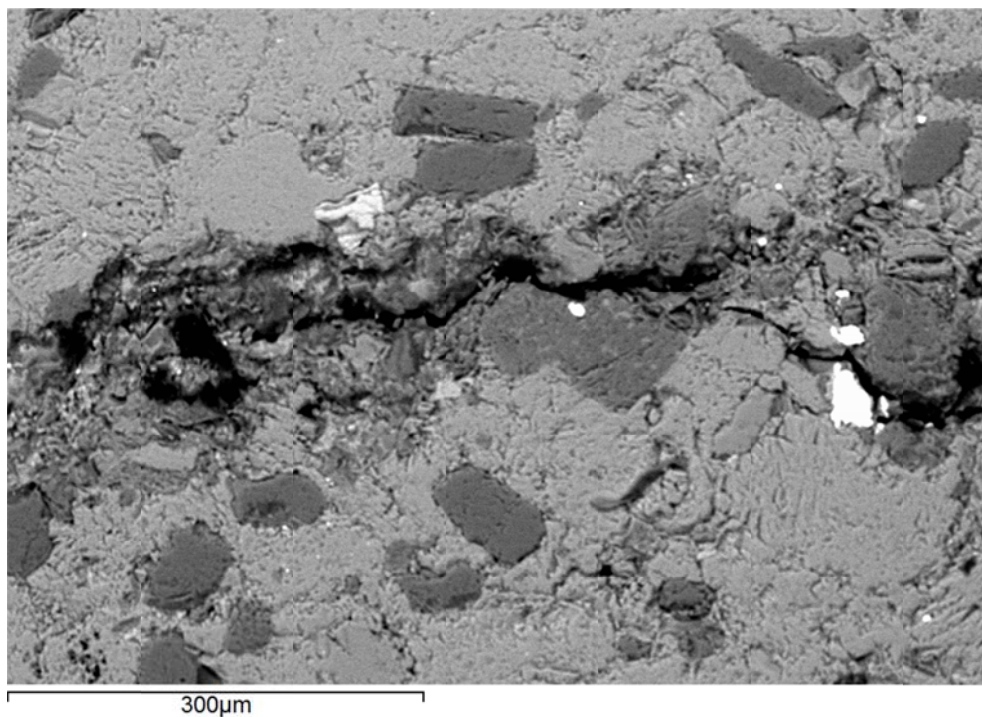
Mineral Phase	Mineral Phase
Calcite	Illite
Pyrite	K-Feldspar
Dolomite	Rutile
Quartz	Albite
Anhydrite	Zircon
Halite	Celestine
Apatite	Chromite

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified

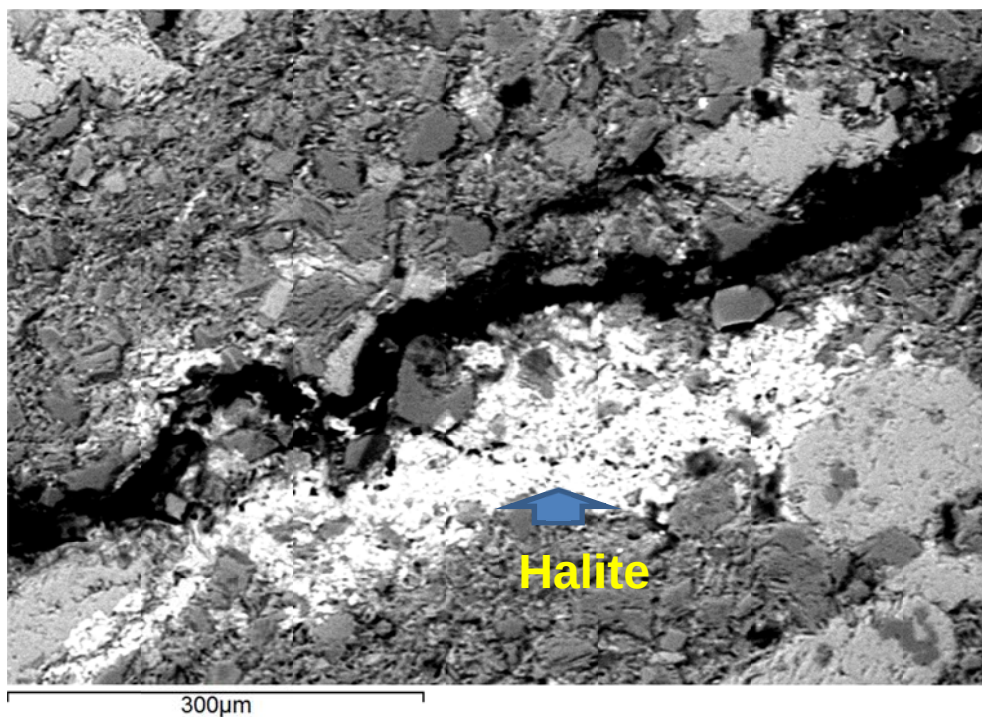


	Applied Geology Laboratory		ID: 116230
	Middle Bakken 3	NDIC Well 16766, Rogné 44-34H	Depth: 10686.3'
	API No.: 33025006640000		Lithology: Silty, oolitic limestone

Fracture Analysis on BSE Images



Halite and illite are filling the fracture.



Halite is noted along a large fracture.

	Applied Geology Laboratory		ID: 116673
	Middle Bakken 3	NDIC Well 16766, Rogne 44-34H	Depth: 10688.5'
	API No.: 33025006640000		Lithology: Calcareous siltstone

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION



Depth 10688.5': A wispy laminated and cross-bedded siltstone.

PHYSICAL PROPERTIES

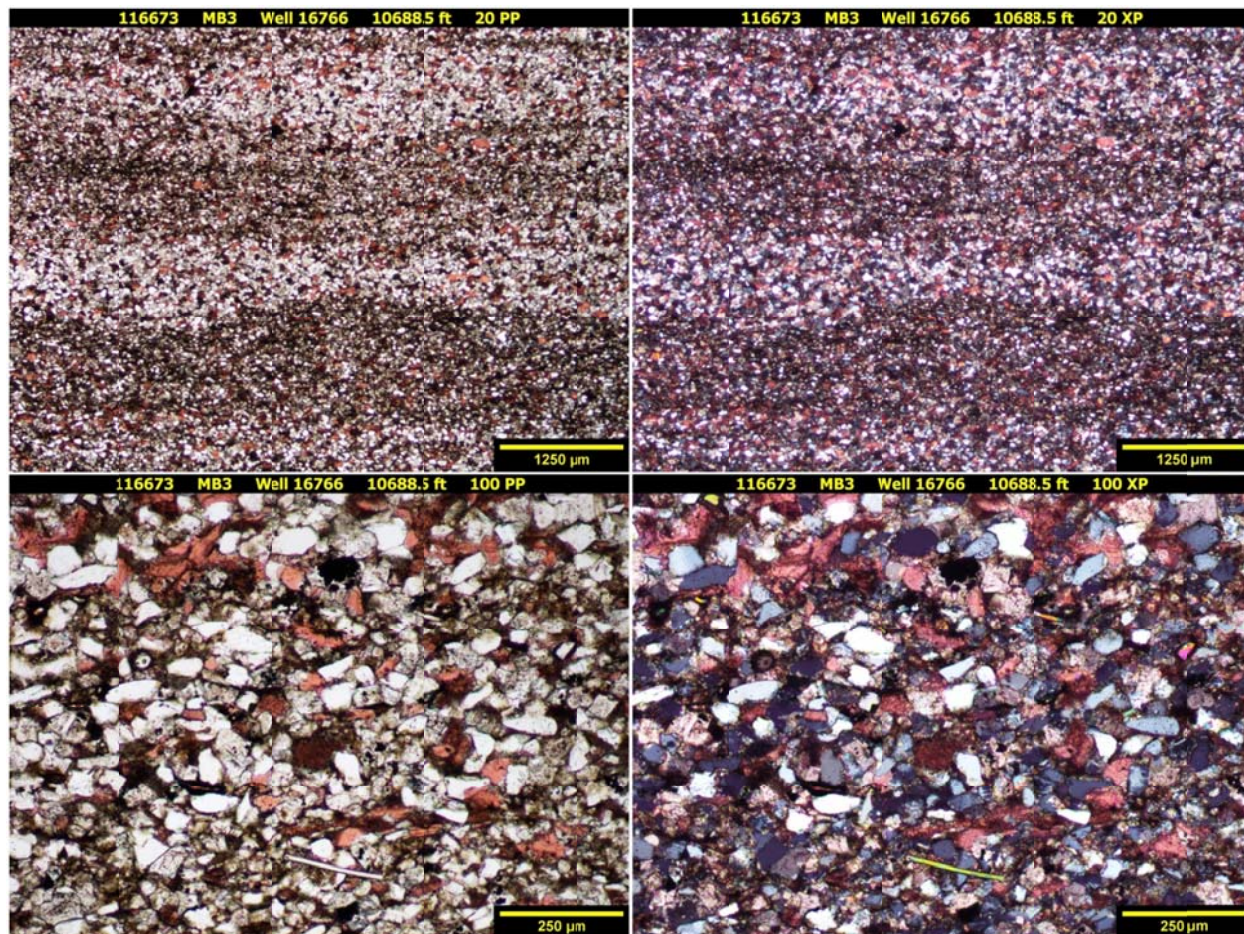
Porosity and Related Measurements Performed by MetaRock Laboratories

Pycnometer Effective Porosity, vol%	Bulk Volume, cm ³	Bulk Density, g/cm ³	Grain Volume, cm ³	Grain Density, g/cm ³
4.42	53.39	2.55	51.03	2.67

	Applied Geology Laboratory		ID: 116673
	Middle Bakken 3	NDIC Well 16766, Rogné 44-34H	Depth: 10688.5'
	API No.: 33025006640000		Lithology: Calcareous siltstone

PHOTOMICROGRAPHS

Transmission



This sample demonstrates calcareous siltstone. Most of the detrital grains are angular to subangular monocrystalline quartz and calcareous nonskeletal grains. Additional detrital minerals detected at trace amounts are feldspars and muscovite (largely horizontally oriented). Grains are well-packed and quartz grains express many concave/convex and sutured contact relationships, evidence for a higher degree of compaction. Microcrystalline, sparry, and rhombohedral dolomite growth act as cement. Small grain size, compaction, and dolomitization aid in the elimination of observable particle-based porosity in the thin section. Multiple filled and unfilled horizontal fractures are observed within this cross-bedded sample. Some of the unfilled fractures appear to be sampling induced; others are partially filled (displaying porosity) or completely filled with opaques (organics and clays).

	Applied Geology Laboratory		ID: 116673
	Middle Bakken 3	NDIC Well 16766, Rogné 44-34H	Depth: 10688.5'
	API No.: 33025006640000		Lithology: Calcareous siltstone

PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	60	Few overgrowths
Calcite	20	Allochem, cement
Dolomite	15	Cement
Clay	5	
Metals	Trace	Pyrite
Muscovite	Trace	Horizontal orientation
Organics	Trace	Tiny globs

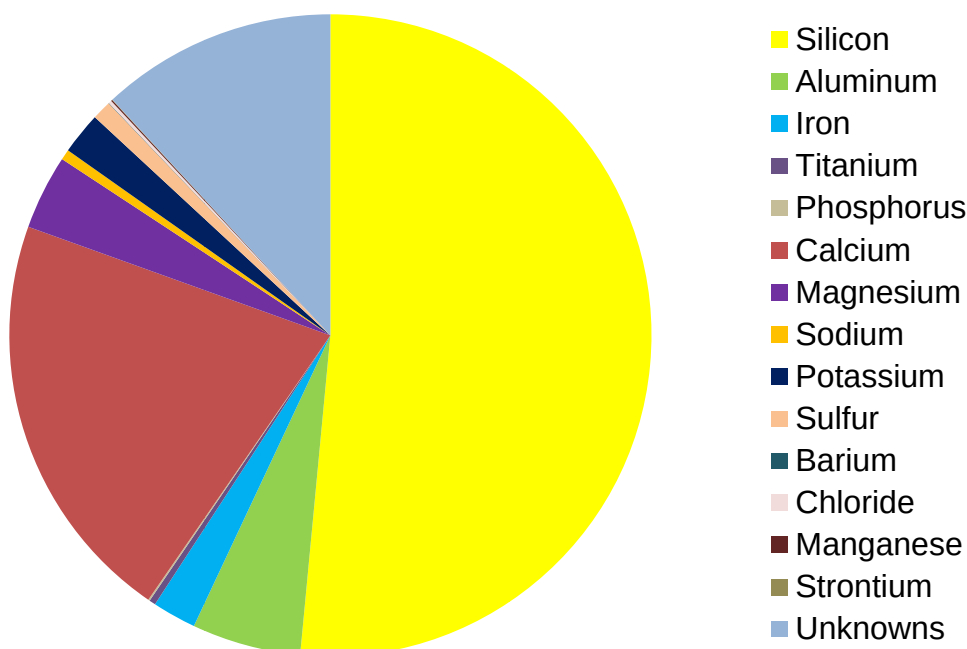
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through XRF and XRD data sets.

Detrital Texture

Category	Classification
Grain Size	Very fine grained
Sorting	Moderately well
Roundness	Angular to subangular

	Applied Geology Laboratory		ID: 116673
	Middle Bakken 3	NDIC Well 16766, Rogne 44-34H	Depth: 10688.5'
	API No.: 33025006640000		Lithology: Calcareous siltstone

XRF BULK CHEMICAL COMPOSITION

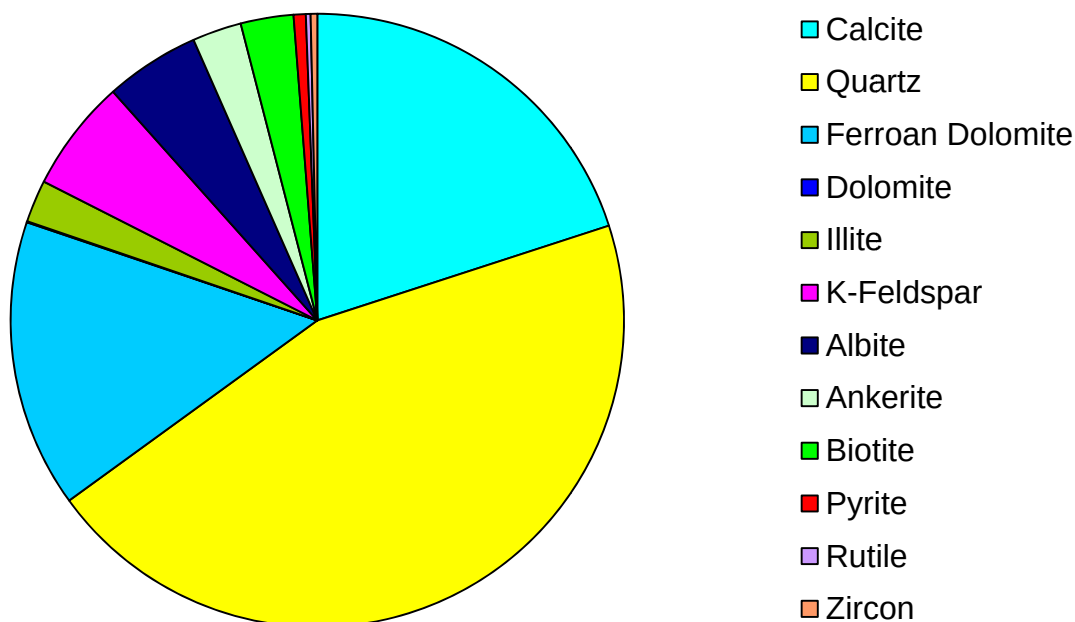


Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	51.51
Al (aluminum)	Al ₂ O ₃	5.49
Fe (iron)	Fe ₂ O ₃	2.21
Ti (titanium)	TiO ₂	0.32
P (phosphorus)	P ₂ O ₅	0.08
Ca (calcium)	CaO	20.89
Mg (magnesium)	MgO	3.76
Na (sodium)	Na ₂ O	0.52
K (potassium)	K ₂ O	2.12
S (sulfur)	SO ₃	0.97
Ba (barium)	BaO	0.02
Cl (chloride)	Cl	0.15
Mn (manganese)	MnO	0.07
Sr (strontium)	SrO	0.02
Unknowns	Due to the presence of carbonates*	11.88
Total		100.01

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

	Applied Geology Laboratory		ID: 116673
	Middle Bakken 3	NDIC Well 16766, Rogné 44-34H	Depth: 10688.5'
	API No.: 33025006640000		Lithology: Calcareous siltstone

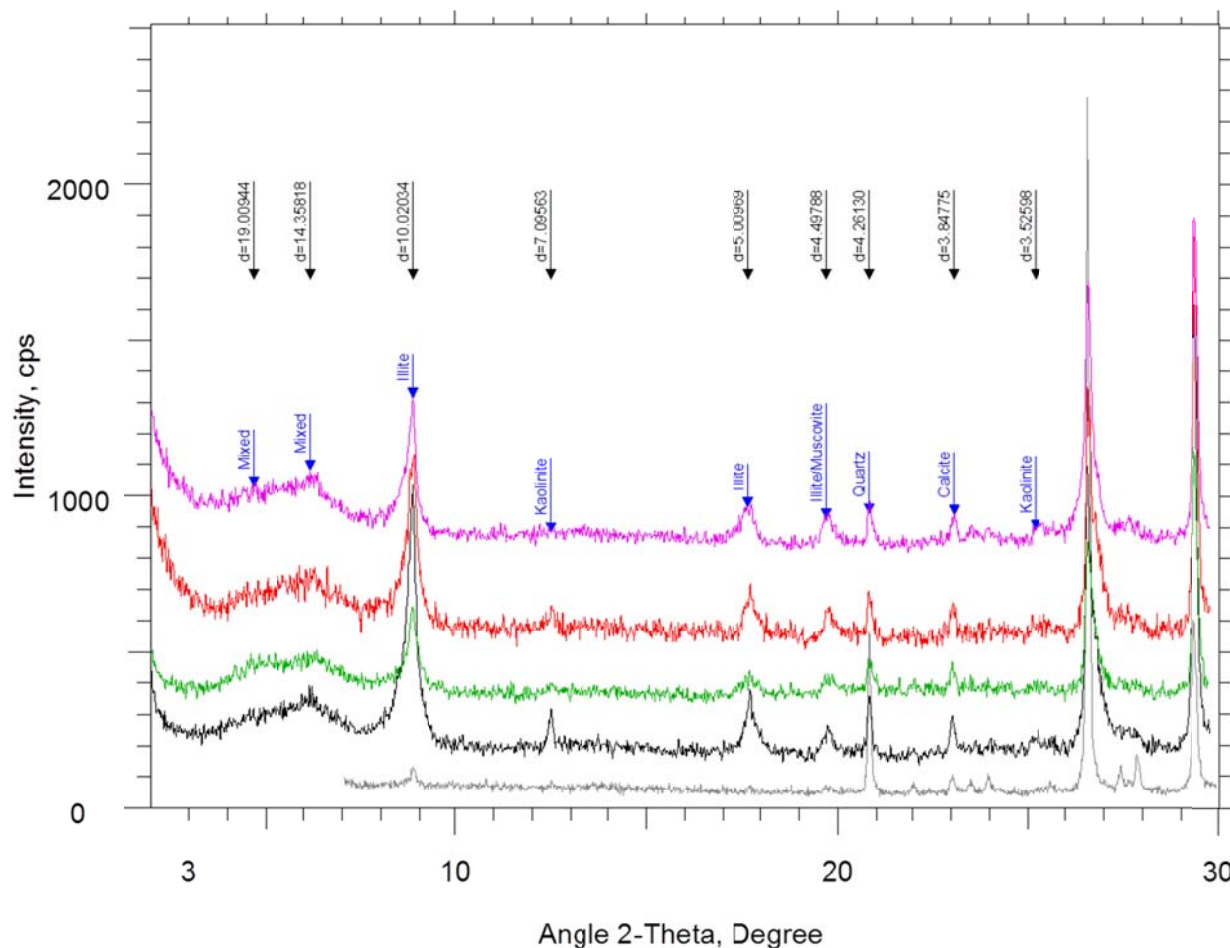
XRD MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	20.0
Quartz	SiO_2	45.0
Ferroan Dolomite	$\text{CaMg}_{0.8}\text{Fe}_{0.2}(\text{CO}_3)_2$	15.2
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	Trace
Illite	$(\text{K}, \text{H}_3\text{O})(\text{Al}, \text{Mg}, \text{Fe})_2(\text{Si}, \text{Al})_4\text{O}_{10}[(\text{OH})_2, (\text{H}_2\text{O})]$	2.2
K-Feldspar	KAlSi_3O_8	5.9
Albite	$\text{NaAlSi}_3\text{O}_8$	5.0
Ankerite	$\text{CaMg}_{0.45}\text{Fe}_{0.55}(\text{CO}_3)_2$	2.6
Biotite	$\text{K}(\text{Mg}, \text{Fe})_3((\text{OH})_2\text{AlSi}_3\text{O}_{10})$	2.8
Pyrite	FeS_2	0.6
Rutile	TiO_2	Trace
Zircon	ZrSiO_4	Trace

	Applied Geology Laboratory		ID: 116673
	Middle Bakken 3	NDIC Well 16766, Rogn 44-34H	Depth: 10688.5'
	API No.: 33025006640000		Lithology: Calcareous siltstone

XRD Clay Typing



Clays Identified

Illite
Mixed-layer clay
Kaolinite

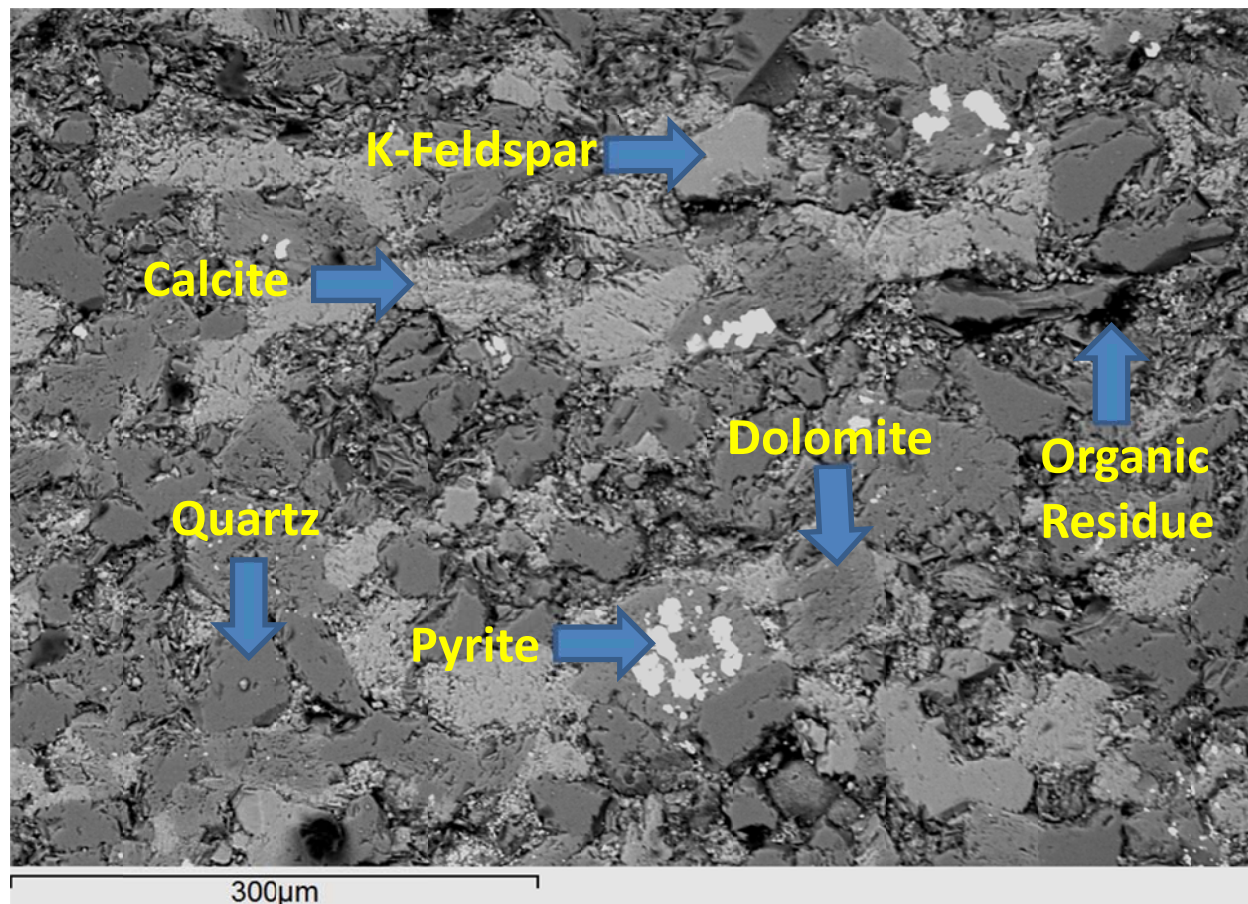
	Applied Geology Laboratory		ID: 116673
	Middle Bakken 3	NDIC Well 16766, Rogné 44-34H	Depth: 10688.5'
	API No.: 33025006640000		Lithology: Calcareous siltstone

SEM

Observed Minerals

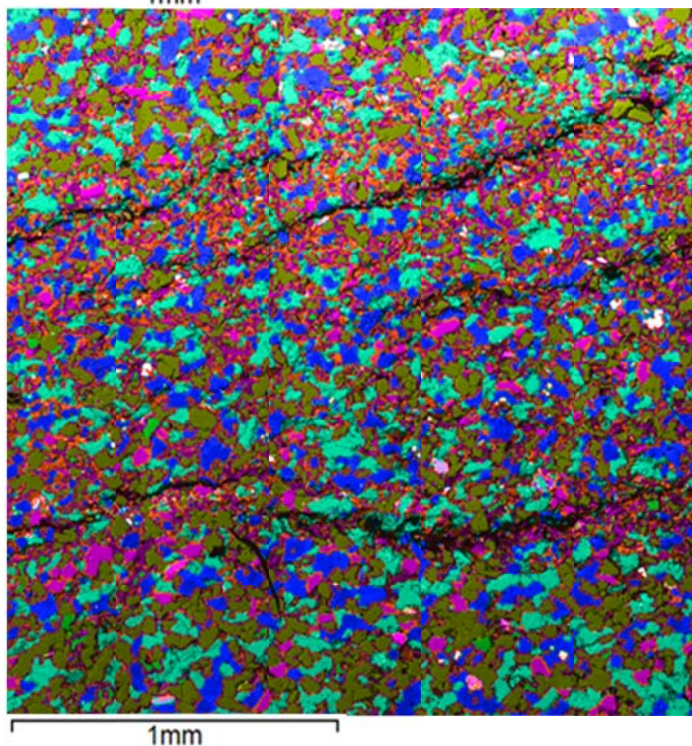
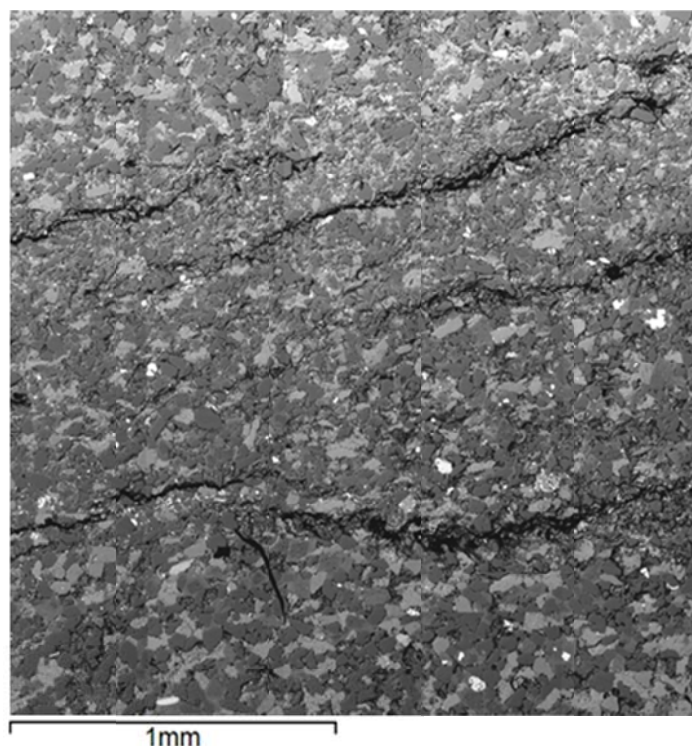
Mineral Phase	Mineral Phase
Quartz	Apatite
Calcite	Rutile
Dolomite	Zircon
Pyrite	Biotite
K-Feldspar	Kaolinite

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified



	Applied Geology Laboratory		ID: 116673
	Middle Bakken 3	NDIC Well 16766, Rogne 44-34H	Depth: 10688.5'
	API No.: 33025006640000		Lithology: Calcareous siltstone

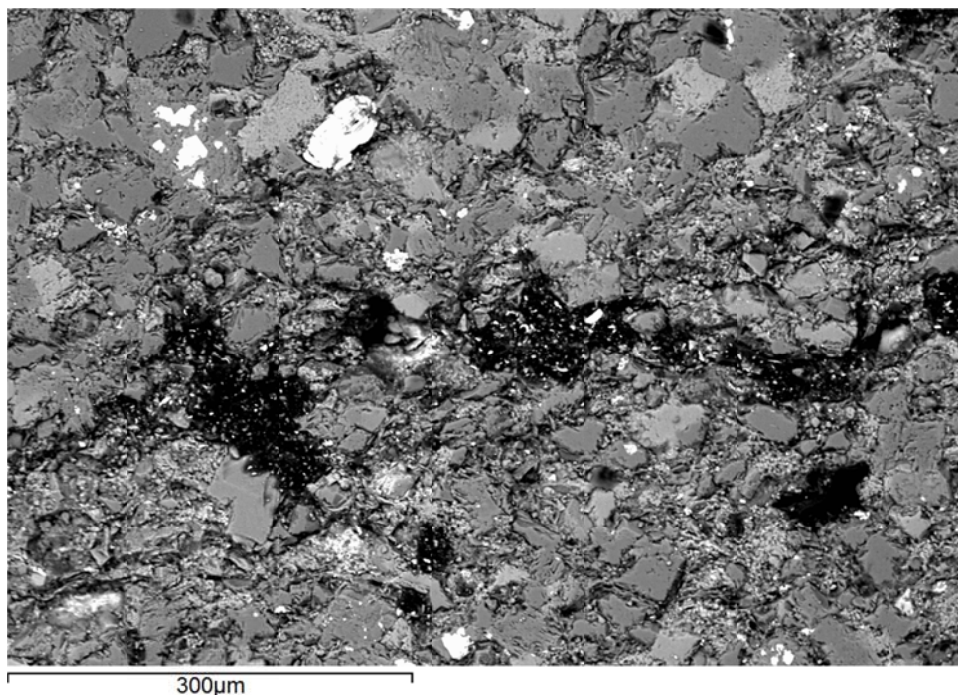
SEM BSE Image and Corresponding Digital Composite Mineral Map Image Overlaid on BSE Image with Mineral-Phase 2-D Area Percentages



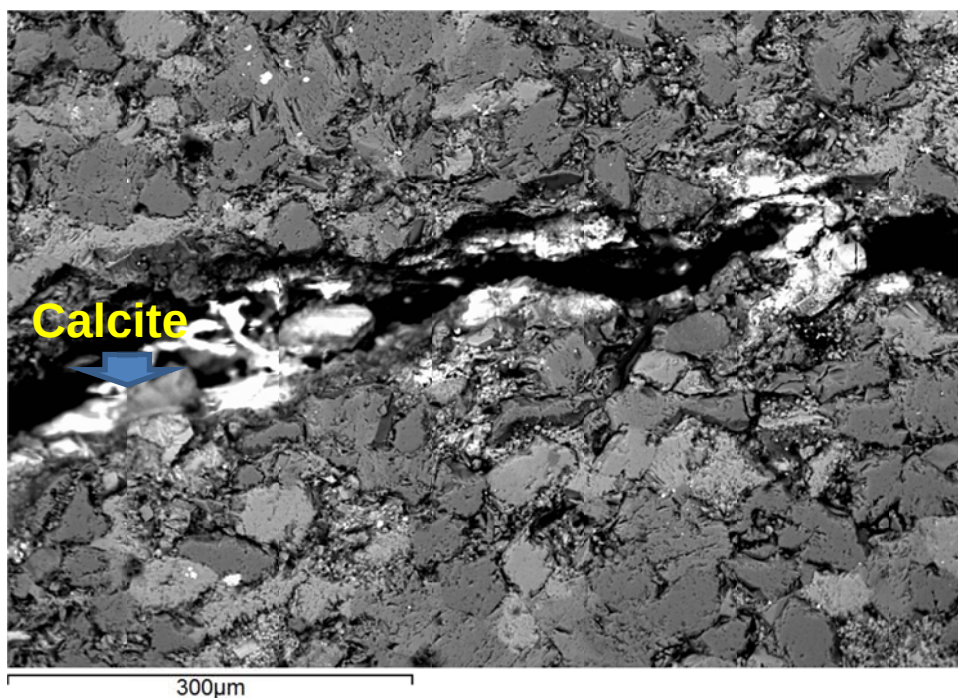
	Pyrite – 0.9%
	Dolomite – 18.8%
	Calcite – 21.4%
	Albite – 0.7%
	Quartz – 21.9%
	K-Feldspar – 15.0%
	Apatite – 0.1%
	Illite – 20.6%
	Zircon – 0.4%

	Applied Geology Laboratory		ID: 116673
	Middle Bakken 3	NDIC Well 16766, Rogne 44-34H	Depth: 10688.5'
	API No.: 33025006640000		Lithology: Calcareous siltstone

Fracture Analysis on BSE Images



The fracture contains organic, oily residue and clay minerals such as illite.



Charged calcite grains are noted in the fracture. Very small illite clay grains appear in the intergranular and fractured spaces.

	Applied Geology Laboratory		ID: 116673
	Middle Bakken 3	NDIC Well 16766, Rogne 44-34H	Depth: 10688.5'
	API No.: 33025006640000	Lithology: Calcareous siltstone	

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	Applied Geology Laboratory		ID: 116231
	Middle Bakken 2	NDIC Well 16766, Rogné 44-34H	Depth: 10696.0'
	API No.: 33025006640000	Lithology: Silty, argillaceous limestone	

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION



Depth 10696.0': A massive to mottled fossiliferous limestone. Horizontal and vertical cemented fractures are observed.

PHYSICAL PROPERTIES

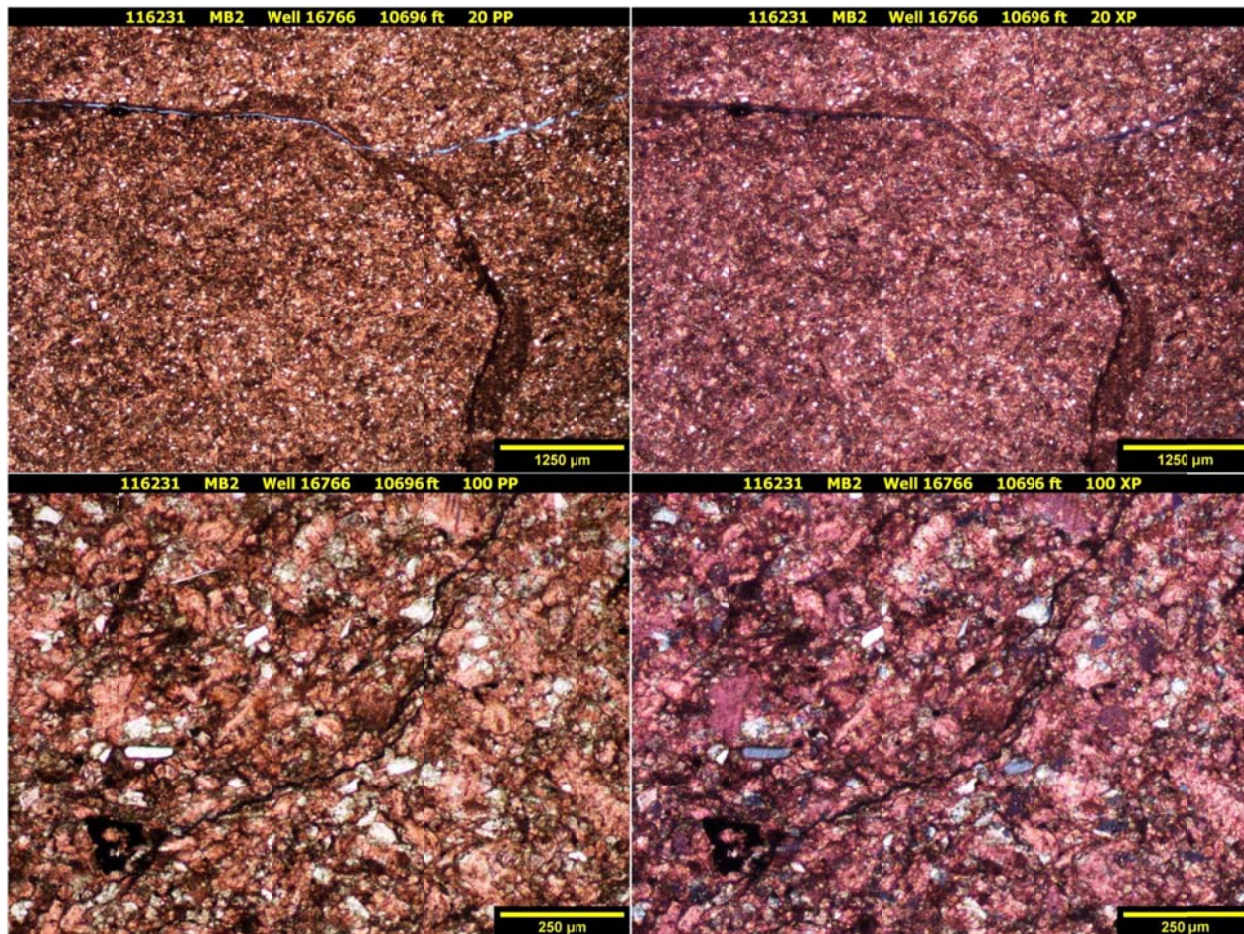
Porosity and Related Measurements Performed by MetaRock Laboratories

Pycnometer Effective Porosity, vol%	Bulk Volume, cm ³	Bulk Density, g/cm ³	Grain Volume, cm ³	Grain Density, g/cm ³
1.32	49.65	2.64	48.99	2.67

	Applied Geology Laboratory		ID: 116231
	Middle Bakken 2	NDIC Well 16766, Rogne 44-34H	Depth: 10696.0'
	API No.: 33025006640000		Lithology: Silty, argillaceous limestone

PHOTOMICROGRAPHS

Transmission



This sample is argillaceous, silty limestone. Detrital subangular to angular monocrystalline quartz have a speckled distribution. Calcareous clasts abundantly occur throughout the sample. Additional detrital minerals observed at trace quantities are muscovite and feldspars. The matrix composes predominantly clay (increased zonal concentrations), sparry calcareous cement, and rare microcrystalline to cryptocrystalline dolomite. Pyrite skeletal and nonskeletal replacement is observed. Trace rhombohedral dolomite is present. Small organic specs are found sporadically throughout and occasionally found in larger masses. Open and filled fractures are observed. The open fractures are likely the result of the coring and sample process. The closed fractures have horizontal and oblique orientations and are filled with clays and organics. No particle-based porosity is observed.

	Applied Geology Laboratory		ID: 116231
	Middle Bakken 2	NDIC Well 16766, Rogné 44-34H	Depth: 10696.0'
	API No.: 33025006640000	Lithology: Silty, argillaceous limestone	

PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	30	Very fine grained
Calcite	55	Allochems, cement
Dolomite	Trace	Microcrystalline, few rhombs
Clay	15	
Metals	Trace	Pyrite
Muscovite	Trace	Random orientation
Organics	Trace	Globular, microfractures

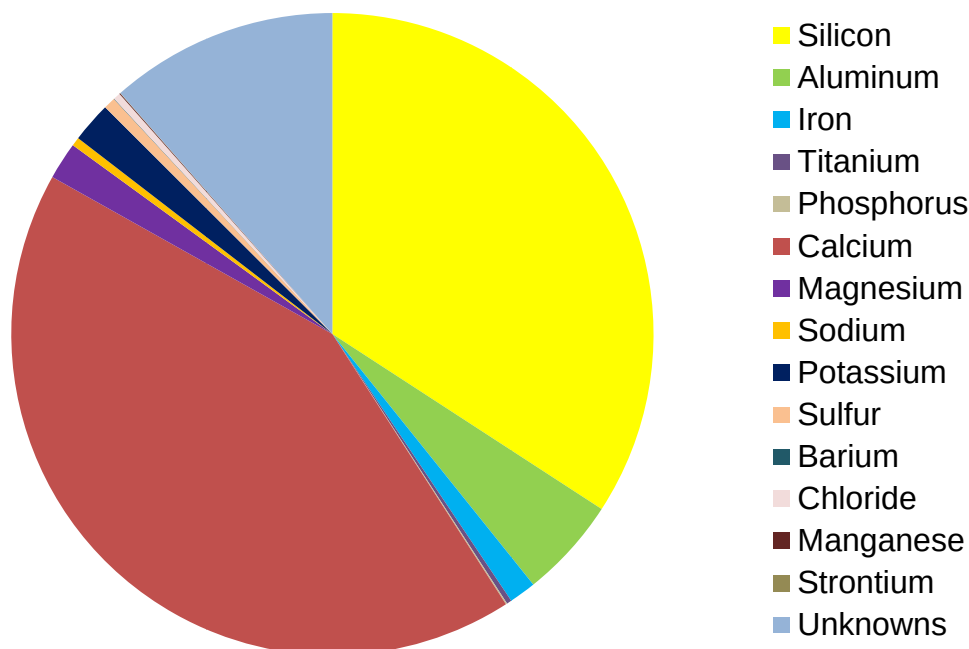
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through XRF and XRD data sets.

Detrital Texture

Category	Classification
Grain Size	Very fine
Sorting	Moderately well
Roundness	Angular to subangular

	Applied Geology Laboratory		ID: 116231
	Middle Bakken 2	NDIC Well 16766, Rogne 44-34H	Depth: 10696.0'
	API No.: 33025006640000	Lithology: Silty, argillaceous limestone	

XRF BULK CHEMICAL COMPOSITION

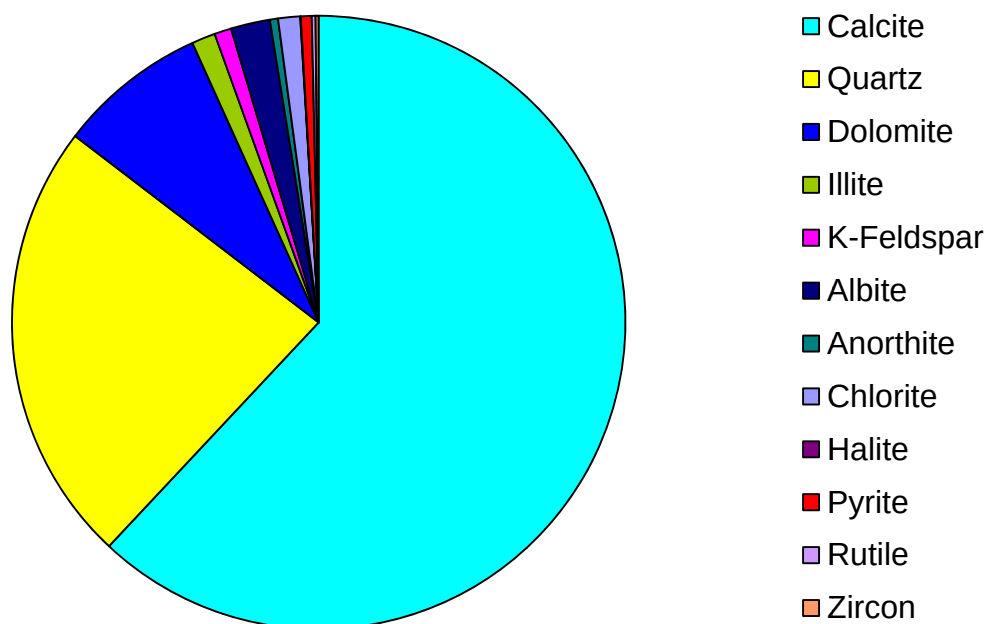


Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	34.17
Al (aluminum)	Al ₂ O ₃	5.07
Fe (iron)	Fe ₂ O ₃	1.36
Ti (titanium)	TiO ₂	0.25
P (phosphorus)	P ₂ O ₅	0.06
Ca (calcium)	CaO	42.22
Mg (magnesium)	MgO	1.88
Na (sodium)	Na ₂ O	0.44
K (potassium)	K ₂ O	2.03
S (sulfur)	SO ₃	0.60
Ba (barium)	BaO	0.02
Cl (chloride)	Cl	0.35
Mn (manganese)	MnO	0.05
Sr (strontium)	SrO	0.02
Unknowns	Due to the presence of carbonates*	11.48
Total		100.00

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

	Applied Geology Laboratory		ID: 116231
	Middle Bakken 2	NDIC Well 16766, Rogné 44-34H	Depth: 10696.0'
	API No.: 33025006640000	Lithology: Silty, argillaceous limestone	

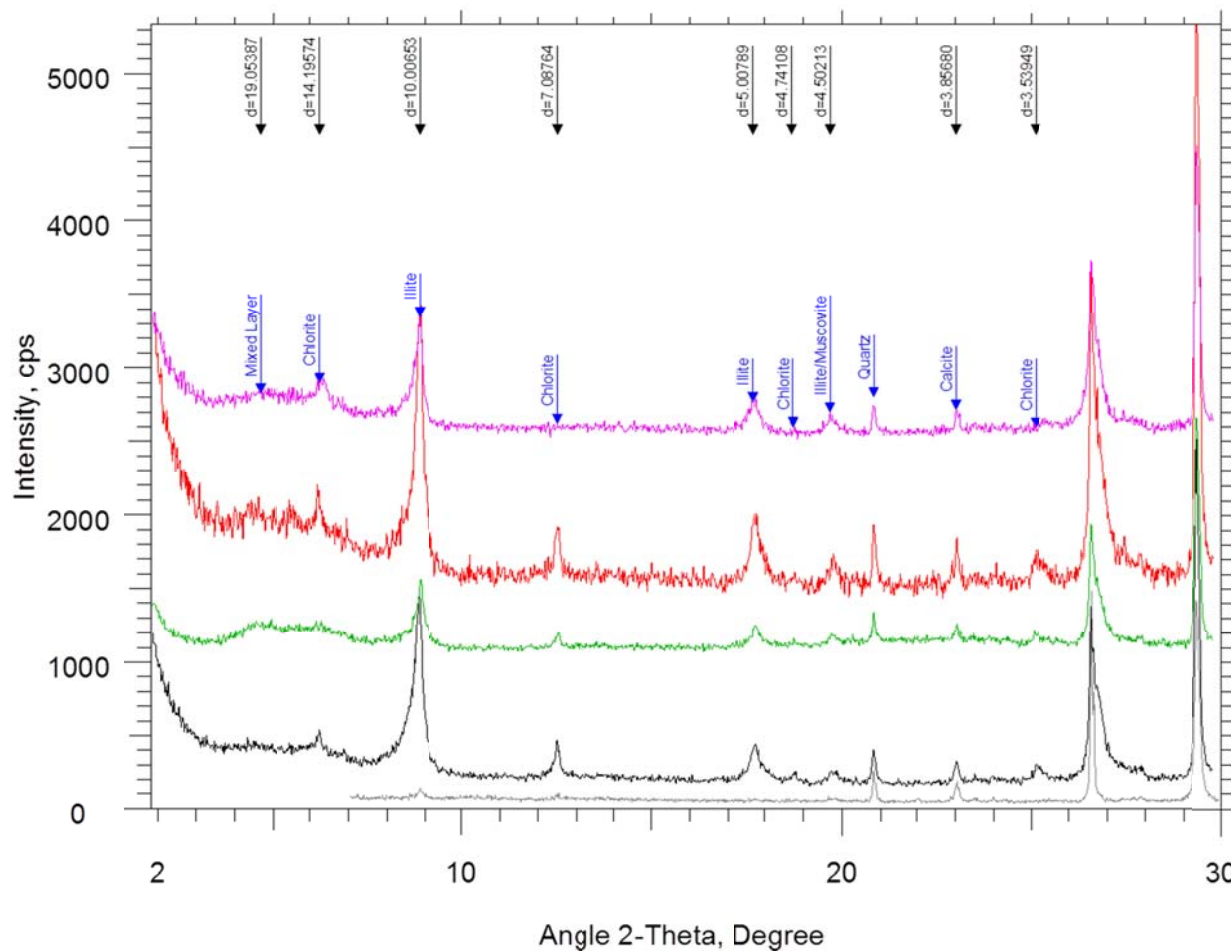
XRD MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	62.0
Quartz	SiO_2	23.4
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	7.9
Illite	$(\text{K}, \text{H}_3\text{O})(\text{Al}, \text{Mg}, \text{Fe})_2(\text{Si}, \text{Al})_4\text{O}_{10}[(\text{OH})_2, (\text{H}_2\text{O})]$	1.2
K-Feldspar	KAlSi_3O_8	0.9
Albite	$\text{NaAlSi}_3\text{O}_8$	2.1
Anorthite	$\text{CaAl}_2\text{Si}_2\text{O}_4$	Trace
Chlorite	$\text{Mg}_{2.96}\text{Fe}_{1.55}\text{Fe}_{0.14}\text{Al}_{1.28}(\text{Si}_{2.62}\text{Al}_{1.38}\text{O}_{10})(\text{OH})_8$	1.2
Halite	NaCl	Trace
Pyrite	FeS_2	0.6
Rutile	TiO_2	Trace
Zircon	ZrSiO_4	Trace

	Applied Geology Laboratory		ID: 116231
	Middle Bakken 2	NDIC Well 16766, Rognø 44-34H	Depth: 10696.0'
	API No.: 33025006640000		Lithology: Silty, argillaceous limestone

XRD Clay Typing



Clays Identified

Illite
Chlorite
Mixed-layer clay

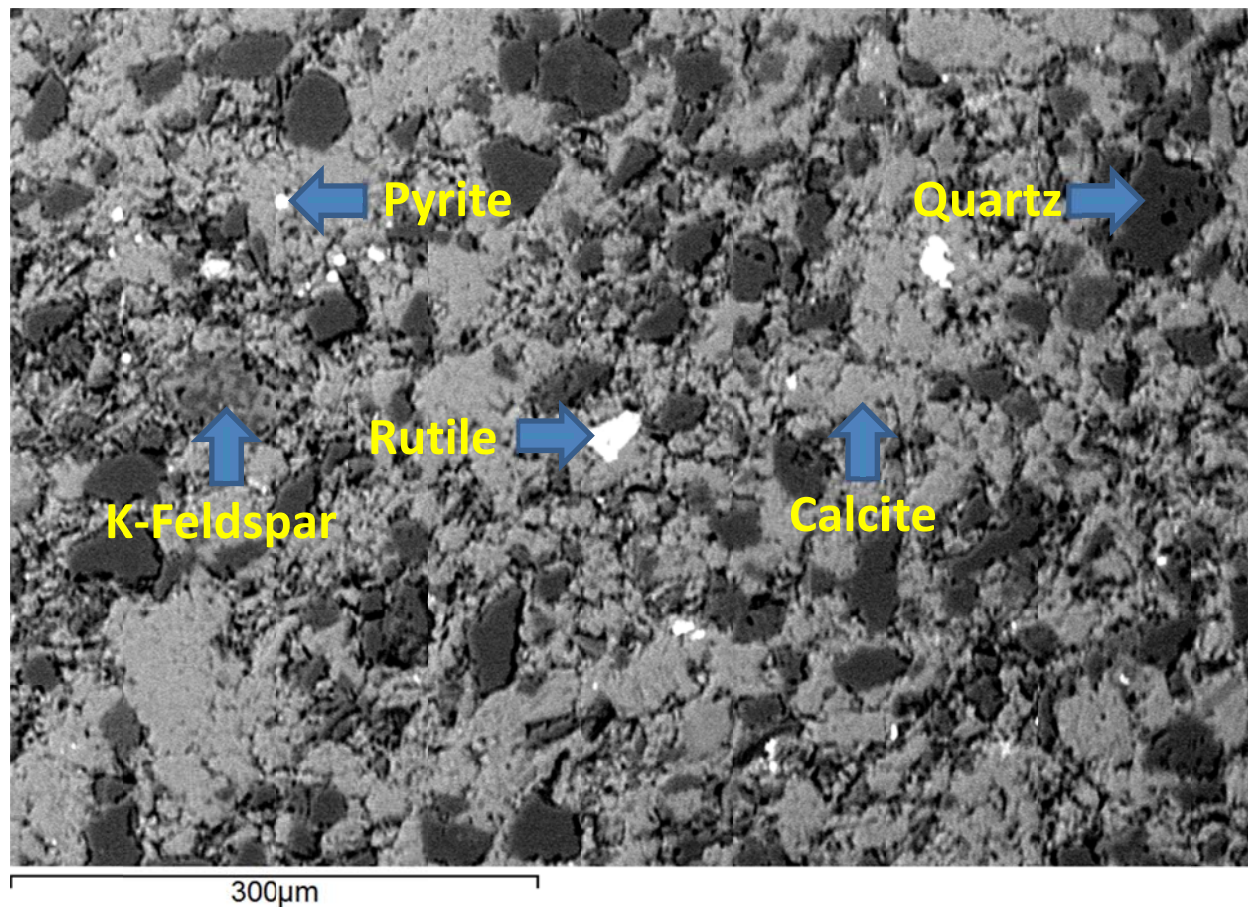
	Applied Geology Laboratory		ID: 116231
	Middle Bakken 2	NDIC Well 16766, Rogné 44-34H	Depth: 10696.0'
	API No.: 33025006640000		Lithology: Silty, argillaceous limestone

SEM

Observed Minerals

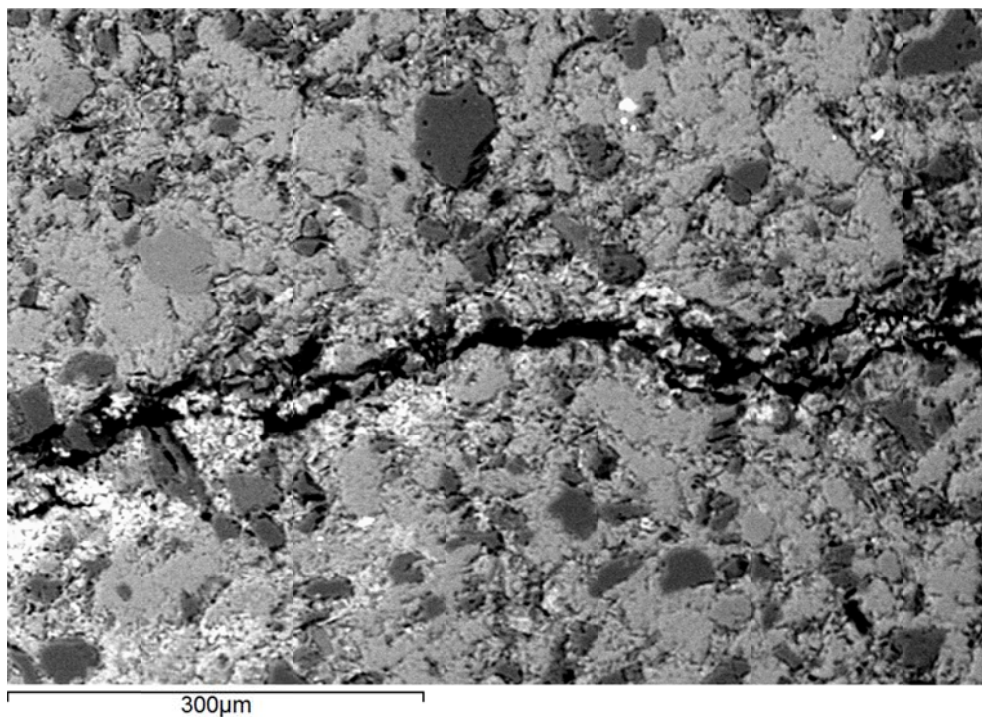
Mineral Phase	Mineral Phase
Quartz	Halite
Pyrite	Dolomite
Apatite	Zircon
K-Feldspar	Illite
Rutile	

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified

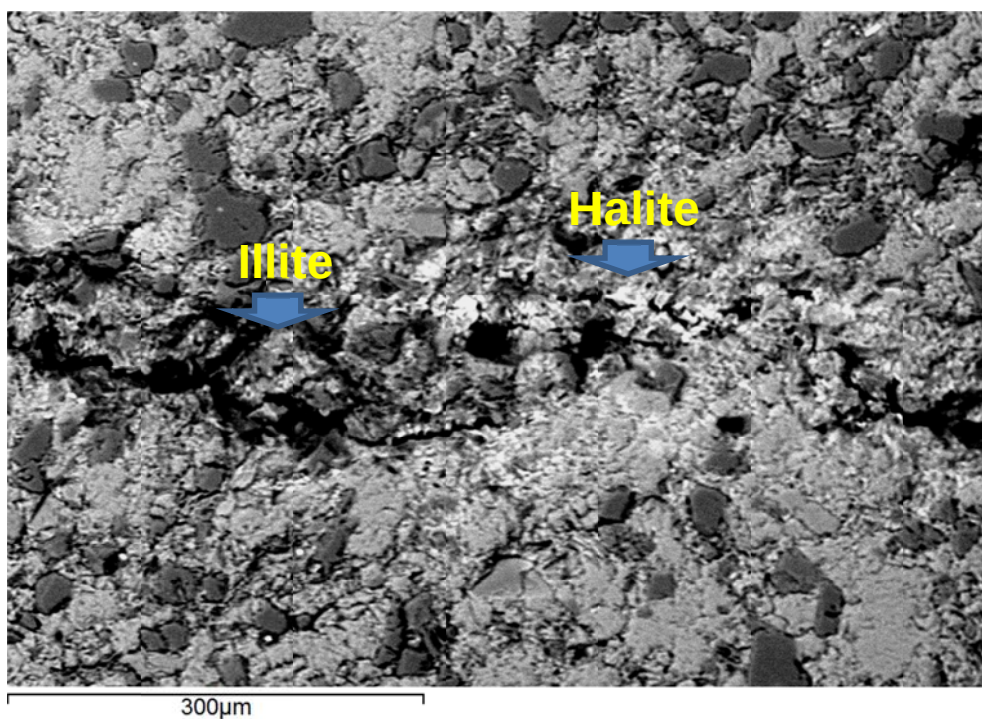


	Applied Geology Laboratory		ID: 116231
	Middle Bakken 2	NDIC Well 16766, Rogne 44-34H	Depth: 10696.0'
	API No.: 33025006640000		Lithology: Silty, argillaceous limestone

Fracture Analysis on BSE Images



Halite from inside the fracture coats minerals along the fracture.



Illite is found in the fracture and there is a halite coating along the fracture.

	Applied Geology Laboratory		ID: 116236
	Middle Bakken 2	NDIC Well 16766, Rogne 44-34H	Depth: 10696.5'
	API No.: 33025006640000		Lithology: Silty limestone

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION

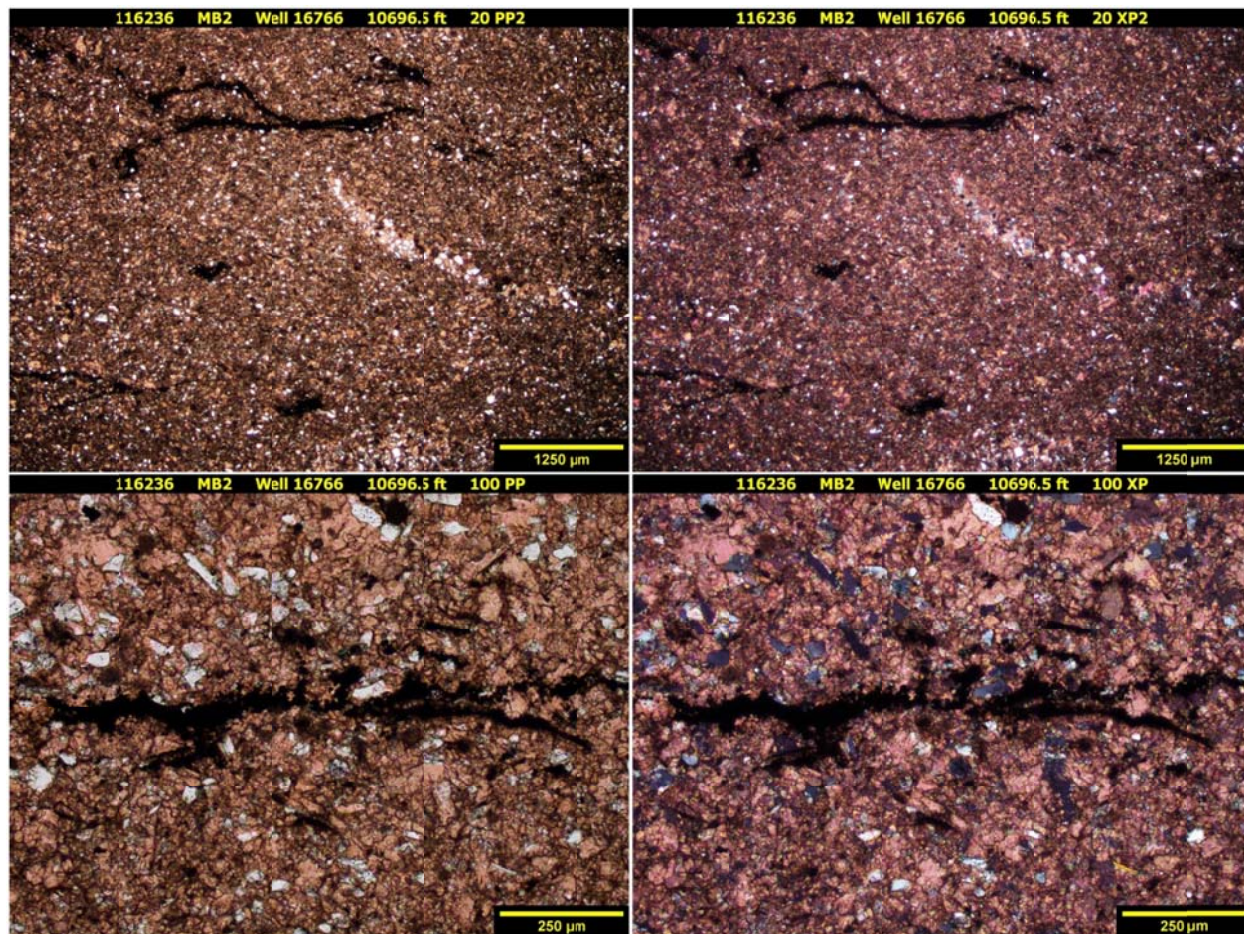


Depth 10696.5': A massive to mottled fossiliferous limestone. Horizontal and vertical cemented fractures are observed.

	Applied Geology Laboratory		ID: 116236
	Middle Bakken 2	NDIC Well 16766, Rogné 44-34H	Depth: 10696.5'
	API No.: 33025006640000		Lithology: Silty limestone

PHOTOMICROGRAPHS

Transmission



This sample displays silty limestone. Subangular to subrounded monocrystalline quartz is commonly dispersed throughout the sample. Calcareous nonskeletal clasts are abundant. Unidentified fossil fragments and nearly intact ostracods and brachiopods are observed with minor dolomite and pyrite replacement. Trace amounts of dolomite rhombs exist. No muscovite, feldspars, or rutile are observed. Evidence of micritization exists on both skeletal and nonskeletal grains. Pore-filling, sparry, calcite cement is prevalent and eliminates any observable interparticle-based porosity in the thin section. Clay is found in trace quantities and spread throughout, concentrating in some areas. Globular clumps of organics are found throughout. Small, nonconnected microfractures filled with opaques (organics and clays) are seen. No observable porosity is detected.

	Applied Geology Laboratory		ID: 116236
	Middle Bakken 2	NDIC Well 16766, Rogne 44-34H	Depth: 10696.5'
	API No.: 33025006640000		Lithology: Silty limestone

PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	20	Very fine grained
Calcite	75	Allochems, cement
Dolomite	Trace	Allochem replacement
Clay	Trace	
Metals	Trace	Pyrite, hematite
Muscovite	0	Not observed
Organics	Trace	Globular, within laminations and microfractures

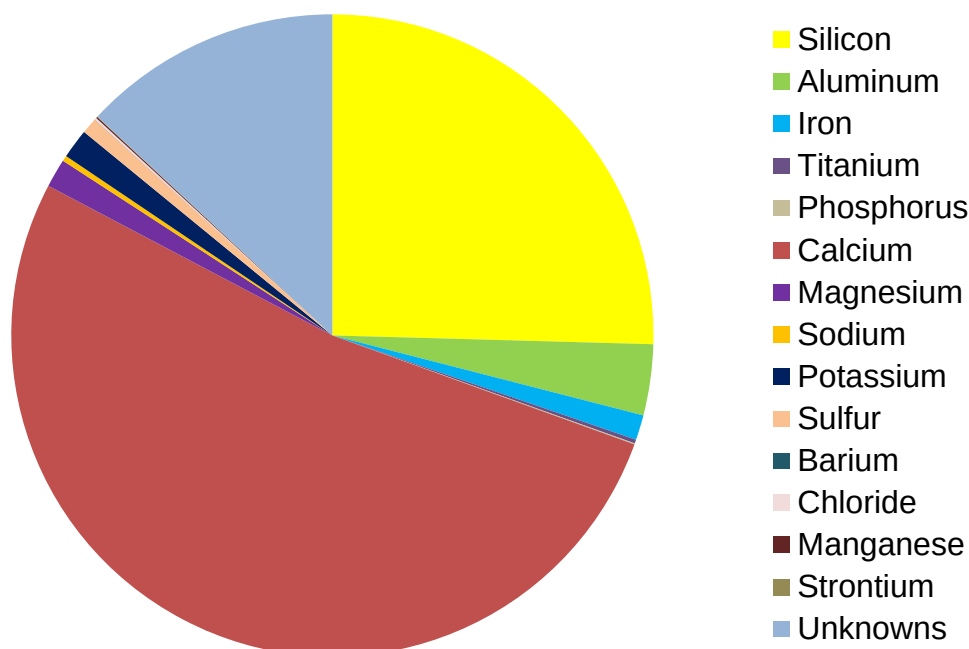
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through XRF and XRD data sets.

Texture

Category	Classification
Grain Size	Very fine
Sorting	Moderately well
Roundness	Subangular to subrounded

	Applied Geology Laboratory		ID: 116236
	Middle Bakken 2	NDIC Well 16766, Rogné 44-34H	Depth: 10696.5'
	API No.: 33025006640000		Lithology: Silty limestone

XRF BULK CHEMICAL COMPOSITION

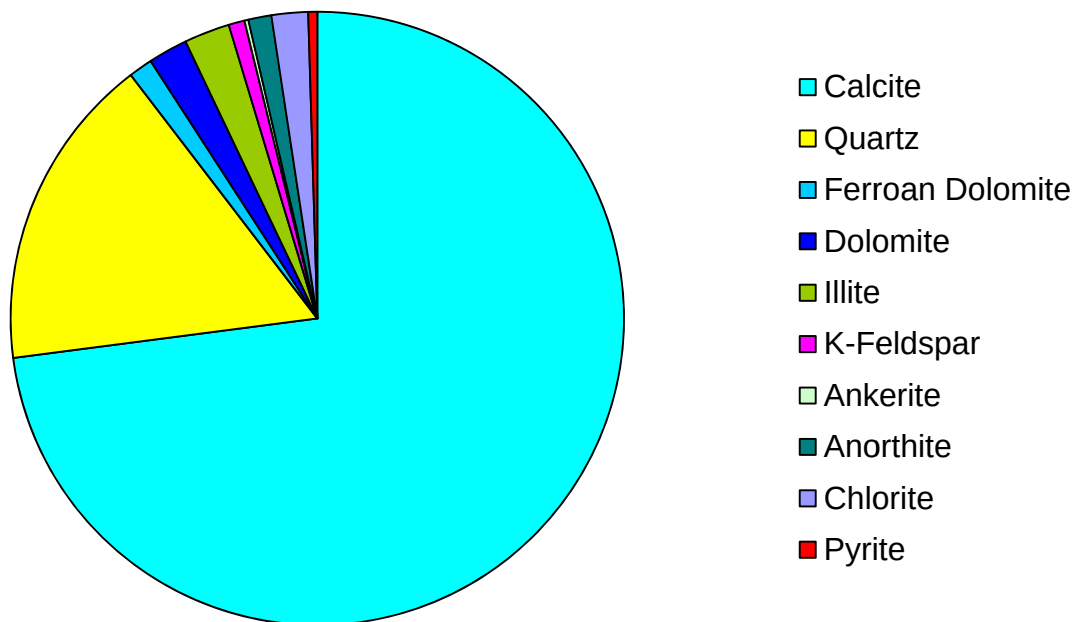


Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	25.44
Al (aluminum)	Al ₂ O ₃	3.57
Fe (iron)	Fe ₂ O ₃	1.26
Ti (titanium)	TiO ₂	0.19
P (phosphorus)	P ₂ O ₅	0.05
Ca (calcium)	CaO	52.20
Mg (magnesium)	MgO	1.44
Na (sodium)	Na ₂ O	0.28
K (potassium)	K ₂ O	1.49
S (sulfur)	SO ₃	0.81
Ba (barium)	BaO	0.01
Cl (chloride)	Cl	0.10
Mn (manganese)	MnO	0.07
Sr (strontium)	SrO	0.02
Unknowns	Due to the presence of carbonates*	13.07
Total		100.00

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

	Applied Geology Laboratory		ID: 116236
	Middle Bakken 2	NDIC Well 16766, Rogné 44-34H	Depth: 10696.5'
	API No.: 33025006640000		Lithology: Silty limestone

XRD MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	72.9
Quartz	SiO_2	16.7
Ferroan Dolomite	$\text{CaMg}_{0.8}\text{Fe}_{0.2}(\text{CO}_3)_2$	1.3
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	2.1
Illite	$(\text{K}, \text{H}_3\text{O})(\text{Al}, \text{Mg}, \text{Fe})_2(\text{Si}, \text{Al})_4\text{O}_{10}[(\text{OH})_2, (\text{H}_2\text{O})]$	2.4
K-Feldspar	KAlSi_3O_8	0.8
Ankerite	$\text{CaMg}_{0.45}\text{Fe}_{0.55}(\text{CO}_3)_2$	Trace
Anorthite	$\text{CaAl}_2\text{Si}_2\text{O}_4$	1.2
Chlorite	$\text{Mg}_{2.96}\text{Fe}_{1.55}\text{Fe}_{0.14}\text{Al}_{1.28}(\text{Si}_{2.62}\text{Al}_{1.38}\text{O}_{10})(\text{OH})_8$	1.9
Pyrite	FeS_2	Trace

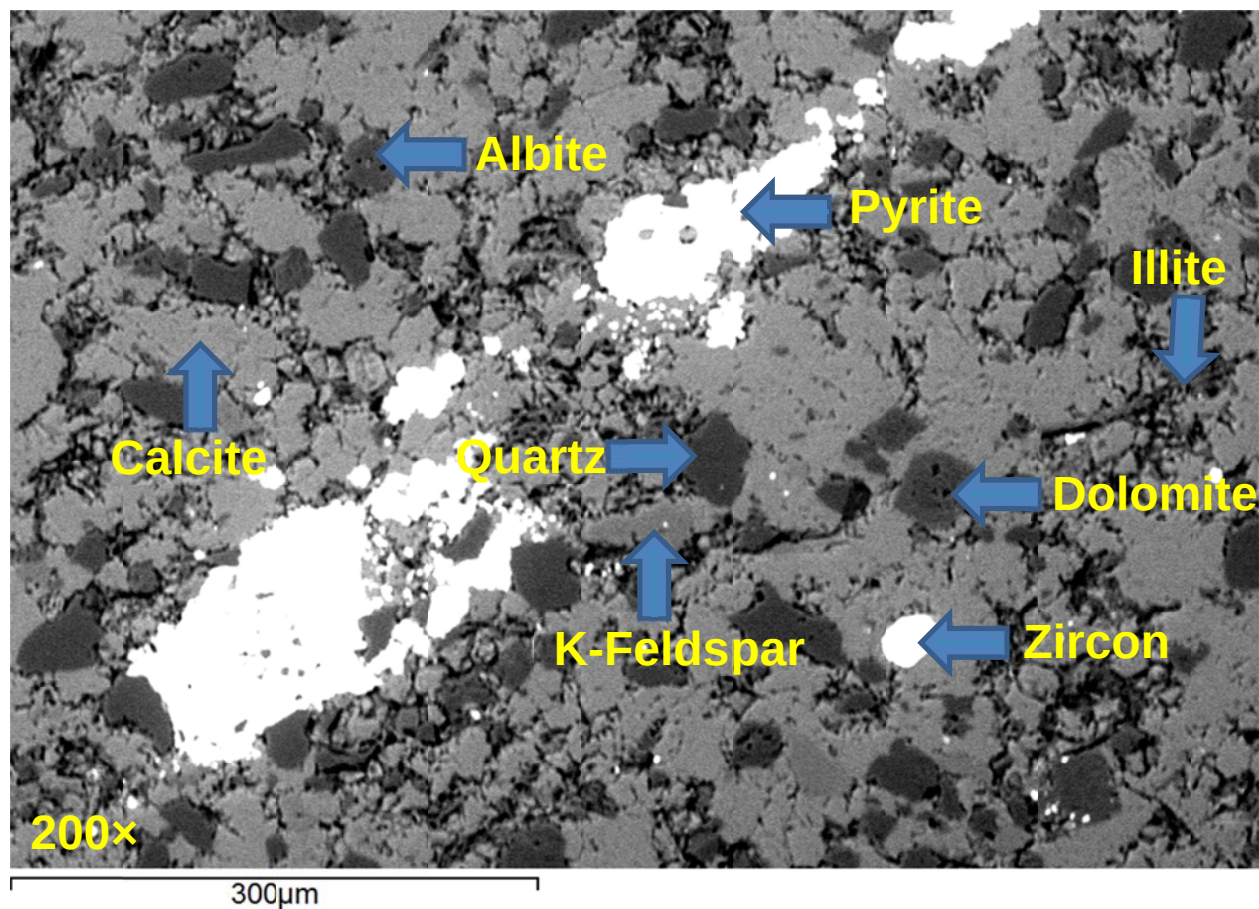
	Applied Geology Laboratory		ID: 116236
	Middle Bakken 2	NDIC Well 16766, Rogné 44-34H	Depth: 10696.5'
	API No.: 33025006640000		Lithology: Silty limestone

SEM

Observed Minerals

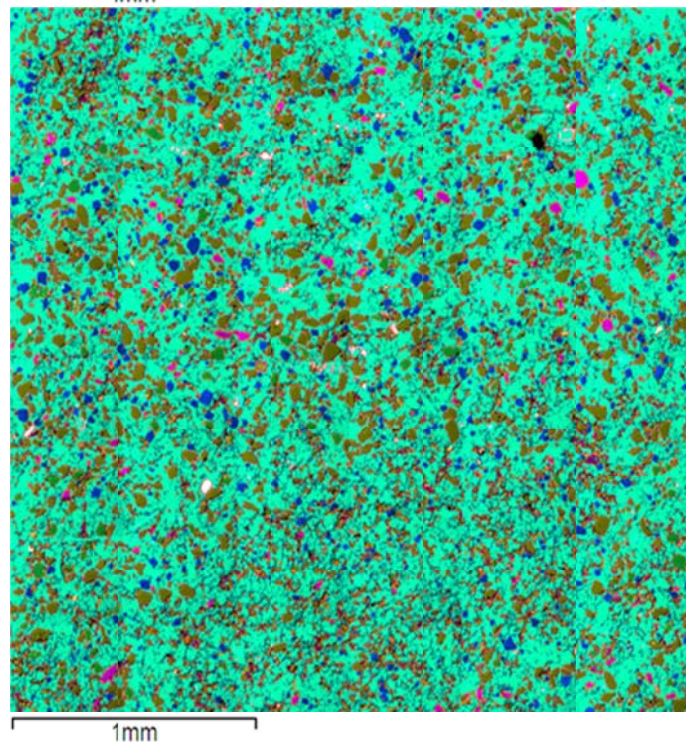
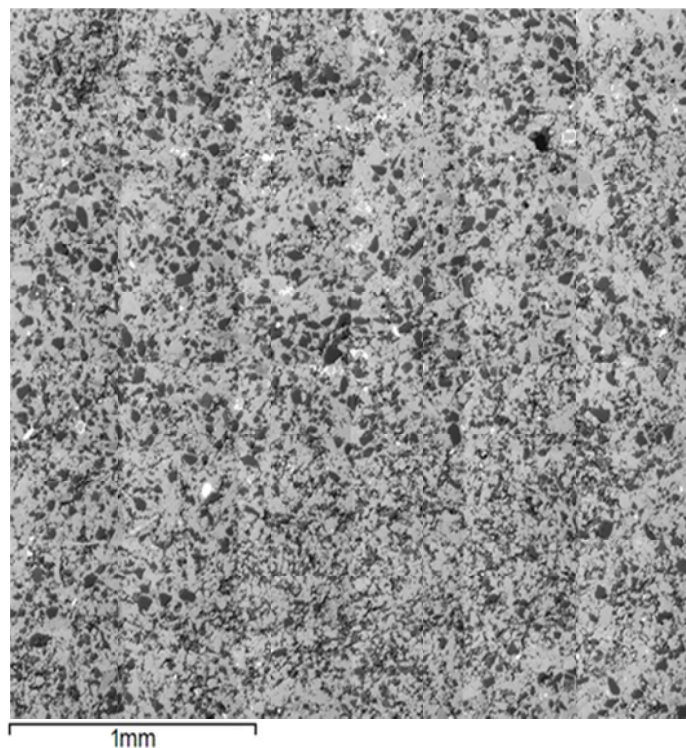
Mineral Phase	Mineral Phase
Calcite	K-Feldspar
Dolomite	Zircon
Quartz	Albite
Pyrite	Rutile
Illite	Apatite

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified



	Applied Geology Laboratory		ID: 116236
	Middle Bakken 2	NDIC Well 16766, Rogne 44-34H	Depth: 10696.5'
	API No.: 33025006640000		Lithology: Silty limestone

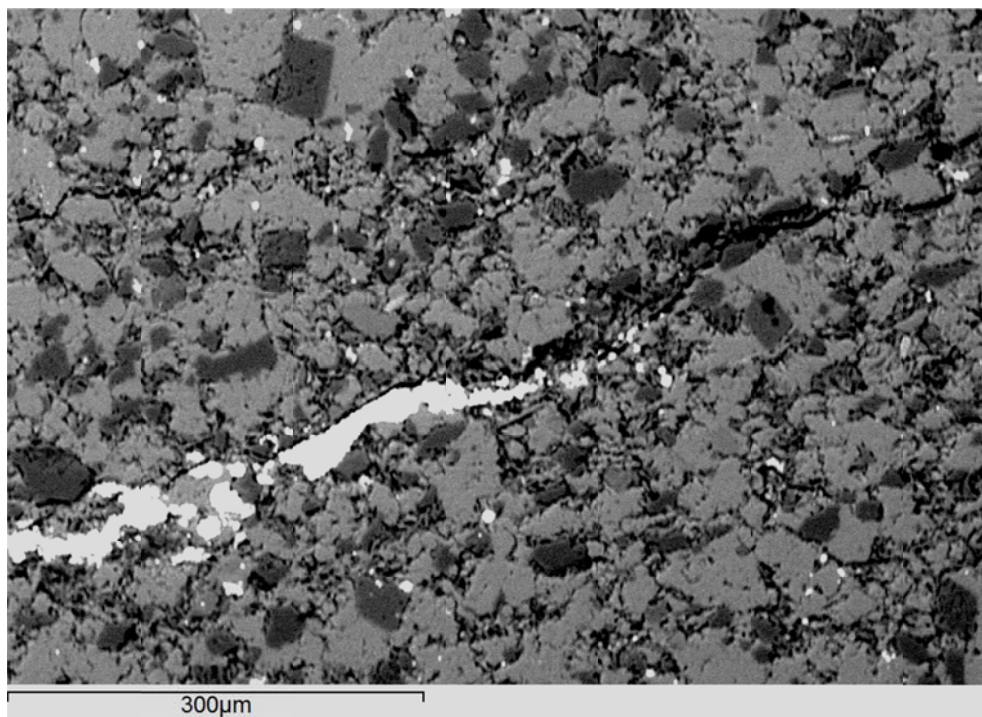
SEM BSE Image and Corresponding Digital Composite Mineral Map Image Overlaid on BSE Image with Mineral-Phase 2-D Area Percentages



	Pyrite – 0.3%
	Dolomite – 4.4%
	Calcite – 67.5%
	Albite – 2.1%
	Quartz – 7.0%
	K-Feldspar – 3.6%
	Illite – 15.2%

	Applied Geology Laboratory		ID: 116236
	Middle Bakken 2	NDIC Well 16766, Rogne 44-34H	Depth: 10696.5'
	API No.: 33025006640000		Lithology: Silty limestone

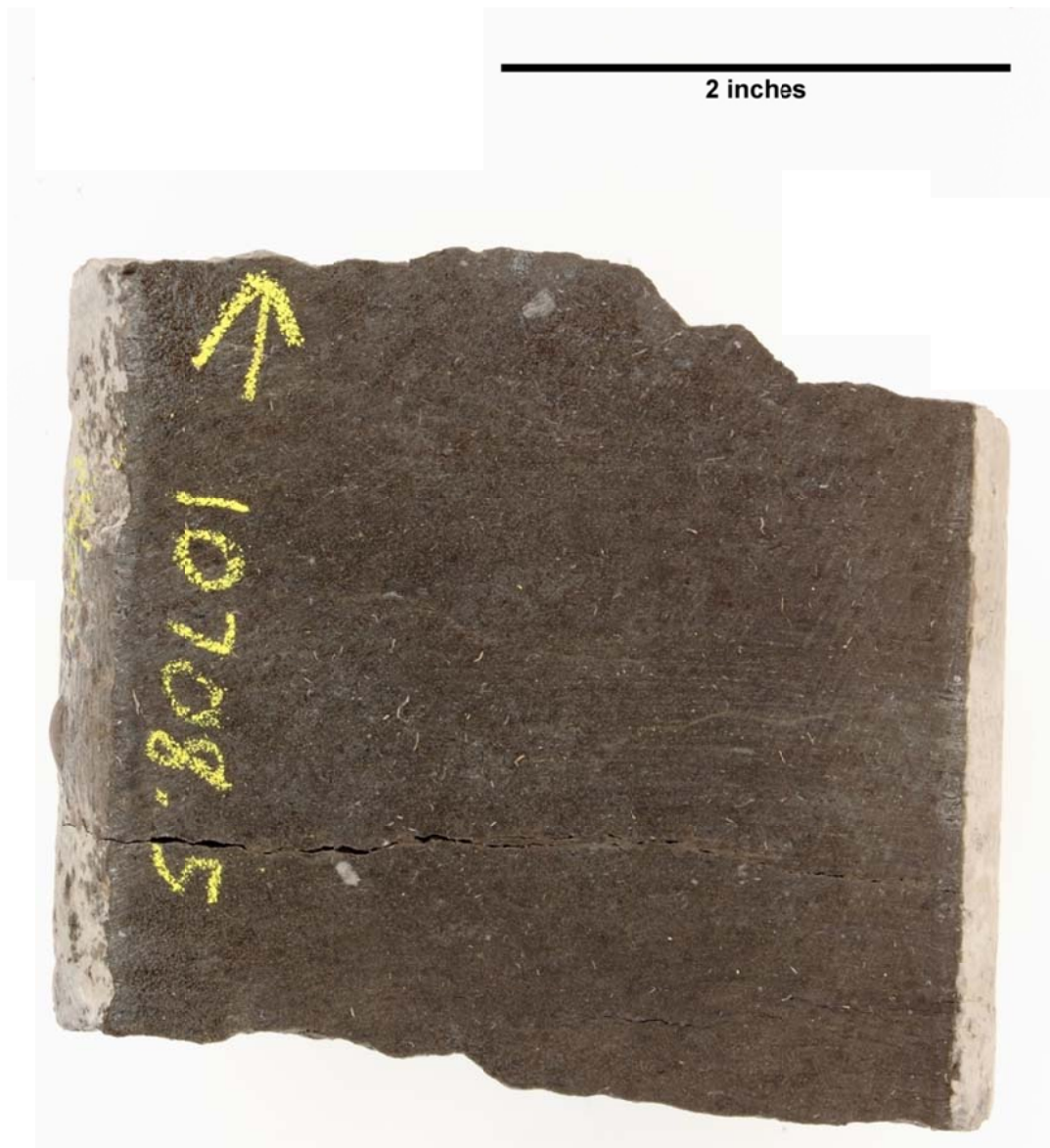
Fracture Analysis on BSE Images



This fracture contains pyrite minerals and illite. Few fractures were noted in this sample.

	Applied Geology Laboratory		ID: 116232
	Middle Bakken 1	NDIC Well 16766, Rogné 44-34H	Depth: 10708.5'
	API No.: 33025006640000		Lithology: Argillaceous, silty limestone

SAMPLE PHOTOGRAPH AND MACROSCALE DESCRIPTION



Depth 10708.5': A massive fossiliferous limestone. Open and cemented fractures are observed.

PHYSICAL PROPERTIES

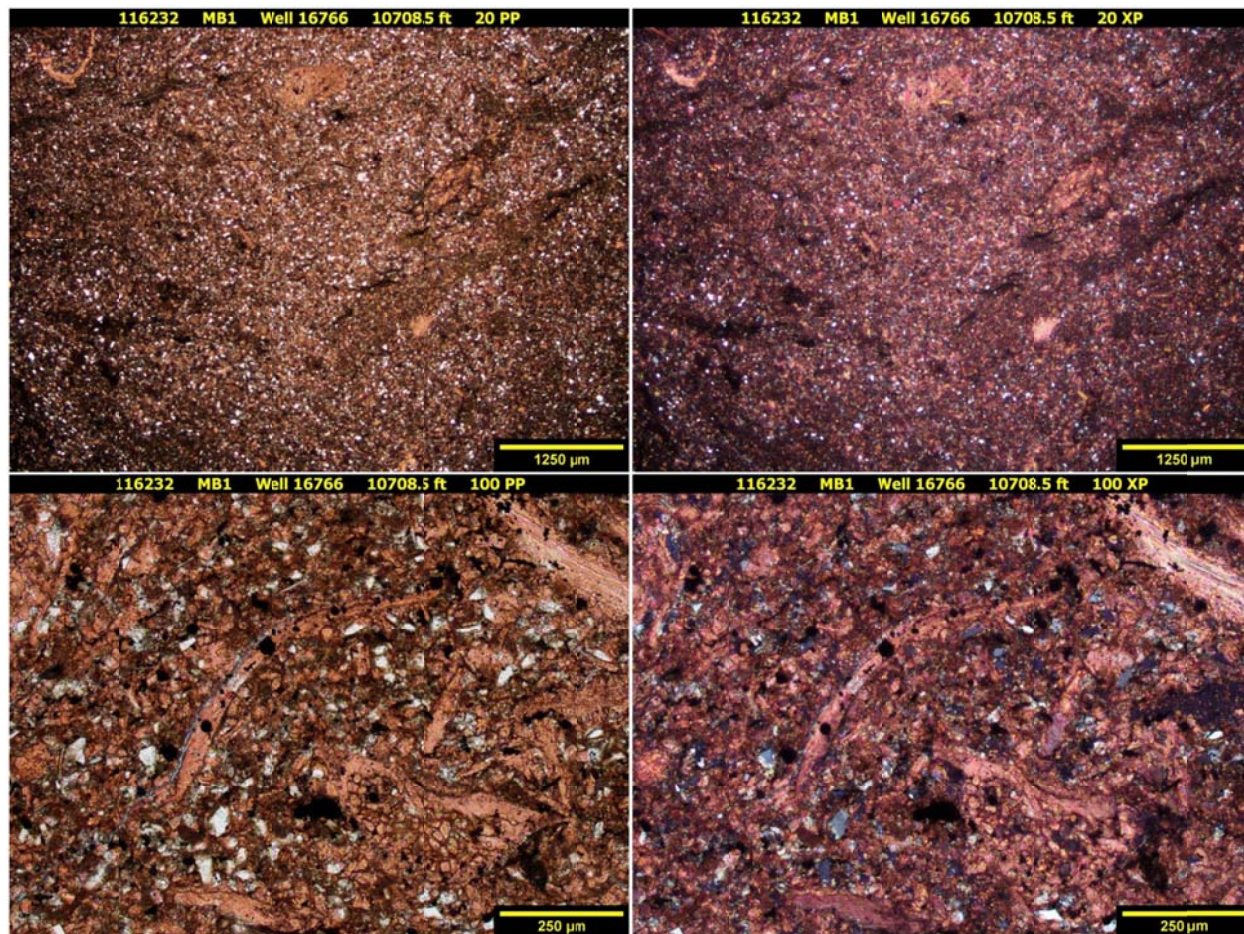
Porosity and Related Measurements Performed by MetaRock Laboratories

Pycnometer Effective Porosity, vol%	Bulk Volume, cm ³	Bulk Density, g/cm ³	Grain Volume, cm ³	Grain Density, g/cm ³
3.87	51.30	2.56	49.31	2.66

	Applied Geology Laboratory		ID: 116232
	Middle Bakken 1	NDIC Well 16766, Rogne 44-34H	Depth: 10708.5'
	API No.: 33025006640000		Lithology: Argillaceous, silty limestone

PHOTOMICROGRAPHS

Transmission



This sample displays argillaceous, silty limestone. Subangular to subrounded monocrystalline quartz is commonly disseminated throughout the sample. Calcareous nonskeletal and skeletal clasts are abundant and observed with moderate pyrite replacement. Trace amounts of microcrystalline dolomite exist within the sample matrix. Trace quantities of muscovite and feldspars are observed. Pore-filling, sparry, calcite cement is prevalent and eliminates any observable interparticle-based porosity in the thin section. Clay is found throughout the sample, concentrating in a few areas. Organics are observed as globular clumps dispersed throughout and within small, nonconnected, randomly-orientated microfractures. No observable porosity is detected. Some fracture-based porosity is evident, but is likely the result of sample preparation process.

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PETROGRAPHIC DESCRIPTIONS

Sample Composition

Assemblage	Estimated Percentage*	Comments
Quartz + Feldspars	30	Very fine grained
Calcite	50	Allochems, cement
Dolomite	Trace	Microcrystalline
Clay	15	
Metals	Trace	Pyrite
Muscovite	Trace	Moderately well orientation
Organics	Trace	Globular, within microfractures

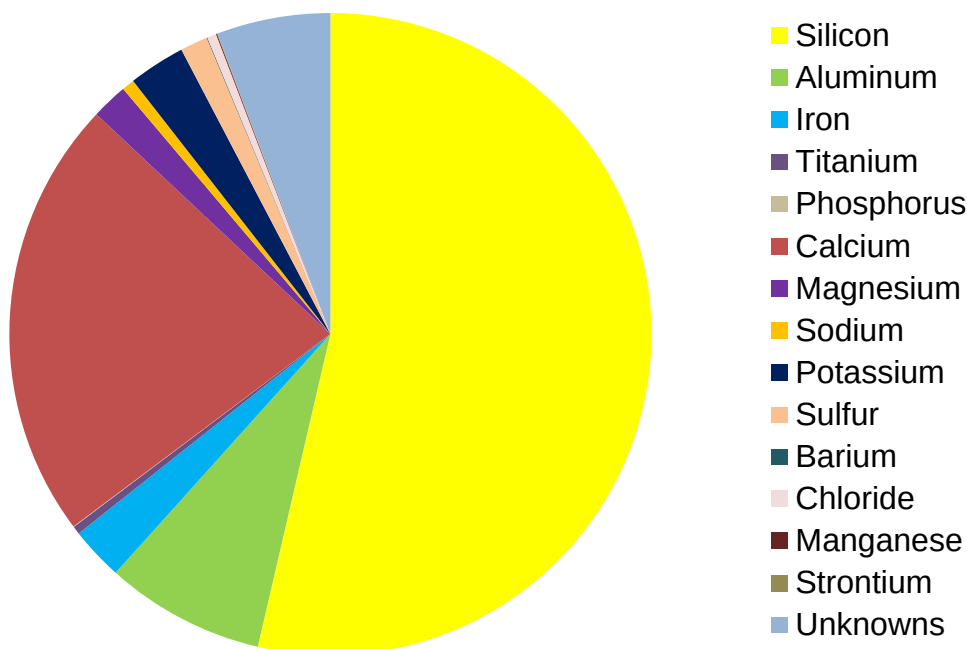
* Values are based on visual estimations of the relative abundance in the thin section. Quantified measurements are provided through XRF and XRD data sets.

Detrital Texture

Category	Classification
Grain Size	Very fine
Sorting	Moderately well
Roundness	Subangular to subrounded

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XRF BULK CHEMICAL COMPOSITION

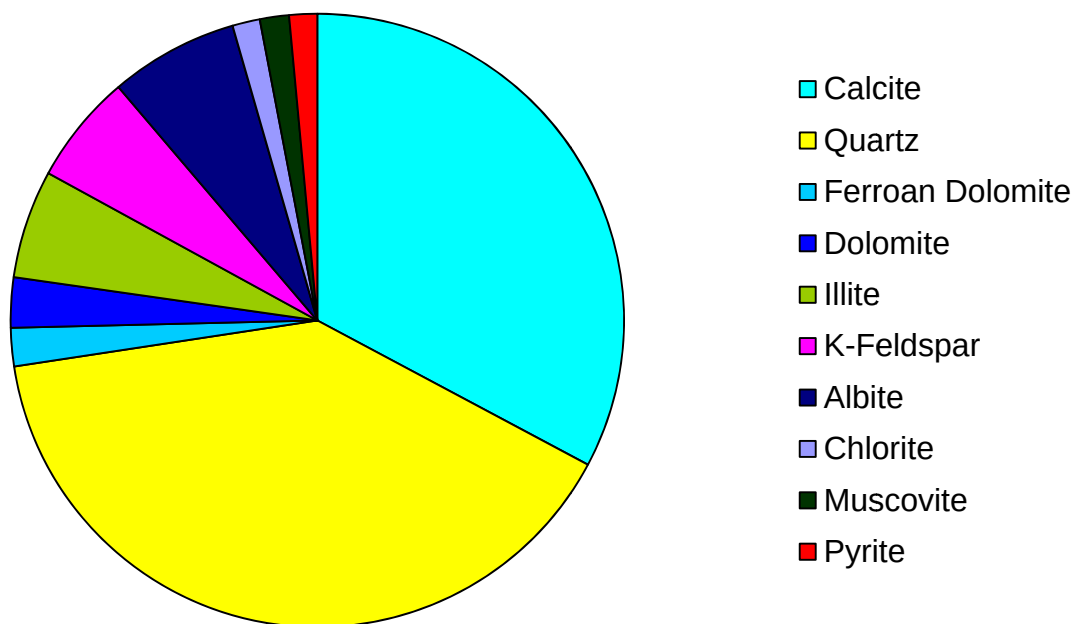


Element	Reporting Convention (oxide)	wt%
Si (silicon)	SiO ₂	53.65
Al (aluminum)	Al ₂ O ₃	8.03
Fe (iron)	Fe ₂ O ₃	2.67
Ti (titanium)	TiO ₂	0.41
P (phosphorus)	P ₂ O ₅	0.03
Ca (calcium)	CaO	22.23
Mg (magnesium)	MgO	1.83
Na (sodium)	Na ₂ O	0.63
K (potassium)	K ₂ O	2.86
S (sulfur)	SO ₃	1.38
Ba (barium)	BaO	0.04
Cl (chloride)	Cl	0.46
Mn (manganese)	MnO	0.05
Sr (strontium)	SrO	0.03
Unknowns	Due to the presence of carbonates*	5.72
Total		100.02

* Sample effervesced in presence of dilute HCl, verifying the presence of carbonates.

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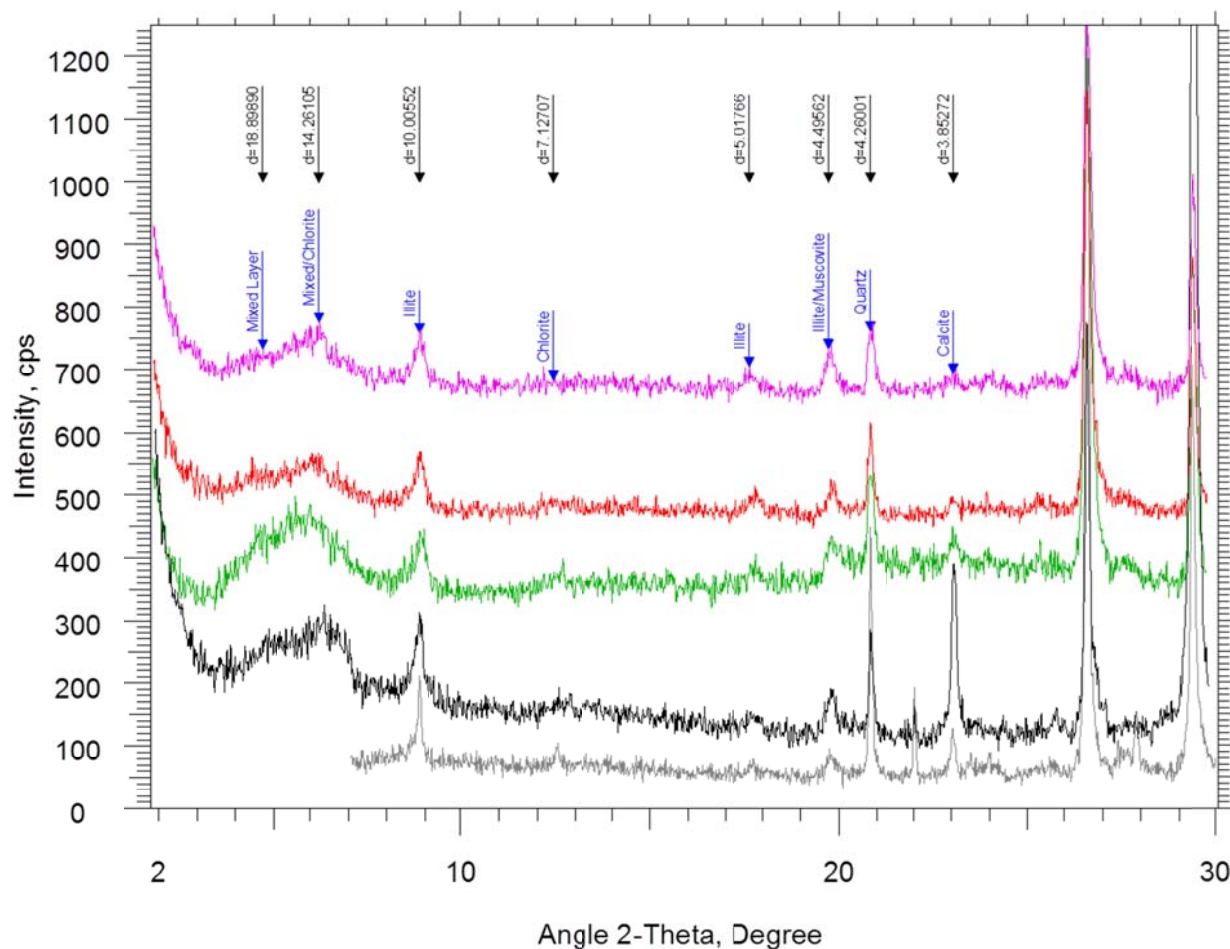
XRD MINERAL-PHASE DISTRIBUTION



Mineral Phase	Formula	Relative wt%
Calcite	CaCO_3	32.8
Quartz	SiO_2	39.8
Ferroan Dolomite	$\text{CaMg}_{0.8}\text{Fe}_{0.2}(\text{CO}_3)_2$	2.0
Dolomite	$\text{CaMg}(\text{CO}_3)_2$	2.6
Illite	$(\text{K}, \text{H}_3\text{O})(\text{Al}, \text{Mg}, \text{Fe})_2(\text{Si}, \text{Al})_4\text{O}_{10}[(\text{OH})_2, (\text{H}_2\text{O})]$	5.7
K-Feldspar	KAlSi_3O_8	5.8
Albite	$\text{NaAlSi}_3\text{O}_8$	6.8
Chlorite	$\text{Mg}_{2.96}\text{Fe}_{1.55}\text{Fe}_{0.14}\text{Al}_{1.28}(\text{Si}_{2.62}\text{Al}_{1.38}\text{O}_{10})(\text{OH})_8$	1.5
Muscovite	$\text{K}_{0.7}\text{Al}_2((\text{OH})_2\text{AlSi}_3\text{O}_{10})$	1.5
Pyrite	FeS_2	1.5

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XRD Clay Typing



Clays Identified

Illite
Mixed-layer clay
Chlorite

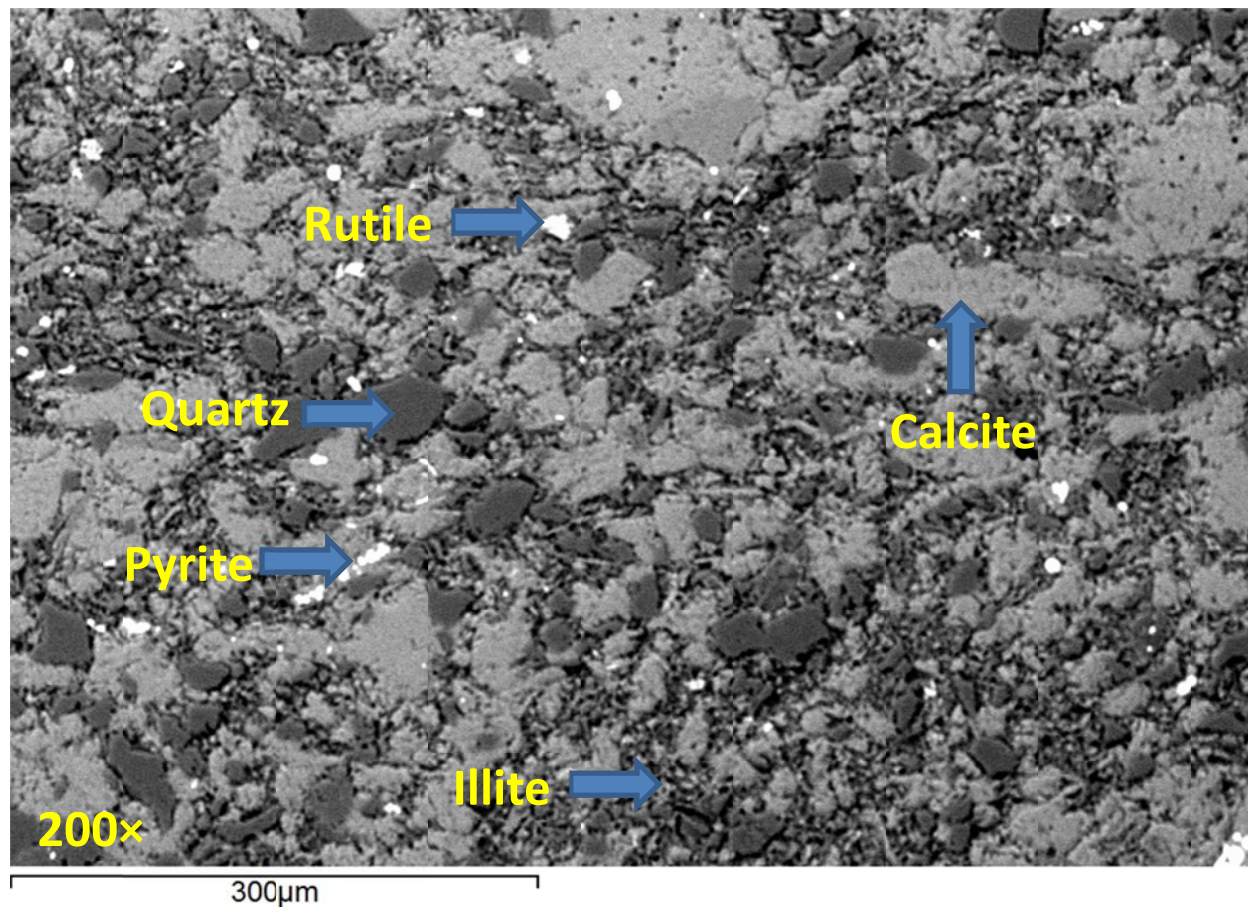
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SEM

Observed Minerals

Mineral Phase	Mineral Phase
Calcite	Pyrite
Quartz	Rutile
Dolomite	Halite
Illite	Albite
K-Feldspar	

High-Magnification BSE Image Annotated with Examples of Mineral Phases Identified



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SEM BSE Image and Corresponding Digital Composite Mineral Map Image Overlaid on BSE Image with Mineral-Phase 2-D Area Percentages

