PETROGRAPHIC ANALYSIS OF NANUSHUK FORMATION SAMPLES FROM THE BARROW, EAST SIMPSON, EAST TOPAGORUK, FISH CREEK, J. W. DALTON, KAOLAK, MEADE, OUMALIK, SOUTH MEADE, TOPAGORUK, TUNALIK, AND TUNGAK CREEK WELLS IN THE NATIONAL PETROLEUM RESERVE IN ALASKA (NPR-A)

Pore Scale Solutions Ltd and Santos Ltd.

Geologic Materials Center Report 471



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PETROGRAPHIC ANALYSIS OF NANUSHUK FORMATION SAMPLES FROM THE BARROW, EAST SIMPSON, EAST TOPAGORUK, FISH CREEK, J. W. DALTON, KAOLAK, MEADE, OUMALIK, SOUTH MEADE, TOPAGORUK, TUNALIK, AND TUNGAK CREEK WELLS IN THE NATIONAL PETROLEUM RESERVE IN ALASKA (NPR–A)

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INTRODUCTION

This report presents petrographic observations of Nanushuk Formation thin-section samples from legacy wells in the National Petroleum Reserve in Alaska (NPR–A). Using a historical dataset archived by the Alaska Geological Materials Center (GMC), the samples were examined to assess their mineralogy, grain textures, and diagenetic features, all of which are relevant to reservoir quality. The analyses provide insight into depositional fabric, framework grains, and ductile components, highlighting factors such as sorting, compaction, and lithic content. These findings enhance understanding of facies variability and diagenetic evolution within the Nanushuk Formation, thereby supporting regional stratigraphic correlations and reservoir characterization.

This work was conducted by a third-party agency. Results and interpretations have not undergone technical review and should not be cited as authoritative or peer-reviewed data. The dataset is released as a Geologic Materials Center Report under an open end-user license and is available on the DGGS website (http://doi.org/10.14509/31742).

DATA PRODUCTS

- **Appendix 1:** Thin section descriptions
- **Grain size data:** The file contains the raw data (a visual estimate of mean grain size by sample/depth) on the "data.input" worksheet and statistical summaries of these data on the "summary.data" worksheet
- Point count data: The file provides a list of samples used in this study on the "T1 Sample List" worksheet, raw petrographic point count data (e.g., mineralogy, cement types, porosity, etc.) on the "T2 Petrography Data" worksheet, and statistical summaries by well of the point count data on the "T3 Stats Table" worksheet.

ACKNOWLEDGMENTS

The Alaska Geologic Materials Center serves as the state's primary repository for geologic collections, connecting research, industry, and education communities to promote geologic understanding, highlight economic opportunities, and encourage public interest in Alaska's geologic history. This data release supports the GMC mission to archive, index, protect, and provide public access to geologic materials and related data, thereby advancing exploration and knowledge of Alaska's natural resources. DGGS staff, Josh Long and Simone Montayne, facilitated the publication of this report.



APPENDIX ONE – THIN-SECTION DESCRIPTIONS

Key to abbreviations on petrographical descriptions:

Pore types

- Ø_{PIM} primary interparticle macroporosity
- Ø_{SIM} secondary intraparticle macroporosity
- Ø_{SOM} secondary oversized macroporosity

Sandstone Classification

QS/QW Quartzitic sandstone/wackestone
 SAS/SAW Subarkosic sandstone/wackestone
 AS/AW Arkosic sandstone/wackestone
 SLS/SLW Sublithic sandstone/wackestone
 LS/LW Lithic sandstone/wackestone

Grain size categories

Abbreviation	Category	Min grain	Max Grain	Min grain	Max Grain
		size (mm)	size (mm)	size (Ø)	size (Ø)
clay			<0.0039		<8.0
vfsilt	Very fine silt	0.0039	0.0078	8.0	7.0
fsilt	Fine silt	0.0078	0.0156	7.0	6.0
msilt	Medium silt	0.0156	0.031	6.0	5.0
csilt	Coarse silt	0.031	0.0625	5.0	4.0
vfsL	Very fine sand, Lower	0.0625	0.088	4.0	3.5
vfsU	Very fine sand, Upper	0.088	0.125	3.5	3.0
fsL	Fine sand, Lower	0.125	0.177	3.0	2.5
fsU	Fine sand Upper	0.177	0.25	2.5	2.0
msL	Medium sand, Lower	0.25	0.354	2.0	1.5
msU	Medium sand Upper	0.354	0.5	1.5	1.0
csL	Coarse sand, Lower	0.5	0.707	1.0	0.5
csU	Coarse sand Upper	0.707	1	0.5	0.0
vcsL	Very coarse sand, Lower	1	1.414	0.0	-0.5
vcsU	Very coarse sand Upper	1.414	2	-0.5	-1.0
gran	Granule	2	4	-1.0	-2.0
pebble		4	32	-2.0	-5.0
cobble		32	256	-5.0	-8.0
boulder		256		-8.0	

Sorting Categories

category		Sorting (Ø)
vws	very well sorted	< 0.35
ws	well sorted	0.35-0.50
mws	moderately well sorted	0.50-0.71
ms	moderately sorted	0.71-1.00
ps	poorly sorted	1.00-2.00
vps	very poorly sorted	>2.00

page 1 of 2

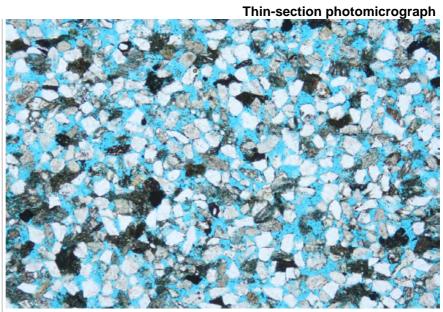


Grain Size: Classification: Well: Barrow 0.116mm (vfsU) LS 169.0ft DD Depth: Sorting: 0.234Ø (vws)

Thin-section scan



Field of view= 23mm

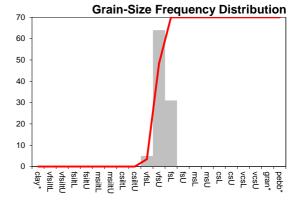


Key: White Grains: Quartz / Feldspar Turquoise Blue = Porosity

Field of View = 2.76mm

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has been very poorly stained, and consequently K-feldspar grains are difficult to differentiate from plagioclase grains (unless twinning is evident), and also demonstrates prominent finely particulate grinding material within the resin, locally obscuring the minor grain-coating and authigenic clays present. Apart from this, the quality of the thin-section is good.

This sample is an exceptionally highly lithic, very fine-grained (Upper), exceptionally well sorted sandstone, which displays an apparently homogeneous / massive depositional fabric. However, in the upper part of the thin-section, a relatively large (~5mm diameter), lenticular structure is apparent. This structure comprises ductile-rich (abundant ductile rock



fragments) sand, surrounded by a thick halo of exceptionally clean sand, which is totally void of any ductile material. This structure is most likely of biogenic origin.

Compaction is weak to moderate, with most rigid grains demonstrating tangential, to more rarely partially elongated, grain contacts. Ductile grains, however, which are relatively abundant in this sample, show minor to moderate plastic deformation (the current measured intergranular volume [IGV] is 21%, down from an estimated original IGV of approximately 40%).

FRAMEWORK GRAINS (71.5%)

- Monocrystalline quartz (24.5%): sub-angular to sub-rounded in shape.
- Polycrystalline quartz (6.5%): most likely of metamorphic origin, and forms a continuum into quartz/mica schist clasts (some polycrystalline quartz grains contain minor mica), as well as into chert (most of the polycrystalline quartz grains are very finely crystalline).
- Chert (4.0%): clean to slightly dirty (clayey) grains, which rarely show signs of corrosion.
- Feldspar (10.5%): the unstained feldspar grains are generally more angular in shape compared to the quartz grains. Many show partial sericitisation (which is more commonly associated with plagioclase in the Nanushuk), and are typically untwinned, although plagioclase twinning is locally observed. A minor component of the feldspar grains demonstrates twinning associated with K-feldspar (some of these grains demonstrate pronounced corrosion).
- Extrabasinal rigid rock fragments (24.5%): form a major component of this sandstone. They principally comprise metamorphic clasts, mainly of schist, which range from quartz-dominated schist, through to micadominated schist (the most highly micaceous of which, that contain little or any quartz, have been point-counted as ductile rock fragments, as they are often somewhat altered [clayey] and demonstrate plastic deformation). However, minor clasts of more ambiguous quartz / plagioclase +/- chlorite, counted as plutonic, have also been identified, along with minor reworked (extrabasinal) sandstone grains (at least second cycle), green (chloritic?)

Sample Descriptions Barrow 169.0 TSD Full.docx



page 2 of 2

Well: Barrow Depth: 169.0ft DD

grains and monocrystalline dolomite grains (which often retain a rhombic shape, although some are more rounded in appearance).

• Heavy minerals (1.5%): small grains of rutile (highly corroded), undifferentiated opaques and zircon.

DUCTILE COMPONENTS (22.0%)

- Ductile rock fragments (18.0%): relatively abundant, and evenly scattered throughout the sample, except within the lenticular biogenic structure at the top of the thin-section, where they are preferentially concentrated / abundant within its core. These grains demonstrate minor to moderate plastic deformation, and comprise a sub-equal mixture of highly micaceous schist clasts and intrabasinal mudclasts (some of which are organic-rich). The micas within the schist clasts are often highly degraded (alteration appears derived), and comprise a varied mixture of mica types.
- **Mica** (1.0%): although mica is abundant in this sample, it tends to occur mainly within extrabasinal, metamorphic clasts, and rarely as individual plates (these comprise altered / undifferentiated mica, with scarce muscovite).
- Detrital clay (3.0%): brown, discontinuous, thin clay coats scattered on some grain surfaces.
- Organic matter (0%):

AUTHIGENIC COMPONENTS (6.5%)

This sandstone has been lightly overprinted by authigenic phases, mainly siderite (5.0%), and more rarely undifferentiated authigenic clay (1.5%), and trace kaolinite. Quartz overgrowths have not been observed, even on clean quartz grain surfaces. However, scarce authigenic dolomite overgrowths / projections have locally been observed on the surfaces of host detrital dolomite grains.

The siderite forms microcrystalline (generally <5µm diameter), subhedral crystals, which preferentially replace mudclasts and more rarely mica plates. However, some of the siderite crystals are also seen coating grain surfaces, often overprinting grain-coating detrital clay. The undifferentiated authigenic clay is also preferentially replacive of grain-coating detrital clay, and is so finely crystalline, that it is almost impossible to observe, and is difficult to differentiate from the host detrital clay. The kaolinite is extremely finely crystalline (individual plates are ≤6µm in diameter), forming loosely packed, small booklets, rather than verms, which replace feldspar grains and locally occlude individual / single primary pores.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 15.9\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 3.6\%$ $\varnothing_{MICRO} = na$

This sample contains abundant, well interconnected primary interparticle macropores, which have only been patchily reduced in size / connectivity, by the plastic deformation of ductile grains, which are scattered throughout the entire sample (facilitating compaction). Pore walls are often clean / smooth, but alteration of minor grain-coating detrital clay (by undifferentiated authigenic clay and microcrystalline siderite) locally roughens the pore walls. Some pores appear oversized, and have been point-counted as secondary oversized macropores. Whilst one cannot rule out the possibility that some grains have been plucked out during thin-section preparation (this sample is not that well consolidated), the fact that a few contain minor grain remnants (?feldspar), suggests that they are genuine secondary pores, produced by corrosion.

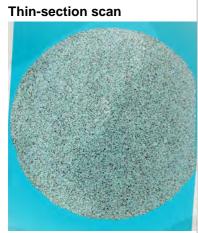
Unfortunately no routine core analysis data is available for this sample. However, one would expect a good / very good reservoir quality.

Barrow 169.0 TSD Full.docx Sample Descriptions

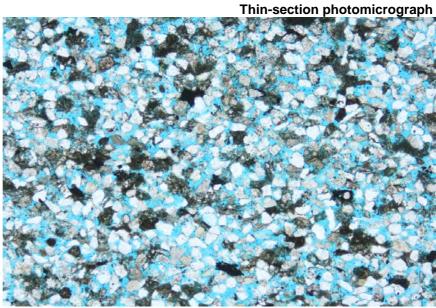
page 1 of 1



Well: Barrow Grain Size: 0.090mm (vfsU) Classification: LS Depth: 179.0ft DD Sorting: 0.254Ø (vws)



Field of view= 24mm



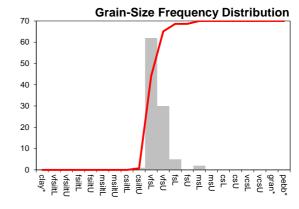
Key:White Grains: Quartz / Plagioclase Turquoise Blue = Porosity

Field of View = 2.76mm
Green / Brown Grains: Ductile Grains + Lithic Grains

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has been poorly stained, but is generally of good quality, although prominent finely particulate grinding material is present within the resin, and locally obscures the minor grain-coating and authigenic clay.

Note that the darker areas of the thin-section in the scanned image above are due to poor cover slipping (variations in the volume of immersion oil used), and not due to changes in mineralogy.

This sample is extremely similar to the previous sample at 169.0ft, except that it is slightly finer grained, and consequently has more ductile material (30.0% in this sample, and 22.0% in sample 169.0ft). Therefore, like sample 169.0ft, this sample is a very fine-grained (Upper), exceptionally well



sorted, highly lithic sandstone, which displays an apparently homogeneous / massive depositional fabric. Compaction is again weak to moderate, and diagenetic overprinting is minor.

RESERVOIR POTENTIAL

Porosity Data: $\emptyset_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\emptyset_{PRIM} = 15.8\%$ $\emptyset_{SIM} = 0\%$ $\emptyset_{SOM} = 1.2\%$ $\emptyset_{MICRO} = na$

This sample contains abundant, well interconnected primary interparticle macropores, which have only been patchily reduced in size / connectivity, by plastic deformation of ductile grains, which are scattered throughout the entire sample (facilitating compaction). Minor secondary oversized macropores are evident where some grains have been near-completely to completely removed by corrosion.

Unfortunately no routine core analysis data is available for this sample. However, one would expect a good / very good reservoir quality.

Barrow_179.0 TSD_Review.docx
Sample Descriptions

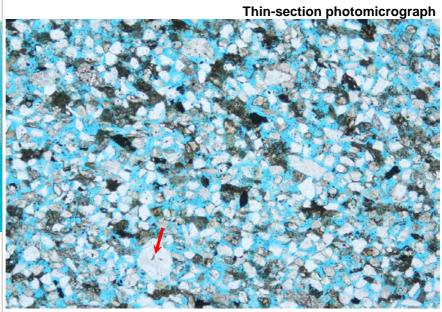
page 1 of 2



Well: Barrow Grain Size: 0.089mm (vfsU) Classification: LS Depth: 181.0ft DD Sorting: 0.364Ø (ws)



Field of view= 22mm



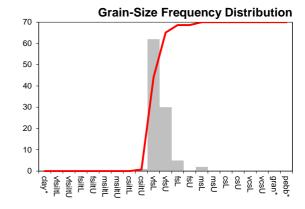
Key:White Grains: Quartz / Plagioclase Turquoise Blue = Porosity

Field of View = 2.76mm

Green / Brown Grains: Ductile Grains + Lithic Grains

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has been very poorly stained, and consequently K-feldspar grains are difficult to differentiate from plagioclase grains (unless twinning is evident), and also demonstrates prominent finely particulate grinding material within the resin, locally obscuring the minor grain-coating and authigenic clays present. Apart from this, the quality of the thin-section is good.

This sample is extremely similar to the previous sample (181.0ft), and as such, is again slightly finer grained and more ductile-rich than sample 169.0ft. As with samples 169.0ft and 181.0ft, this sample also represents a highly lithic, very finegrained (Upper), well sorted sandstone, which displays an apparently homogeneous / massive depositional fabric. A few oversized quartz grains are locally apparent (see red arrow on



the thin-section photomicrograph above), resulting in the subtly poorer sorting of this sample compared to samples 169.0ft and 181.0ft.

Compaction is weak to moderate, with most rigid grain demonstrating tangential, to more rarely partially elongated grain contacts.

FRAMEWORK GRAINS (72.0%)

- Monocrystalline quartz (31.0%):
- Polycrystalline quartz (8.0%):
- Chert (4.0%):
- Feldspar (11.5%):
- Extrabasinal Rigid rock fragments (16.0%): the carbonate grains almost solely comprise single crystals of dolomite, many of which still retain their originally rhombic shape.
- Heavy minerals (1.5%): well-rounded zircon grains, and sub-rounded grains of titanite, garnet and undifferentiated opaques.

DUCTILE COMPONENTS (26.0%)

- **Ductile rock fragments** (20.0%): dominated by brown (?illitic) intrabasinal mudclasts, which show moderate, to more rarely pronounced plastic deformation (locally tightening grain fabrics). Subordinate extrabasinal schist clasts, which are often highly degraded, have experienced less deformation (they are slightly more rigid compared to the mudclasts). Rare grain of possible glauconite observed.
- Mica (1.0%):



page 2 of 2

Well: Barrow Depth: 181.0ft DD

• **Detrital clay** (5.0%): grain-coating detrital clay is slightly more abundant in this sample compared to the other Barrow samples. Although locally relatively thick, these grain coats tend to be highly discontinuous around their host grains.

• Organic matter (0%):

AUTHIGENIC COMPONENTS (2.0%)

This sandstone has been very poorly overprinted by authigenic phases, with only very minor volumes of microcrystalline siderite (1.0%; mainly replacive of mudclasts, and more rarely lining pore walls), undifferentiated authigenic clay (0.5%), and kaolinite (0.5%; very finely crystalline, loosely packed booklets sitting in rare primary pore). Quartz overgrowths have not been observed, even on clean quartz grain surfaces.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 16.6\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 2.4\%$ $\varnothing_{MICRO} = na$

This sample has a well preserved primary pore network, because it is well sorted, has only been weakly to moderately compacted, and only very poorly overprinted by authigenic cements. Also, although relatively ductile-rich, most of the ductile material is bound within grains (ductile rock fragments), rather than as pore-filling matrix clay. These ductile grains do not appear to have experienced significant plastic deformation, suggesting that this sandstone was never at any point in its history deeply buried. Primary interparticle macropores are therefore abundant and well interconnected, as well as being locally enhanced by minor secondary oversized macropores.

Unfortunately no routine core analysis data is available for this sample. However, one would expect a good / very good reservoir quality.

Barrow 181.0 TSD Brief.docx Sample Descriptions

page 1 of 1

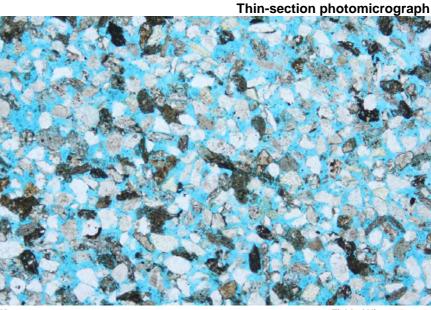


Well: Barrow Grain Size: 0.123mm (vfsU) Classification: LS

Depth: 184.0ft DD Sorting: 0.299Ø (vws)



Field of view= 22mm



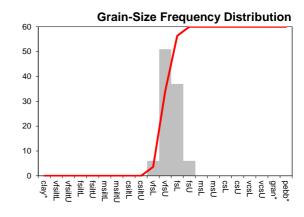
Key:White Grains: Quartz / Plagioclase
Turquoise Blue = Porosity

Field of View = 2.76mm

Green / Brown Grains: Ductile Grains + Lithic Grains

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has been very poorly stained for K-feldspar, making it impossible to differentiate K-feldspar grains from plagioclase grains during modal analysis. Overall the thin-section is of generally of good quality, although prominent finely particulate grinding material is present within the resin, and locally obscures the minor grain-coating and authigenic clay.

This sample is extremely similar to the adjacent sample at 185.0ft, and as such, is also represented in thin-section by a very fine-grained (Upper), exceptionally well sorted, highly lithic sandstone, which displays an apparently homogeneous / massive depositional fabric. Compaction is again relatively weak, with a high intergranular volume preserved, and diagenetic overprinting is minor.



RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 22.0\%$ $\varnothing_{SIM} = 0.4\%$ $\varnothing_{SOM} = 3.0\%$ $\varnothing_{MICRO} = na$

This clean, well sorted, weakly compacted and poorly cement sandstone contains abundant, very well interconnected primary macropores, locally supported by minor secondary oversized macropores (produced by the near-complete to complete dissolution of feldspar grains, and also possibly chert), and is likely to have a very good reservoir quality.

Barrow_184.0 TSD_Review.docx
Sample Descriptions

page 1 of 2

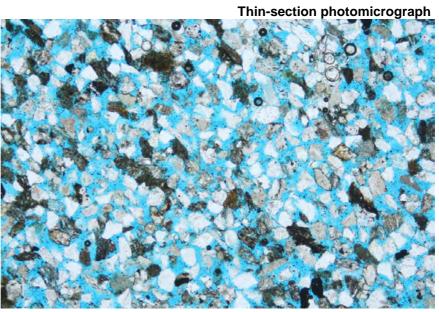


Well: Barrow Grain Size: 0.121mm (vfsU) Classification: LS

Depth: 185.0ft DD Sorting: 0.268Ø (vws)





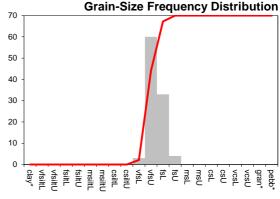


Key:White Grains: Quartz / Feldspar
Turquoise Blue = Porosity

Field of View = 2.76mm
Green / Brown Grains: Ductile Grains + Lithic Grains

The thin-section is a legacy thin-section (provided by OSA / Santos). At first glance the thin-section appears not to have been have been stained. However, on closer inspection poor K-feldspar staining is observed (some K-feldspar grains contains only a few small dots of stain). Prominent finely particulate grinding material is present within the resin, and locally obscures the minor grain-coating and authigenic clay. Also, the rounded, brighter areas / patches of the thin-section represent areas where resin impregnation is poor (no resin is patchily absent).

This sample is a very fine-grained (Upper), very well sorted, relatively clean, highly lithic sandstone, which demonstrates a homogeneous, massive depositional fabric. Compaction is relatively weak, and consequently a high intergranular volume



is preserved (most grain contacts are tangential), although some minor, to more rarely moderate, plastic deformation of ductile rock fragments is evident.

This sample is very similar to the preceding samples, particularly sample 184.0ft. As with sample 184.0ft, this sample is slightly coarser grained than most of the other samples from this well, and hence has a lower volume of ductile rock fragments, and consequently is slightly less compacted, with a higher volume of primary macroporosity preserved.

FRAMEWORK GRAINS (81.0%)

- Monocrystalline quartz (28.0%): sub-angular to sub-rounded in shape.
- **Polycrystalline quartz** (9.0%): these grains tend to have sub-equigranular to equigranular textures, with welded / sutured crystallite contacts, suggesting a metamorphic derivation. Crystal size is very fine, and some grains grade into chert. There is also a gradation into / overlap with grains of quartz schist (metamorphic extrabasinal rigid rock fragments).
- Chert (6.0%): a few grains demonstrate spongy textures, and some contain minor, small, secondary intraparticle pores.
- Feldspar (11.5%): feldspar grains are generally easily differentiated from monocrystalline quartz grains, as they tend to demonstrate minor, to more rarely pronounced, weathering (derived alteration, often by sericite). The K-feldspar grains have been very poorly stained (some contain only a few dots of staining), and consequently it has not been possible to differentiate plagioclase from K-feldspar during modal analysis. However, K-feldspar grains appear to be a very minor component of this sample on closer examination. Both plagioclase and K-feldspar grains locally show pronounced corrosion.
- Extrabasinal rigid rock fragments (26.5%): overwhelmingly dominated by metamorphic clasts, which
 predominantly comprise schist (quartz-dominated, although some are quite highly micaceous), although welded,
 very finely crystalline, hornfels like grains have also been identified. The minor carbonate grains comprise a
 mixture of monocrystalline and polycrystalline dolomite / dolostone, although a few of the carbonate grains

Barrow 185.0 TSD Full.docx Sample Descriptions



page 2 of 2

Well: Barrow Depth: 185.0ft DD

comprise reddened (?oxidized) Fe-rich carbonate (?siderite). Rare, isotropic volcanic glass grains have also been observed.

• Heavy minerals (trace): zircon, tourmaline and undifferentiated opaque grains.

DUCTILE COMPONENTS (15.5%)

- **Ductile rock fragments** (14.5%): although prominent, ductile rock fragments are not overly abundant in this sample. They mainly comprise extrabasinal, highly micaceous schist fragments, which often show notable alteration (alteration is probably mainly derived), although many of the micaceous, foliated clasts are relatively fresh. These micaceous clasts tend to demonstrate only minor plastic deformation (although the more altered / clayey fragments are more highly deformed / squashed). Minor, small intrabasinal mudclasts (and more rarely siltclasts), complete the ductile rock fragment suite.
- Mica (trace): individual mica flakes are extremely rare in this sample (mica is prominent, but tends to be held within
 rigid and ductile extrabasinal rock fragments).
- **Detrital clay** (1.0%): rare, discontinuous, thin clayey grain coats.
- Organic matter (0%):

AUTHIGENIC COMPONENTS (3.5%)

This sandstone has been very lightly overprinted by minor microcrystalline, ductile-replacive siderite (2.5%), and minor undifferentiated authigenic clay (1.0%). The latter forms an exceptionally finely crystalline replacement of detrital clay (individual plates are extremely difficult to resolve). The microcrystalline siderite principally replaces mudclasts, and more rarely mica plates, although is also locally seen replacing carbonate grains.

Trace authigenic dolomite has been observed as small rhombic projections off host detrital dolomite grains.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 22.2\%$ $\varnothing_{SIM} = 0.4\%$ $\varnothing_{SOM} = 2.3\%$ $\varnothing_{MICRO} = na$

This clean, relatively loosely packed / compacted, very well sorted sandstone contains abundant, very well interconnected primary macropores, which have only been locally / patchily reduced in size and connectivity where ductile rock fragments have plastically deformed (deformation is typically minor to moderate, with original grain shapes being only somewhat changed). The primary pore network is locally enhanced by the typically advanced (as opposed to partial) dissolution of rigid grains (some were definitely feldspar grains, as minor relic grain material is often present), generating minor secondary oversized macropores. Prominent microporosity is likely to be associated with the ductile rock fragments.

Unfortunately, no routine core analysis data is available for this sample. However, given the excellent preservation of the primary pore network, one would expect a very good reservoir quality.

Barrow 185.0 TSD Full.docx Sample Descriptions

page 1 of 2

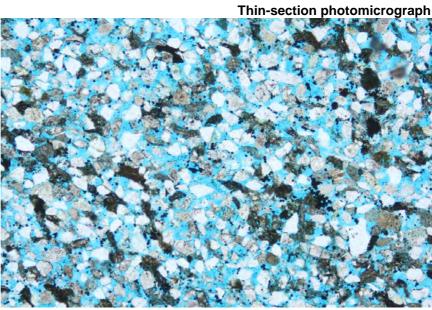


Well: Barrow Grain Size: 0.104mm (vfsU) Classification: LS

Depth: 194.0ft DD Sorting: 0.294Ø (ws)



Field of view= 22.5mm

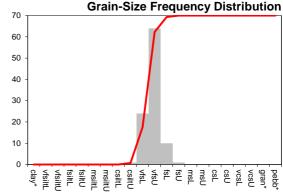


Key:White Grains: Quartz / Plagioclase
Black Microcrystalline: Pyrite

Field of View = 2.76mm
Green / Brown Grains: Ductile Grains + Lithic Grains
Turquoise Blue = Porosity

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has been very poorly stained, and consequently K-feldspar grains are difficult to differentiate from plagioclase grains (unless twinning is evident), and also demonstrates prominent finely particulate grinding material within the resin, locally obscuring the minor grain-coating and authigenic clays present. Apart from this, the quality of the thin-section is good.

This sample is a very well sorted, relatively ductile-rich (abundant ductile grains), highly lithic, very fine-grained, massive sandstone, similar to the shallower samples from this well 169.0-181.0ft). As with the shallower samples, this sample has experienced only weak to moderately compaction, and retains a relatively high intergranular volume



(22%). Again cementation is light, although this sample stands apart from all the other Barrow samples, as it contains prominent, albeit still relatively minor, pyrite (see below).

FRAMEWORK GRAINS (69.0%)

- Monocrystalline quartz (26.0%):
- Polycrystalline quartz (6.0%):
- Chert (3.0%):
- Feldspar (10.0%):
- Extrabasinal Rigid rock fragments (23.5%): the rigid rock fragment suite is characteristic for this well, and the Nanushuk in general, being dominated by grain of metamorphic material (mainly schist), with minor plutonic grains (quartz / feldspar / chlorite crystalline composites with massive fabrics), dolomitic carbonate grains, altered / undifferentiated grains and reworked (extrabasinal [at least 2nd cycle]) sandstone. However, minor volumes of very unusual green grains have been observed, which do not appear chloritic or glauconitic, and represent altered material of some form.
- Heavy minerals (0.5%):

DUCTILE COMPONENTS (24.5%)

- **Ductile rock fragments** (19.5%): the scarce altered ductile rock fragments are elongated, and comprise unusual greenish-brown clay, and possibly represent thick stacks of micas, which have been so highly altered, that their original foliated fabric has been destroyed.
- Mica (3.0%):
- **Detrital clay** (2.0%):
- Organic matter (0%):

Barrow 194.0 TSD Brief.docx Sample Descriptions



page 2 of 2

Well: Barrow Depth: 194.0ft DD

AUTHIGENIC COMPONENTS (6.5%)

This sample has been overprinted by prominent microcrystalline pyrite (5.0%), and minor undifferentiated authigenic clay (1.5%). It is interesting to note that siderite is absent from this sample, whereas all the other Barrow samples contain minor siderite. The other Barrow samples also tend to lack pyrite. This suggests a significant change in early diagenesis between this sample and all the shallower Barrow samples.

The pyrite forms angular framboids and pyritohedra that are typically 10-25µm in diameter, that principally sit at pore margins (generally singular / isolated, but locally in small clusters), and more rarely replace ductile material (mainly ductile rock fragments).

RESERVOIR POTENTIAL

Porosity Data: \emptyset_{He} = naPermeability Data: K_h = naMacroporosity Data: \emptyset_{PRIM} = 15.8% \emptyset_{SIM} = 0.8% \emptyset_{SOM} = 2.4% \emptyset_{MICRO} = na

This sample has a relatively well preserved primary pore network, because it is well sorted, has only been weakly to moderately compacted, and only poorly overprinted by authigenic cements (pyrite slightly reduces pore volume, but has little, if any, impact on permeability). Although relatively ductile-rich, most of the ductile material is bound within grains (ductile rock fragments), rather as pore-filling matrix clay. These ductile grains do not appear to have experienced significant plastic deformation, suggesting that this sandstone was never at any point in its history deeply buried. Primary interparticle macropores are therefore abundant and well interconnected, as well as being locally enhanced by minor secondary oversized macropores (mainly formed via the near-complete to complete corrosion of feldspar grains).

Unfortunately no routine core analysis data is available for this sample. However, one would expect a good / very good reservoir quality.

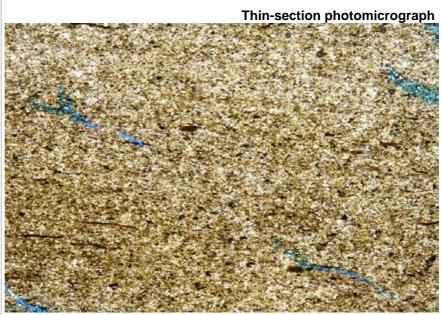
Barrow 194.0 TSD Brief.docx Sample Descriptions

page 1 of 1



Well:East SimpsonGrain Size:naClassification:naDepth:2380.50ft DDSorting:na

Thin-section scan



Field of view= 23mm

Key:White Grains: Quartz / Plagioclase
Brown Matrix: Detrital Clay

Field of View = 2.76mm
Black: Pyrite / Organic Matter

The thin-section is a legacy thin-section (provided by OSA / Santos). Two thin-sections were provided for this sample / depth, with the better quality section chosen for description. The thin-sections were not stained for carbonate or K-feldspar, but the quality is overall acceptable.

This sample is a mudstone, and therefore has not been included for either textural or modal analysis.

The mudstone is very finely laminated, and comprises a central, thick horizon of lighter brown, silty mudstone (pictured in the thin-section photomicrograph), with subordinate fine silt grains, floating within a dominant matrix of brown detrital matrix clay. This horizon is bounded above and below by dark brown, relatively silt-free mudstone (very fine silt grains are minor in these mudstone horizons). Dotted throughout the siltier and silt-free mudstone horizons are elongated, lenticular burrow structures, which are filled with markedly clean, and sometimes, but not always, slightly coarser siltstone (i.e. the silt grains within the burrow-fill structures are sometimes, but not always, coarser grained than the silt grains in the main body of the mudstone). Long, thin strands and small irregular-shaped particles of organic material are prominent throughout both the more mud-prone (silt-free) and siltier horizons.

The irregular shaped turquoise / greenish structures that criss-cross the sample are artefact, and represent thin cracks (probably produced by clay shrinkage), where the blue-dyed resin has impregnated slightly into the mudstone matrix, but no further.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = na$ $\varnothing_{SIM} = \%$ $\varnothing_{SOM} = na$ $\varnothing_{MICRO} = na$

No routine core analysis data is available for this sample, but given that it is a mudstone, it is expected to have negligible reservoir quality (non-reservoir).

E Simpson_2380.5 TSD_Review.docx

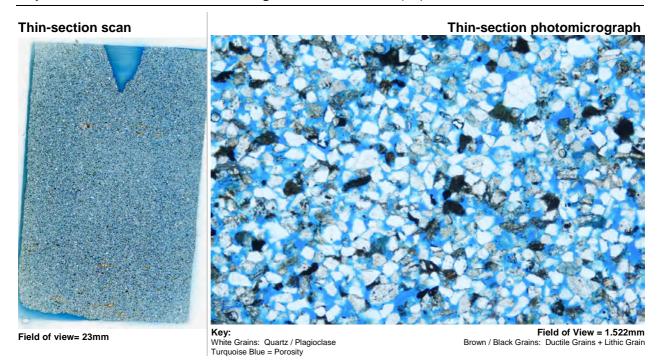
Sample Descriptions

page 1 of 2



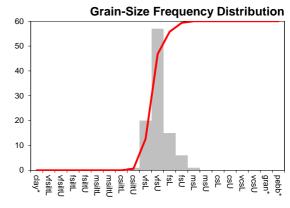
Well: East Simpson Grain Size: 0.114mm (vfsU) Classification: LS

Depth: 2389.0ft DD Sorting: 0.412Ø (ws)



The thin-section is a legacy thin-section (provided by OSA / Santos). Two thin-sections were provided for this sample / depth, with the better quality section chosen for description. The thin-sections were not stained for carbonate or K-feldspar, but the quality is relatively good (the sections are slightly on the thick-side, with uneven finish / thickness, presenting minor issues with "fuzzy" grain edges and focussing, but are overall acceptable / workable).

This sample is a highly lithic, very fine-grained (Upper), well sorted, relatively clean, poorly cemented sandstone. At first glance the depositional fabric appears massive. However, on closer inspection, a very subtle churned / disrupted fabric is apparent. A few biogenic structures have been locally observed, suggesting that the disruption maybe due to bioturbation. A couple of structures represent thin (single



sand grain thickness), long, curved lines of quartz grains (potentially accreted out from the gut of some form of worm). A few other structures comprise small, mud-prone burrow-fills (sub-mm scale).

Compaction is relatively weak to moderate, with most rigid grain demonstrating tangential, to more rarely partially elongated grain contacts. Ductile grains, however, show minor to moderate plastic deformation, and as detailed below, chert grains locally demonstrate minor chemical compaction (partially stylolitised contacts with other rigid grains).

FRAMEWORK GRAINS (82.0%)

- Monocrystalline quartz (30.5%): grains are principally sub-angular in shape.
- **Polycrystalline quartz** (10.0%): finely to very finely crystalline, typically sub-equigranular to equigranular (?quartzite). Foliated metamorphic fabrics are locally observed.
- Chert (6.0%): the prominent chert grains range from clean through to relatively dirty / clayey, and show variable
 corrosion (the cleaner chert grains often demonstrate spongy textures, with prominent secondary microporosity).
 A few chert grains demonstrate concave-convex to interpenetrant contacts with adjacent quartz / lithic grains, with
 minor stylolitisation (chemical compaction) evident.
- **Feldspar** (12.5%): K-feldspar grains have not been stained in this sample. However, plagioclase twinning is commonly observed, and many of the untwinned grains appear more akin to partially sericitised plagioclase, rather than K-feldspar. Minor corrosion of feldspar grains is observed.
- Extrabasinal rigid rock fragments (22.5%): form a major component of this sandstone. Typical of the Nanushuk, they principally comprise metamorphic clasts, mainly of schist, which range from quartz-dominated schist, through to mica-dominated schist (the most highly micaceous of which, that contain little or any quartz, have been point-counted as ductile rock fragments). Also included in the rigid rock fragment assemblage are minor volumes of the following (in order of decreasing relative abundance):

E Simpson 2389.0 TSD Full.docx
Sample Descriptions



page 2 of 2

Well: East Simpson Depth: 2389.0ft DD

- finely to coarsely crystalline composites of quartz / feldspar +/- chlorite, counted as plutonic (these are most likely of metamorphic derivation, but an igneous origin cannot be ruled out),
- monocrystalline (and rare polycrystalline) dolomite grains (which often retain a rhombic shape),
- altered and / or exceptionally finely crystalline (almost cryptocrystalline) clasts, of undifferentiated origin or composition,
- reworked (extrabasinal) sandstone clasts (at least second cycle) the quartz and lithic material in these clasts are granular / particulate, rather than crystalline (fabrics are tightly compacted), and
- green, altered grains (possibly chloritised), of unknown origin.
- Heavy minerals (0.5%): zircon, opaques and garnet have been observed.

DUCTILE COMPONENTS (17.0%)

- **Ductile rock fragments** (12.5%): brown, intrabasinal mudclasts are minor, and show moderate degrees of plastic deformation. Some of the mudclasts are relatively large (up to ~1mm in diameter). Most of the ductile grains in this sample are of extrabasinal origin, and represented by typically quite degraded / altered mica-schist fragments, which demonstrate less plastic deformation compared to the intrabasinal mudclasts.
- **Mica** (2.5%): most of the mica in this sample is bound within lithic grains (mainly metamorphic clasts). However, some thick individual plates of mica are dotted throughout the sample, and although most is highly altered, and of ambiguous composition, fresh plates of muscovite, biotite and chlorite have been observed.
- **Detrital clay** (2.0%): very poorly developed (thin and discontinuous) grain-coats (brown and possibly illitic).
- Organic matter (trace): rare, small grain / particle of organic matter.

AUTHIGENIC COMPONENTS (1.0%)

Authigenic cements are scarce in this sample, with only very minor volumes of pore-filling kaolinite (0.5%) and quartz overgrowths (0.5%) encountered, and exceptionally scarce (few crystals only) of microcrystalline, framboidal pyrite (note that pyrite is commonly seen associated with / replacive of chert grains, but this pyrite is probably derived [i.e. was not formed in-situ]). The kaolinite is typically very finely crystalline, with plates (~3-7µm in diameter) being stacked into small booklets (no verms have been observed) that are very loosely packed. The booklets locally replace feldspar grains and occlude a few, scattered / patchy primary pores. The quartz overgrowths are extremely small (incipient to rarely small outgrowths). Due to the scarcity of authigenic phases, no paragenetic relationships have been observed.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 21.2\%$ $\varnothing_{SIM} = 0.8\%$ $\varnothing_{SOM} = 0.8\%$ $\varnothing_{MICRO} = na$

This sample has a very well preserved primary pore network, as it is relatively clean (most clayey material is bound within discrete grains [ductile rock fragments]), well sorted, poorly cemented and weakly compacted. Primary interparticle macropores are therefore abundant, and well interconnected via clean, open, wide pore throats. Secondary macroporosity is very minor, and produced by the partial, to more rarely advanced / complete dissolution of feldspar grains, and has little impact on enhancing porosity or permeability. Relatively low volumes of microporosity are likely to be associated with clay-rich / clayey phases (mainly ductile grains, with only minor detrital clay and very minor kaolinite), and to a lesser extent with altered lithic grains and spongy, partially corroded chert grains.

No routine core analysis data is available for this sample, but given that it is relatively clean (most clayey ductile material is bound within ductile grains, rather than as pore-filling / -lining clay), well sorted, weakly compacted, with scarce authigenic cementation, and hence a very well preserved primary pore network, a very good reservoir quality is expected.

E Simpson 2389.0 TSD Full.docx Sample Descriptions

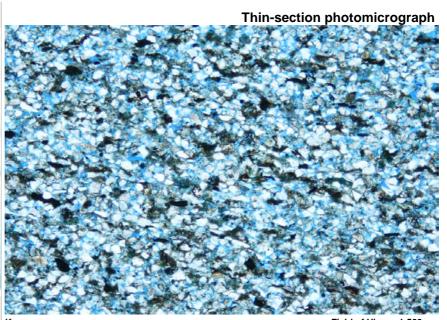
page 1 of 2



Well: East Simpson Grain Size: 0.069mm (vfsL) Classification: LS Depth: 2399.5ft DD Sorting: 0.311Ø (vws)

Thin-section scan

Field of view= 23mm



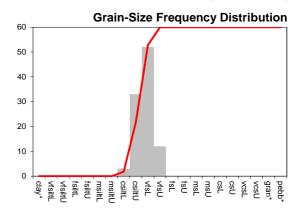
White Grains: Quartz / Plagioclase
Brown Matrix: Detrital Clay +/- Deformed Ductile Grains

Field of View = 1.522mm

Green / Brown Grains: Ductile Grains + Lithic Grains
Turquoise Blue = Porosity

The thin-section is a legacy thin-section (provided by OSA / Santos). Two thin-sections were provided for this sample / depth, with the better quality section chosen for description. The thin-sections were not stained for carbonate or K-feldspar, but the quality is relatively good (the sections are slightly on the thick-side, with uneven finish / thickness, presenting minor issues with "fuzzy" grain edges and focussing, but are overall acceptable / workable).

This sample is a very well sorted, very fine-grained (Lower), ductile-rich sandstone, which displays a very finely laminated fabric (lamination is defined by subtle through to notably strong changes in ductile abundance). The lamination is locally very subtly churned / deformed, on a sub-mm scale, with rare, extremely small, roundish structures evident. These appear more biogenic in origin, although one cannot rule out soft sediment deformation.



This sample is finer grained, and thus more ductile-rich and less lithic, than the preceding sandstone sample from this well (2389.0ft). Because of the higher ductile content, this sample demonstrates a notably tighter grain fabric / packing (ductile-facilitated compaction) than sample 2389.0ft.

FRAMEWORK GRAINS (57.5%)

- Monocrystalline quartz (23.5%):
- Polycrystalline quartz (1.5%):
- Chert (2.0%): chert grains are notably less abundant in this finer grained sample compared to sample 2389.0ft.
- Feldspar (11.0%):
- Extrabasinal Rigid rock fragments (19.5%): the rigid rock fragment assemblage is similar to that of sample 2389.0ft, although most rock fragment types are less abundant here. Dolomite grains, however, are the exception and are almost four times more abundant in this sample (7.5%) than they are in sample 2389.0ft (2.0%). The dolomite grains are extremely small, and more reworked / rounded (less rhombic shaped) in this sample than those seen in sample 2389.0ft (where they are more rhombic in shape).
- Heavy minerals (trace):

DUCTILE COMPONENTS (42.0%)

 Ductile rock fragments (28.0%): ductile rock fragments are abundant in this sample, and dominate the ductile suite. They tend to be preferentially concentrated within thin, ductile-rich laminae, although are also common within the intervening cleaner laminae. They mainly comprise a sub-equal mixture of brown intrabasinal mudclasts



page 2 of 2

Well: East Simpson Depth: 2399.5ft DD

and micaceous (often altered) extrabasinal clasts (i.e. mica-schist). A minor volume of green, possibly chloritic, spongy ductile grains have also been observed.

• Mica (5.0%):

- **Detrital clay** (7.0%): pore-filling matrix clay is locally present in some of the more ductile-rich laminae, although some of the detrital clay point-counted is undifferentiated matrix (possibly represents plastically deformed mudclasts or pseudo-matrix, rather than actual pore-filling detrital clay).
- Organic matter (2.0%): small, irregular shaped particles. Long(er) strands of organic material are rare.

AUTHIGENIC COMPONENTS (0.5%)

This sample has barely been diagenetically modified, with only scarce microcrystalline, ductile-replacive pyrite framboids (0.5%), and even rarer incipient quartz overgrowths (trace) having been identified.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 8.2\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0.5\%$ $\varnothing_{MICRO} = na$

Primary interparticle macropores are absent to very minor in the ductile-rich lamina, which tend to show pronounced plastic deformation of ductile material. Within the cleaner laminae, ductile material is still relatively common, facilitating variable, but overall moderate, compaction. Here primary macropores, whilst relatively abundant, are very small, and more tortuously interconnected via narrow pore throats. The cleaner laminae are extremely thin (<1mm thick, and often <0.5mm thick), and at some point along their length encounter plastically deformed ductile rock fragments, "closing-down" pore throats and reducing primary pore volume. Therefore, this sandstone is likely to have a relatively poor to moderate reservoir potential.

E Simpson 2399.5 TSD Brief.docx Sample Descriptions

page 1 of 1



Well:East SimpsonGrain Size:naClassification:naDepth:2679.0ft DDSorting:na



The thin-section is a legacy thin-section (provided by OSA / Santos). Two thin-sections were provided for this sample / depth, with the better quality section chosen for description. The thin-sections were not stained for carbonate or K-feldspar, but the quality is overall good.

No modal or textural analysis has been conducted on this sample, as it is a mudstone.

This sample is a silty mudstone, comprising subordinate fine silt, to more typically medium silt grade (with rarer coarse silt grade) grains, floating in a brown clay matrix. Most of these grains appear to comprise quartz, with rarer feldspar. Silt grade carbonate grains (?dolomitic) are also prominent, along with very small particles of organic material. The brown matrix clay appears illitic, although the presence of abundant clay shrinkage cracks (where resin impregnation into the adjacent mudrock forms a greenish halo – see the thin-section scan above) suggests some water sensitivity (?subordinate smectite).

The silty mudstone demonstrates a very finely laminated depositional fabric. However, some of the lamination is very subtle disturbed / deformed. That, and the localised presence of extremely small, oval to lenticular shaped mud-filled structures (some are highlighted with a red arrow on the thin-section scan above), suggest some minor bioturbation.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = na$ $\varnothing_{SIM} = \%$ $\varnothing_{SOM} = na$ $\varnothing_{MICRO} = na$

No routine core analysis data is available for this sample, but given that it is a mudstone, it is expected to have negligible reservoir quality (non-reservoir).

E Simpson_2679.0 TSD_Review.docx

Sample Descriptions

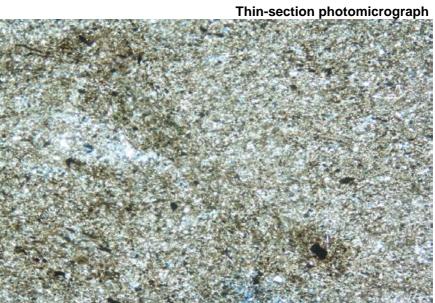
page 1 of 1



Well:E TopagorukGrain Size:naClassification:naDepth:2016.0ft DDSorting:na







Key: White Grains: Quartz / Plagioclas Brown Matrix: Detrital Clay

Field of View = 2.76mm Black: Pyrite / Organic Matter

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-sections were not stained for carbonate or K-feldspar, but the quality is overall good.

No textural or modal analysis has been undertaken upon this sample, as it is a mudstone.

This sample is a silty mudstone. The "way-up" of the sample is unknown. However, it is likely that the top of the thinsection does represent the top of the sample, as there is a clear fining / muddying up character to the main body of the sample, which is then overlain by a layer of mud-prone siltstone, which fines and muddies upwards, with an increase in the proportion of very finely intercalated mudstone laminae. The base of this latter mud-prone siltstone laminae is marked by a very thin horizon of markedly coarser sand grains, some of which are up to fine sand Upper in size.

The depositional fabric is very finely laminated throughout (sub-mm scale lamination). However, deformation (biogenic churning) is noted in the muddier top of the main body of the sample, as well as at the base of the siltstone horizon. Organic material is overall minor, although is notably more prominent in the upper muddier portion of the main silty mudstone horizon.

RESERVOIR POTENTIAL

Porosity Data: \emptyset_{He} = naPermeability Data: K_h = naMacroporosity Data: \emptyset_{PRIM} = na \emptyset_{SIM} = % \emptyset_{SOM} = na \emptyset_{MICRO} = na

No routine core analysis data is available for this sample, but given that it is a mudstone, it is expected to have negligible reservoir quality (non-reservoir).

E Topagoruk 2016.0 TSD Review.docx

Sample Descriptions



Ductile Grains + Lithic Grains

Turquoise Blue = Porosity

Grain Size: Classification: Well: E Topagoruk 0.037mm (csiltL) LS 2485.00ft DD Depth: Sorting: 0.440Ø (ws)

Thin-section scan



Thin-section photomicrograph Field of View = 2.76mm

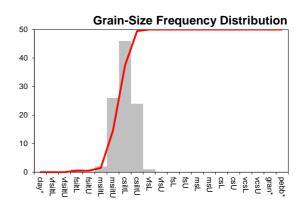
Field of view= 21mm

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-sections were not stained for carbonate or K-feldspar, but the quality is overall good. The dark coloured marks near the base of the thin-section are artefact (produced during thin-section preparation), and do not represent real geological features.

White Grains: Quartz / Feldspar

Black: Pyrite / Organic Matter / Heavy Minerals

This sample is a ductile-rich, well sorted, coarse siltstone, which displays a very finely laminated fabric (sub-mm scale), defined by subtle to locally more pronounced changes in ductile abundance (there appears to be little or no change in grain size between the laminae). Elongated grains and mica plates also show a preferred long axis orientation (parallel to bedding). Some of the laminae show a slight change in inclination, suggesting possible current rippling.



Green / Brown Grains:

Abundant ductile rock fragments show notable plastic deformation, resulting in a tightening of the grain framework and the closing-down of (i.e. reduction in the size and number of) primary macropores.

FRAMEWORK GRAINS (58.0%)

- Monocrystalline quartz (20.5%):
- Polycrystalline quartz (3.0%):
- Chert (2.0%):
- Feldspar (9.0%):
- Extrabasinal Rigid rock fragments (20.0%): the rigid rock fragments are dominated by extremely small grains of dolomite (dolostone), which tend to be monocrystalline. Some of the dolomite grains still preserve euhedral rhombic shapes. However, many show notable erosion / reworking, and have more sub-angular to sub-rounded shapes.
- Heavy minerals (3.5%):

DUCTILE COMPONENTS (39.0%)

- Ductile rock fragments (25.0%):
- Detrital clay (9.0%): due to the very fine (silt) grain size, and notable plastic deformation of ductile grains, it is often difficult to differentiate actual (real) pore-filling detrital matrix clay from highly plastically deformed mudclasts (pseudo-matrix). Therefore, most of the detrital clay point-counted represents undifferentiated matrix. On closer inspection, it appears that most of this undifferentiated matrix clay is probably derived from plastically deformed mudclasts.



page 2 of 2

Well: E Topagoruk Depth: 2485.00ft DD

• Organic matter (0%):

AUTHIGENIC COMPONENTS (3.0%)

Very minor to minor volumes of finely crystalline, pore-filling dolomite (1.0%), spongy, undifferentiated authigenic clay (1.0%; neomorphic replacement of detrital clay and locally lines pores), ductile-replacive microcrystalline siderite (0.5%) and microcrystalline, framboidal pyrite (0.5%) have been observed. The scarcity of these authigenic phases, and their often preferentially replacive habits, means that no paragenetic relationships have been observed.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 2.9\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0\%$ $\varnothing_{MICRO} = na$

This siltstone has only minor, extremely small, remnant primary interparticle macropores, that overall appear poorly interconnected with one another. The primary macropores have been significantly reduced in number and size by the plastic deformation of abundant ductile material, particularly ductile rock fragments, which facilitate compaction (the squashed ductile grains, particularly the intrabasinal mudclasts, act as a pore-filling, pseudo-matrix). No secondary macroporosity has been observed. Significant microporosity is expected within the abundant clayey ductile material (mudclasts, altered micaceous schist clasts and detrital / matrix clay).

This sample lacks routine core analysis data, and although a good porosity is expected, permeability is likely to be poor.

E Topagoruk 2485.00 TSD Brief.docx

Sample Descriptions

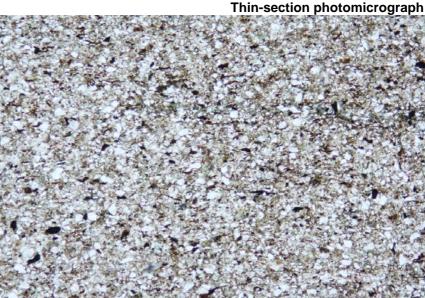
page 1 of 1



Well: E Topagoruk Grain Size: 0.043mm (csiltL) Classification: LW Depth: 3569.0ft DD Sorting: 0.571∅ (mws)







Field of view= 20mm

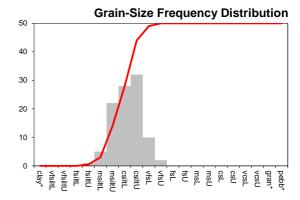
Key:White Grains: Quartz / Plagioclase
Brown Matrix: Detrital Clay

Field of View = 2.76mm Black: Pyrite / Organic Matter

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-sections were not stained for carbonate or K-feldspar, but the quality is overall good.

This sample is a mud-prone, coarse siltstone. Most of the silt grains are coarse grade, but range in size from fine silt through to very fine sand (Lower). However, at the far left of the thinsection, the silty laminae / horizon here contains scattered over-sized grains, up to medium sand Lower grade (these were not included in the textural analysis). Therefore, overall this siltstone is moderately well sorted.

The sample displays a very finely laminated fabric, with a few thin, markedly muddier laminae / horizons. In addition, the sample is cross-cut by a vertical micro-fracture, which results



in a slight displacement / deformation of the laminae. Off-set at approximately 90 degrees from this micro-fracture is another small, truncated micro-fracture.

The abundant clayey ductile material is dominated by brown, pore-filling detrital matrix clay. Mudclasts are very minor, and the lithic grain suite is dominated by metamorphic clasts, with rarer carbonate (dolomite) grains.

RESERVOIR POTENTIAL

Porosity Data: \emptyset_{He} = naPermeability Data: K_h = naMacroporosity Data: \emptyset_{PRIM} = 0% \emptyset_{SIM} = 0% \emptyset_{MICRO} = na

No routine core analysis data is available for this sample, but given that it is a mud-prone siltstone, it is expected to have negligible reservoir quality (non-reservoir).

E Topagoruk_3569.0 TSD_Review.docx

Sample Descriptions

page 1 of 2



Well: Fish Creek Grain Size: 0.067mm (vfsL) Classification: LS Depth: 2966.50ft DD Sorting: 0.575Ø (mws)

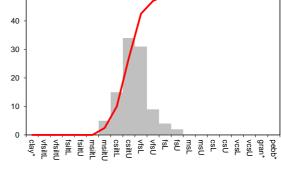


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The thin-section is a legacy thin-section (provided by OSA / Santos). It has been stained for K-feldspar, and is generally of good quality.

This sample is a lithic, poorly cemented, moderately well sorted sandstone, with abundant ductile material. It displays a faintly to locally more pronounced, very fine grain size lamination, with alternations of medium to coarse silt and more rarely (thinner laminae) very fine-grained sand. Ductile material, oddly enough, is often more abundant in the coarser grained laminae. Also, some laminae comprise very fine to fine silt grains, forming a matrix between larger grains (coarse silt to very fine sand grade), and are quite poorly sorted.

Compaction is overall moderate, with compaction facilitated by the high abundance of plastically deformed ductile material (ductile rock fragments, mica and detrital clay).



Grain-Size Frequency Distribution

FRAMEWORK GRAINS (61.0%)

- Monocrystalline quartz (26.5%): angular to sub-rounded in shape, mainly sub-angular.
- Polycrystalline quartz (3.0%): very finely crystalline, with inequigranular and equigranular textures, but uniformly
 metamorphic fabrics (some are foliated, others more massive, but with highly welded / sutured crystallite contacts).
 There is a clear gradation between some grains of very finely crystalline, foliated polycrystalline quartz and
 extrabasinal, quartz-schist rock fragments.
- Chert (2.0%): these grains are more rounded in shape than the quartz grains, and often, but not always, show spongy (partially corroded) textures.
- Feldspar (12.0%): the feldspar grains, particularly the K-feldspar grains, are highly angular in shape (noticeably
 more angular compared to the quartz grains). They are dominated by plagioclase (which is often slightly
 sericitised), with minor K-feldspar. Both locally show advanced corrosion, producing secondary intraparticle and
 oversized macropores.
- Extrabasinal rigid rock fragments (16.0%): dominated by metamorphic clasts, most of which are schistose, although some are more massive, and more highly micaceous / altered and exceptionally finely crystalline (hornfels-like). Minor volcanic grains have also been observed. These are isotropic, and are green to brown in colour, with occasionally thin laths of plagioclase preserved (altered glass and basalt). Very minor green (?chloritic) grains and reworked extrabasinal sandstone clasts have also been observed.
- **Heavy minerals** (1.5%): rutile, garnet, opaques and zircon.



page 2 of 2

Well: Fish Creek Depth: 2966.50ft DD

DUCTILE COMPONENTS (37.5%)

- Ductile rock fragments (18.0%): dominated by micaceous schist (extrabasinal) clasts, which comprise a mixture
 of mica species, many of which appear slightly to highly altered. However, extrabasinal metamorphic ductile rock
 fragments also include a minor component of massive looking, very finely crystalline to almost cryptocrystalline,
 welded composites of unknown composition / type. The mica schist clasts demonstrate minor to moderate plastic
 deformation, and tend to be larger than intrabasinal mudclasts, which are also common in this sample (8.0%). The
 brown intrabasinal mudclasts are more highly plastically deformed.
- **Mica** (8.5%): individual mica plates are relatively abundant in this sample, although overall mica is still somewhat more abundant within extrabasinal rock fragments
- Detrital clay (9.5%): principally forms prominent, thick grain coats and small masses of detrital clay that sit on grain surfaces. The detrital clay appears illitic, at least in part.
- Organic matter (1.5%): very fine particles, through to more typically relatively larger particles (4-6 times larger than adjacent quartz grains) scattered throughout the thin-section, although more abundant (preferentially concentrated within) the coarser grained laminae.

AUTHIGENIC COMPONENTS (1.5%)

This sample has been extremely poorly overprinted by authigenic phases. Very minor undifferentiated authigenic clay has been point-counted (1.0%). This clay is so finely crystalline and highly microporous (loosely packed) in nature, that it appears spongy. It is extremely difficult to differentiate it from the host detrital clay with which it appears to replace.

The authigenic assemblage is completed by very minor to scarce microcrystalline siderite (0.5%), which forms anhedral crystals, <5µm in diameter, locally concentrated / clustered together, replacing mica plates and mudclasts, and microcrystalline pyrite (trace).

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 5.0\%$ $\varnothing_{SIM} = 1.8\%$ $\varnothing_{SOM} = 1.4\%$ $\varnothing_{MICRO} = na$

This sample contains minor remnant primary interparticle macropores, which are extremely small, and very poorly interconnected. They are notably larger and more volumetric abundant in those coarser grained laminae that are cleaner, compared to those which are ductile-rich (and which contain very little visible macroporosity). However, these cleaner, coarser grained laminae are subordinate relative to the ductile-rich, coarser grained laminae, and even though they are larger, they still tend to be <40µm in diameter. Within the finer grained laminae, primary macropores are so small, that they border on microporosity (here they are <20µm in diameter, with most being <10µm in diameter), and have been reduced in size / number patchily by poor sorting, and more typically by the compression / deformation of ductile material (ductile-facilitated compaction).

Therefore, the overall silty to very fine grain size, combined with the presence of ductile material (which facilitates compaction), results in a poor reservoir quality.

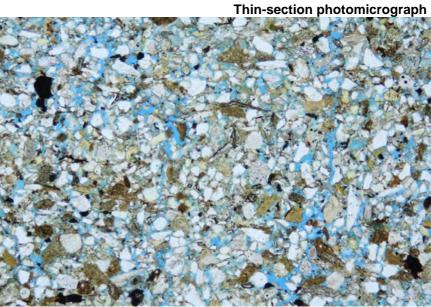
Fish Creek 2966.50 TSD Full.docx Sample Descriptions

page 1 of 2



Well: Fish Creek Grain Size: 0.086mm (vfsL) Classification: LS Depth: 2969.30ft DD Sorting: 0.673Ø (mws)





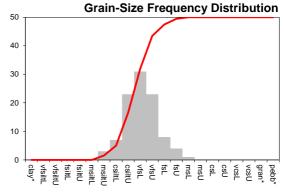
White Grains: Quartz / Feldspar Black: Pyrite / Organic Matter / Heavy Minerals Field of View = 2.76mm

Green / Brown Grains: Ductile Grains + Lithic Grains

Turquoise Blue = Porosity

The thin-section is a legacy thin-section (provided by OSA / Santos). It has been stained for K-feldspar, and is generally of good quality.

This sample is similar to the sample directly above at 2966.5ft, also being a lithic, poorly cemented, moderately well sorted sandstone, with abundant ductile material. Detrital grains again range widely in size, from fine silt through to fine sand Upper, and although average / mean grain size is very fine sand Lower, both median and median grain size is coarse silt (refer to the grain size frequency chart opposite). Sorting is notably poorer in this sample compared to most of the other Nanushuk samples included in this study.



The depositional fabric again appears to have been laminated, as in the sample above (with notable changes in ductile abundance). However, much of the lamination appears slightly deformed / distorted, and in a few places is highly churned. It is not possible to determine whether this distortion is related to biogenic medication, or due to water escape / soft sediment deformation.

FRAMEWORK GRAINS (66.0%)

- Monocrystalline quartz (21.0%):
- Polycrystalline quartz (4.0%):
- Chert (4.5%):
- Feldspar (13.5%):
- Extrabasinal Rigid rock fragments (22.0%): dominated by metamorphic clasts. Minor highly altered, glassy volcanic grains are again present in this sample, as they are in sample 2366.5ft. No dolomite / carbonate grains have been observed.
- Heavy minerals (1.0%):

DUCTILE COMPONENTS (31.0%)

- **Ductile rock fragments** (20.0%): brown (?illitic) intrabasinal mudclasts are notably more abundant in this sample compared to the sample above (266.5ft), and often show significant plastic deformation. Some of the mudclasts are quite organic-rich in nature, but most lack organic matter, as well as silt grains.
- Mica (2.0%):
- **Detrital clay** (8.5%): again, as with sample 2666.5ft, brown detrital clay coats are prominent. They are not present on every grain surface, but where they are present, they are typically relatively thick and fairly continuous around their host grains. The clays particles / sheets locally tend to orientated parallel to grain surfaces.



page 2 of 2

Well: Fish Creek Depth: 2969.30ft DD

• Organic matter (0.5%):

AUTHIGENIC COMPONENTS (3.0%)

Minor undifferentiated authigenic clay (2.0%), which is so finely crystalline, that it appears spongy in thin-section, is locally seen replacing detrital clay. The authigenic assemblage is completed by replacive, microcrystalline pyrite (0.5%) and anatase (0.5%).

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 3.3\%$ $\varnothing_{SIM} = 1.4\%$ $\varnothing_{SOM} = 0.5\%$ $\varnothing_{MICRO} = na$

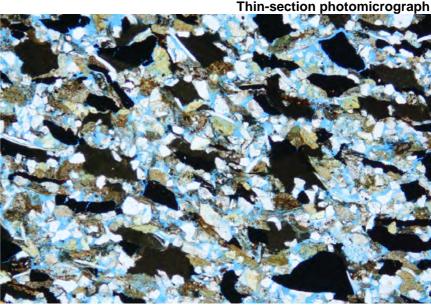
Despite the fact that this sample is slightly coarser grained, and thus overall contains slightly less ductile material, than the sample above at 2366.5ft, it yields subtly less macroporosity, and is expected to have a similar to subtly poorer reservoir quality compared to sample 2366.5ft. This is because although total ductile material is lower in this sample compared to sample 2366.5ft, the abundance / proportion of intrabasinal mudclasts is higher in this sample (14.0%) compared to sample 2366.5ft (8.0% mudclasts) – this sample has notably less mica and micaceous ductile grains (8.0%) compared to sample 2366.5ft (18.0%). The mudclasts demonstrate greater plastic deformation than the micaceous clasts / mica, and therefore facilitate greater compaction.

Fish Creek 2969.30 TSD Brief.docx
Sample Descriptions



Grain Size: Classification: Well: Fish Creek 0.093mm (vfsU) 2970.60ft DD Depth: Sorting: 0.488Ø (ws)





Yellow Grains: K-feldspa Turquoise Blue = Porosity

Field of View = 2.76mm Green / Brown Grains: Ductile Grains + Lithic Grains Black: Organic Matter

Grain-Size Frequency Distribution

The thin-section is a legacy thin-section (provided by OSA / Santos). It has been stained for K-feldspar, and is generally of good quality. The top and bottom of the sample appear sheared / deformed and somewhat brecciated (the shearing / brecciation appear induced, and not a natural or in-situ feature of this sample).

This sample stands apart from most of the other Fish Creek samples, as it contains abundant, large particles of organic material (black in the images above). It is, therefore, a well sorted, highly lithic, organic-rich, very fine-grained (Upper) sandstone. This sample is also the coarsest grained of the Fish Creek sample set.

Ductile rock fragments are also abundant in this sample, and

these, along with the abundant particles of organic matter, have facilitated compaction, and exhibit notable plastic deformation. In small scattered, subordinate realms (only 3-5 grains across), which lack ductile material, rigid grain contacts are only tangential. However, the primary pore network has been significantly destroyed / degraded in most of the sample by ductile grains / organic matter and ductile-facilitated compaction (this sample has an overall present intergranular volume of only 7%, down from an original / depositional intergranular volume of approx. 35%.

50

40

30

20

10



- Monocrystalline quartz (14.0%):
- Polycrystalline quartz (4.0%):
- Chert (6.5%): many, but by no means most, of the chert grains demonstrate partial, to more rarely advanced, corrosion, exhibiting small intraparticle macropores and / or spongy (microporous) textures.
- Feldspar (10.0%):
- Extrabasinal Rigid rock fragments (13.0%): Includes isotropic, highly corroded volcanic glassy grains.
- Heavy minerals (trace):

DUCTILE COMPONENTS (45.5%)

- Ductile rock fragments (24.0%): dominated by brown, intrabasinal mudclasts, some of which are organic-rich. These mudclasts are often of similar, if not overall slightly larger, size compared to the organic particles derived below, and thus also significantly larger than adjacent sand grains. Smaller mudclasts are evident, but are volumetrically rarer. Many of the large mudclasts have been replaced by microcrystalline siderite.
- Mica (5.0%):
- Detrital clay (0%):

Sample Descriptions



page 2 of 2

Well: Fish Creek Depth: 2970.60ft DD

Organic matter (16.5%): abundant, large, angular particles / grains of organic material (the organic grains are
typically 5-10 times larger than adjacent rigid sand grains, although some are over 1mm in diameter). A few of
the organic particles have a cellular / plant structure preserved, and a subordinate volume represent more
elongated particles, and more rarely strands, more typically associated within organic material in sedimentary
rocks

AUTHIGENIC COMPONENTS (7.0%)

Microcrystalline siderite is prominent in this sample (7.0%), and principally occurs as a microcrystalline replacement of larger intrabasinal mudclasts. The siderite crystals are densely packed, and rarely larger than 5µm in diameter.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 6.5\%$ $\varnothing_{SIM} = 0.5\%$ $\varnothing_{SOM} = 0\%$ $\varnothing_{MICRO} = na$

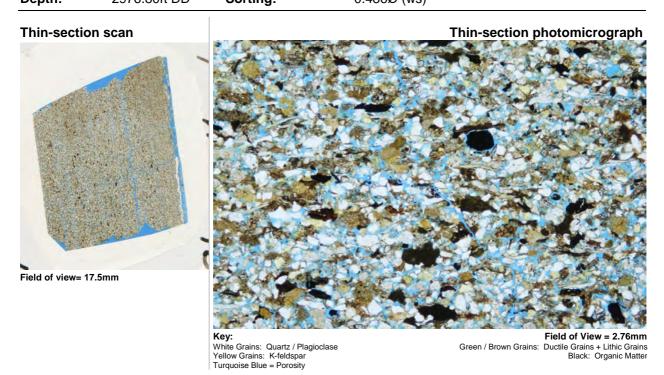
This sandstone contains a relatively low volume of remnant primary macroporosity, with most primary macropores having been destroyed or significantly reduced in size by ductile-facilitated compaction, resulting in ductile material, particularly mudclasts, deforming / squeezing into adjacent primary macropores, forming a pseudo-matrix. Reservoir potential is likely to be relatively poor to at best moderate.

Fish Creek 2970.60 TSD Brief.docx
Sample Descriptions

page 1 of 1



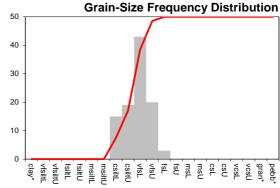
Well: Fish Creek Grain Size: 0.073mm (vfsL) Classification: LS Depth: 2976.80ft DD Sorting: 0.486Ø (ws)



The thin-section is a legacy thin-section (provided by OSA / Santos). It has been stained for K-feldspar, and is generally of good quality.

This sample is a well sorted, highly lithic, ductile-rich, very fine-grained (Lower) sandstone, similar to that at 2669.3ft, although this sample is better sorted and notably more ductile-rich (it contains notably more abundant mudclasts and organic material). As with sample 2669.3ft, this sample also shows a finely laminated fabric, with lamination defined by subtly changes in ductile abundance (no grain size lamination is evident). A slight churning / deformation of the fabric / lamination is locally apparent.

The mudclasts and organic particles are much smaller than they are in the adjacent sample at 2970.6ft, although are still larger (2-4 times larger) than adjacent rigid sand grains, and demonstrate notable plastic deformation.



RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 9.0\%$ $\varnothing_{SIM} = 0.5\%$ $\varnothing_{SOM} = 0.5\%$ $\varnothing_{MICRO} = na$

This ductile-rich sandstone contains prominent, but not abundant, very small primary interparticle macropores, that are moderately interconnected via extremely narrow pore throats. Reservoir quality is likely to be moderate, at best, and although a few, thin, cleaner, better quality laminae are apparent, these are truncated (by deformation / churning) by ductile-rich material, and therefore do not cross the entire length of the thin-section.

Fish Creek 2976.80 TSD Review.docx

Sample Descriptions

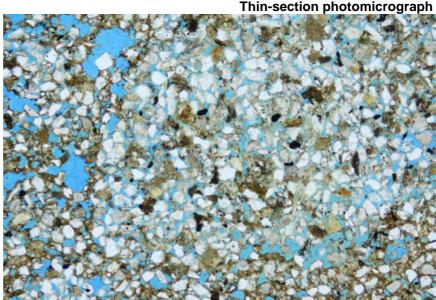
page 1 of 2



Well: Fish Creek Grain Size: 0.076mm (vfsL) Classification: LW Depth: 2990.50ft DD Sorting: 0.419Ø (ws)



Field of view= 18.5mm



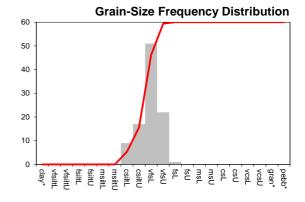
Key: Field of View = 2.76mm
Note: the larger holes are artefact (material plucked out during sample coring and / or thin-section preparation)
White Grains: Quartz / Plagioclase Green / Brown Grains: Ductile Grains + Lithic Grains
Black: Organic Matter / Heavy Minerals
Turquoise Blue = Porosity

Field of View = 2.76mm
Are Turquoise Sample coring and / or thin-section preparation)

Green / Brown Grains: Ductile Grains + Lithic Grains
Yellow Grains: K-feldspar

The thin-section is a legacy thin-section (provided by OSA / Santos). The K-feldspar staining and resin impregnation in this thin-section is poor. In addition, significant amounts of material have been plucked out, resulting in small to large oversized holes. This plucking could have occurred either during sample acquisition (coring / collection of the plug) and / or during thin-section preparation. In addition, the sample is in a relatively poor state of preservation, and has broken apart significantly, with large, open fractures (these fractures are induced / artefact, and do not represent in-situ geological features).

This sample is a well sorted, very fine-grained (Lower), lithic sandstone. Its poor preservation makes it difficult to determine its depositional fabric, but it appears to be



somewhat churned / disrupted, containing subordinate, scattered / patchy, irregular shaped realms, where pore-filling matrix (detrital) clay is abundant and pervasive. Around these (and representing the bulk of the sample), detrital clay is prominent, as are ductile rock fragments, and although overall cleaner than these detrital clay-rich patches, they are still relatively ductile-rich (within the bulk of the sample, the detrital clay also has a more grain-coating habit, rather than a pore-filling habit, as seen in the subordinate muddier / clay-rich patches).

Compaction in the cleaner, albeit still ductile-rich, patches is overall moderate, with significant tightening of the grain fabric (and hence degradation of the primary pore network) as a result of prominent plastic deformation of ductile material (i.e. ductile facilitated compaction).

FRAMEWORK GRAINS (50.0%)

- Monocrystalline quartz (20.0%): principally sub-angular to more rarely sub-rounded in shape.
- Polycrystalline quartz (5.0%): very finely crystalline, with a clear gradation into chert.
- Chert (5.0%): a minor / subordinate proportion of the chert grains show advanced corrosion (generating small secondary macrospores and secondary micropores).
- **Feldspar** (8.5%): the poor staining of K-feldspar grains has made it impossible to differentiate plagioclase from K-feldspar within untwinned feldspar grains (which are more abundant relative to twinned feldspar grains). Where twinned, most of the grains appear to be plagioclase, and more rarely K-feldspar. Both locally show partial corrosion
- Extrabasinal rigid rock fragments (9.0%): unusually the rigid rock fragments suite comprises almost solely metamorphic clasts (mainly quartz-mica schist), with only very rare (trace), extremely small dolomite grains.
- **Heavy minerals** (2.5%): comprises a diverse assemblage of zircon, garnet, rutile, opaques, titanite and undifferentiated amphibole / pyroxene. Garnet is the dominant heavy mineral type, and is unusually prominent in this sample.

Fish Creek 2990.50 TSD Full.docx Sample Descriptions



page 2 of 2

Well: Fish Creek Depth: 2990.50ft DD

DUCTILE COMPONENTS (50.0%)

- Ductile rock fragments (19.0%): abundant, plastically deformed intrabasinal mudclasts and micaceous schist fragments (mudclasts are slightly more abundant than the mica schist fragments). Unusually, no altered / undifferentiated or green ductile grains have been observed, which ties in with a lack of rigid grain equivalents.
- **Mica** (4.0%): dominated by small, highly altered flakes of mica. Very minor, fresh plates of muscovite and biotite have also been observed. No chlorite has been observed (either as individual mica plates, or bound within extrabasinal rock fragments).
- **Detrital clay** (26.5%): principally occurs as a pervasive, pore-filling, brown matrix clay within the scattered, mudprone patches. Within the cleaner areas, it forms relatively thick, variably continuous (although often fairly continuous) grain coats (as observed in many of the other Fish Creek samples).
- Organic matter (0.5%): small, scattered, irregular shaped to locally sub-rounded particles.

AUTHIGENIC COMPONENTS (trace)

Another feature of this sample which makes it stand out from all the other samples from this well, is an almost complete lack of authigenic cements. Only a few, extremely rare microcrystalline framboids of pyrite have been observed, sitting at pore margins, or replacing detrital clay / mudclasts.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 5.4\%$ $\varnothing_{SIM} = trace$ $\varnothing_{SOM} = 0.7\%$ $\varnothing_{MICRO} = na$

Remnant primary interparticle macropores are relatively minor overall, although are variably distributed. They are absent within the detrital clay-rich realms (where they have been pervasively occluded by pore-filling detrital clay), and variably minor to more rarely prominent within the cleaner realms, where they are relatively poorly interconnected (in a few realms they are moderately well interconnected, but these realms are small, and do not connect with one another). In the cleaner realms, primary macropores have been significantly reduced in size and connectivity by the presence of prominent, thick grain-coatings of detrital clay, and more significantly by the plastic deformation of ductile rock fragments (which facilitate compaction, as well as form a pseudo pore-filling matrix).

Secondary macroporosity is very minor, with small secondary intraparticle pores, and larger secondary oversized pores formed by the localised corrosion of feldspar and chert grains.

Reservoir quality is expected to be poor, to possibly moderate.

Fish Creek 2990.50 TSD Full.docx Sample Descriptions

page 1 of 1

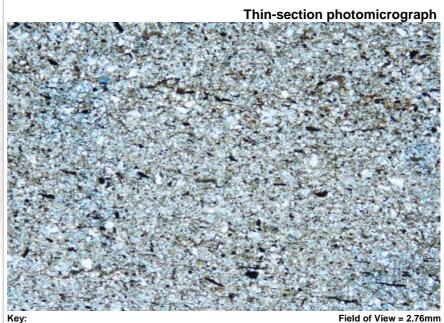


Well: Fish Creek Grain Size: 0.029mm (msiltU) Classification: LS Depth: 3003.00ft DD Sorting: 0.612Ø (mws)

Thin-section scan



Field of view= 24.5mm



Key:
White Grains: Quartz / Plagioclase
Yellow Grains: K-feldspar
Turquoise Blue = Porosity
Green / Bro

Field of View = 2.76mm
Green / Brown Grains: Ductile Grains + Lithic Grains
Black: Organic Matter

The thin-section is a legacy thin-section (provided by OSA / Santos). It has not been stained for K-feldspar, and is generally of good quality.

This sample is a well sorted, lithic, extremely ductile-rich / highly micaceous, siltstone. Most of the silt grains are fine to medium silt grade, and the abundant ductile material, which dominates the bulk volume of this sample (57.5%), is dominated by exceptionally small plates of mica or micaceous ductile rock fragments, with lesser amounts of mudclasts and matrix clay.

The siltstone displays a very finely laminated fabric, which is locally very weakly deformed.

Grain-Size Frequency Distribution 50 40 30 20 10 0 | Csl. |

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 1.0\%$ $\varnothing_{SIM} = trace$ $\varnothing_{SOM} = trace$ $\varnothing_{MICRO} = na$

Primary intraparticle macropores are rare, extremely small (<10µm in diameter) and typically isolated. The extremely ductile-rich nature of this siltstone sample means that it is likely to have a very poor reservoir quality.

Fish Creek_3003.00 TSD_Review.docx

Sample Descriptions

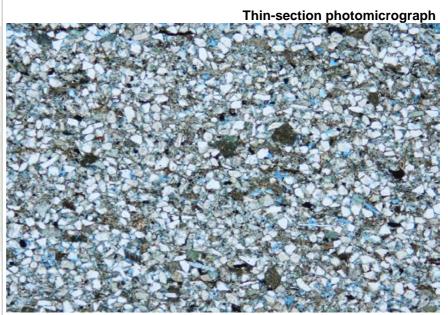
page 1 of 2



Well: Fish Creek Grain Size: 0.059mm (csiltU) Classification: LS Depth: 3004.30ft DD Sorting: 0.450Ø (ws)

Thin-section scan

Field of view= 23mm

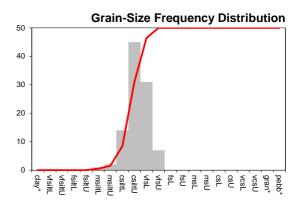


Key: White Grains: Quartz / Plagioclase Black: Organic Matter / Heavy Minerals Turquoise Blue = Porosity

Field of View = 2.76mm
Green / Brown Grains: Ductile Grains + Lithic Grains
Yellow Grains: K-feldspar

The thin-section is a legacy thin-section (provided by OSA / Santos). It does not appear to have been stained for K-feldspar, and has a variably polished surface, making it difficult to focus clearly at lower magnifications (this is not such a problem at higher magnifications, and so mineral identification has been possible).

This sample is a well sorted, coarse siltstone, although the mean grain size of 0.059mm is close to the coarse siltstone / very fine-grained sandstone (Lower) boundary. Ductile material is abundant, and has facilitated compaction, and the abundant plastically deformed ductile rock fragments present, along with abundant detrital clay, form a near pervasive, pore-filling clay matrix (a very minor volume of small, isolated primary macropores are preserved).



The fabric appears very faintly laminated (very subtle changes in ductile abundance).

FRAMEWORK GRAINS (57.5%)

- Monocrystalline quartz (25.0%):
- Polycrystalline quartz (5.5%):
- Chert (0%):
- Feldspar (12.5%):
- Extrabasinal Rigid rock fragments (11.0%): again, apart from metamorphic clasts, and minor altered / undifferentiated grains, other rock fragment types are unusually absent in this sample, although a few possibly reworked sandstone clasts have been observed.
- **Heavy minerals** (3.5%): unusually prominent. These very small grains comprise a mixture of tourmaline, rutile, zircon, opaques and garnet.

DUCTILE COMPONENTS (42.0%)

- Ductile rock fragments (21.0%):
- Mica (5.5%):
- **Detrital clay** (15.0%): comprises a sub-equal mixture of relatively thick and continuous grain coats / rims, and pore-filling matrix, although most of the matrix clay point-counted is undifferentiated / ambiguous, and possibly actually represents pseudo-matrix (i.e. highly plastically deformed mudclasts, which are of similar composition to, and hence difficult to differentiate from, pore-filling detrital clay).
- Organic matter (0.5%):



page 2 of 2

Well: Fish Creek Depth: 3004.30ft DD

AUTHIGENIC COMPONENTS (0.5%)

Rare microcrystalline lozenges / rhombs replacing a few scattered, although typically larger, mudclasts and more rarely biotite mica plates.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 0.5\%$ $\varnothing_{SIM} = 1.0\%$ $\varnothing_{SOM} = trace$ $\varnothing_{MICRO} = na$

As alluded to above, this siltstone sample is ductile-rich, and comprises an abundant clayey matrix, made up of a combination of plastically deformed ductile rock fragments and detrital clay), which have facilitated compaction (compaction is only moderate, and hence the clayey ductile material still retains significant microporosity). Primary macropores are very minor, and isolated, and hence this sample most likely has a negligible to very poor reservoir quality.

Fish Creek_3004.30 TSD_Brief.docx

Sample Descriptions

page 1 of 2



Well: Fish Creek Grain Size: 0.060mm (csiltU) Classification: LS Depth: 3004.70ft DD Sorting: 0.475Ø (ws)

Thin-section scan

scan



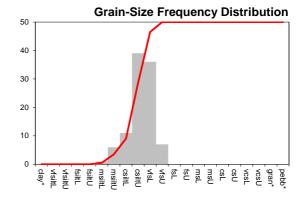
Field of view= 22.5mm

Key:White Grains: Quartz / Plagioclase
Black: Organic Matter / Heavy Minerals
Beige Pore-filling Material = Carbonate

Field of View = 2.76mm
Grey / Brown Grains: Ductile Grains + Lithic Grains
Yellow Grains: K-feldspar

The thin-section is a legacy thin-section (provided by OSA / Santos). It has been stained for K-feldspar, the staining is very poor (and hence it has not been possible to differentiate untwinned K-feldspar grains from untwinned plagioclase grains during modal analysis). It is unclear whether the abundant, pervasive carbonate species present has been stained or not (see below).

This sample is a well sorted, coarse siltstone (mean grain size is close to the coarse siltstone / very fine-grained sandstone (Lower) boundary). It is extremely similar to the adjacent sample 3004.3ft, which lies only 3 inches away. However, this sample has been pervasively overprinted by carbonate, which also significantly replaces abundant ductile material (this siltstone sample appears to have been



originally ductile-rich). The carbonate preserves a very high intergranular volume.

At first glance the depositional fabric appears relatively massive. However, on closer inspection, a very subtle mottling / churning is apparent. The nature / origin of this churning is impossible to ascertain at this scale.

FRAMEWORK GRAINS (42.0%)

- Monocrystalline quartz (16.5%): mainly sub-angular in shape.
- Polycrystalline quartz (3.0%):
- Chert (2.0%): typically clean and fresh, with little signs of corrosion.
- **Feldspar** (8.0%): although poorly stained, some K-feldspar grains are identifiable by their twinning. Twinned plagioclase grains, however, are significantly more abundant than twinned K-feldspar grains, suggesting that overall the feldspar grains are represented by plagioclase.
- Extrabasinal rigid rock fragments (11.0%): unusually the rigid rock fragments suite comprises almost solely metamorphic clasts (mainly quartz-mica schist), with only very rare (trace), green (?chloritic) altered grains (these grains contrast with quartz grains, not just in colour, but also because they are well rounded).
- Heavy minerals (1.5%): garnet, zircon and opaques.

DUCTILE COMPONENTS (13.0%)

• **Ductile rock fragments** (8.5%): the remnant ductile grains that have not been replaced by carbonate comprise a sub-equal mixture of brown intrabasinal mudclasts and extrabasinal micaceous schist fragments. They show little, if any plastic deformation (the pervasive carbonate cement has inhibited compaction, and clearly precipitated relatively early).

Fish Creek 3004.70 TSD Full.docx Sample Descriptions



page 2 of 2

Well: Fish Creek Depth: 3004.70ft DD

- Mica (2.5%): most of the small, individual mica plates are highly altered. A few flakes of fresh muscovite, however, have been observed.
- **Detrital clay** (1.0%): most of the detrital clay that was originally present in this sample, and was possibly relatively abundant, has been replaced / overprinted by carbonate. A few pores, however, still retains some small pockets of clay that has been partially, rather than completely, overprinted by carbonate. This clay is brown, and has a pore-filling habit.
- Organic matter (1.0%): small, scattered, irregular shaped to locally sub-rounded particles

AUTHIGENIC COMPONENTS (45.0%)

The primary pore network of this sample, as well as a significant volume of the ductile material present, has been overprinted by exceptionally abundant, pervasive authigenic carbonate (42.0%). It is not clear whether the carbonate has been stained or not. It is possible that all the carbonate represents non-ferroan dolomite and / or siderite (or a combination of both), both of which do not stain. It may also be possible that this carbonate represents calcite and / or ferroan dolomite, and that staining has not been applied.

Minor siderite (3.0%), with a much stronger pleochroism than the majority of the carbonate present, has been definately identified, and is of similar character as seen elsewhere in this well, and the other wells included in this study (i.e. microcrystalline, and preferentially replacive of mudclasts, and more rarely micaceous rock fragments, and more rarely lines pores).

The main type of carbonate present, however, is mainly microcrystalline to very finely crystalline, with weaker pleochroism compared to the microcrystalline siderite, and does not show characteristics that are normally associated with siderite. The finely crystalline carbonate, where possible to tell, appears to form rhombs that appear similar to non-ferroan dolomite noted in previous Nanushuk wells studied. Therefore, it is possible that this carbonate represents non-ferroan dolomite (given that K-feldspar has been stained, it is likely that carbonate staining was applied too, and therefore the fact that this carbonate shows no stain, suggests that it might be non-ferroan dolomite).

The carbonate appears to have completely replaced / overprinted prominent detrital clay coats (where this occurs, the carbonate has been point-counted as cement, to reflect the fact that it occurs in what would have originally been primary macroporosity). It also has replaced most (abundant) ductile rock fragments (both mudclasts and micaceous schist clasts). The fact that quartz / rigid framework grains appear to float within a carbonate matrix, suggests that the carbonate precipitated relatively early, before stabilisation of the sediment / silt. However, the undifferentiated carbonate clearly engulfs microcrystalline siderite, and so siderite precipitated even earlier.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 0\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0\%$ $\varnothing_{MICRO} = na$

This sample has no reservoir potential, as it has been pervasively cemented by carbonate.

Fish Creek 3004.70 TSD Full.docx

Sample Descriptions

page 1 of 2



Well: Fish Creek Grain Size: 0.067mm (vfsL) Classification: LS Depth: 3005.40ft DD Sorting: 0.288Ø (vws)

Thin-section scan



Thin-section photomicrograph

Field of View = 2.76mm

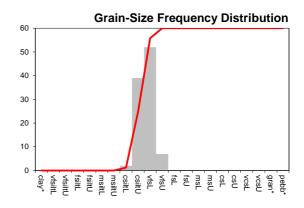
Field of view= 11mm

White Grains: Quartz / Plagioclase Black: Organic Matter / Heavy Minerals Turquoise Blue = Porosity

Field of View = 2.76mm
Green / Brown Grains: Ductile Grains + Lithic Grains
Yellow Grains: K-feldspar

The thin-section is a legacy thin-section (provided by OSA / Santos). It has been stained for K-feldspar, and is generally of good quality. The piece of sample material mounted into the thin-section is very small (only 6mm wide and 16mm tall)

This sample is an extremely well sorted, very fine-grained (Lower), lithic sandstone, which contains abundant ductile material (mainly ductile rock fragments, with subordinate detrital clay). The piece of sample material mounted into the thin-section is very small (only 6mm wide and 16mm tall), and therefore it is difficult to gauge the depositional fabric of the thin-section. The ductile material appears to be preferentially concentrated within a thick, discrete laminae, with some possible subtle deformation apparent, although is also still prominent within the cleaner horizon. An extremely



large intrabasinal mudclast is apparent towards the base of the thin-section, within the cleaner laminae / horizon.

FRAMEWORK GRAINS (64.5%)

- Monocrystalline quartz (27.0%):
- Polycrystalline quartz (7.5%):
- Chert (6.0%):
- **Feldspar** (15.5%): dominated by plagioclase, with minor K-feldspar grains. The K-feldspar grains locally demonstrate advanced dissolution, whereas the plagioclase grains only rarely demonstrate dissolution.
- Extrabasinal Rigid rock fragments (7.5%):
- Heavy minerals (1.0%):

DUCTILE COMPONENTS (35.0%)

- Ductile rock fragments (21.5%): dominated by brown (?illitic) intrabasinal mudclasts, which often show notable
 plastic deformation, and have been "squeezed" into adjacent primary macropores (via ductile-facilitated
 compaction), forming small, yet abundant, patches of pseudo-matrix. Most of the mudclasts are 1.5 to 2 times
 larger than adjacent framework grains. However, a couple of oversized / large intrabasinal, silty mudclasts are
 apparent, which range in size from 0.8-2.2mm in length.
- Mica (2.5%):
- Detrital clay (11.0%): principally forms thin, to locally thick, variably continuous, brown (?illitic) coats / rims
 around many, but not all, framework grains (mainly quartz, but also observed around lithic and feldspar grains).
- Organic matter (0%):



page 2 of 2

Well: Fish Creek Depth: 3005.40ft DD

AUTHIGENIC COMPONENTS (0.5%)

Scarce microcrystalline siderite is observed replacing intrabasinal mudclasts.

RESERVOIR POTENTIAL

Porosity Data: \varnothing_{He} = naPermeability Data: K_h = naMacroporosity Data: \varnothing_{PRIM} = 11.2% \varnothing_{SIM} = 0.9% \varnothing_{SOM} = 2.1% \varnothing_{MICRO} = na

Primary interparticle macropores are abundant and relatively well interconnected in the cleaner horizon, but are considerably less abundant, smaller and more poorly interconnected within the ductile-rich horizon. The plastic deformation of ductile rock fragments (mainly mudclasts) has facilitated compaction, and resulted in a reduction in the size and number of primary macropores. Obviously this is more pronounced in the ductile-rich horizon, compared to the cleaner horizon. The abundant ductile rock fragments therefore degrade reservoir quality both directly (by being squeezed into, and thus filling, primary macropores) and indirectly (by facilitating compaction of the grain framework).

Prominent detrital clay coats also reduce the size of pore throats, further degrading permeability.

The cleaner horizon potentially has a moderately good reservoir quality, although given the small size of the sample material, it is not possible to tell how laterally extensive this cleaner sandstone material is.

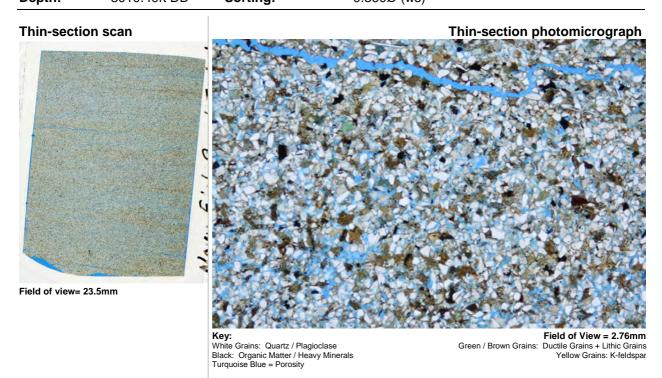
Fish Creek 3005.40 TSD Brief.docx
Sample Descriptions

page 1 of 1



Well: Fish Creek Grain Size: 0.058mm (csiltU) Classification: LS

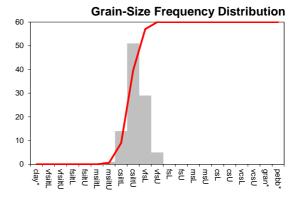
Depth: 3010.40ft DD Sorting: 0.360Ø (ws)



The thin-section is a legacy thin-section (provided by OSA / Santos). It has been stained for K-feldspar, and is generally of good quality.

This sample is a well sorted, ductile-rich, highly lithic, coarse siltstone, which exhibits a laminated fabric, characterised by subtle, to more rarely distinct, changes in grain size. The lamination often appears to be partially deformed / disrupted, although in a few areas, the deformation is more pronounced, with more ductile-rich silt being irregularly / patchily intermixed with cleaner silt.

The abundant ductile material is dominated by plastically deformed ductile rock fragments (principally intrabasinal mudclasts), which although small, act as micro-baffles, and



pore-filling matrix clay (some mudclasts are so highly plastically deformed that they have been "pushed" into, and thus occlude, at least 3-4 surrounding primary macropores). Cementation, as with most of the other samples from this well, is light.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 9.4\%$ $\varnothing_{SIM} = 0.9\%$ $\varnothing_{SOM} = 0.4\%$ $\varnothing_{MICRO} = na$

This sample comprises prominent, but not highly abundant, very small remnant primary interparticle macropores, which have been reduced significantly in size and number by plastically deformed ductile grains (and more rarely other ductile phases), which also facilitate compaction of the grain framework. Pore throats are extremely narrow (only a few microns in diameter) and reservoir quality is likely to be poor to possibly moderate (permeability will be significantly poorer relative to porosity, as significant microporosity is likely to be held within the abundant ductile rock fragments, as well as within prominent detrital clay).

Fish Creek 3010.40 TSD Review.docx

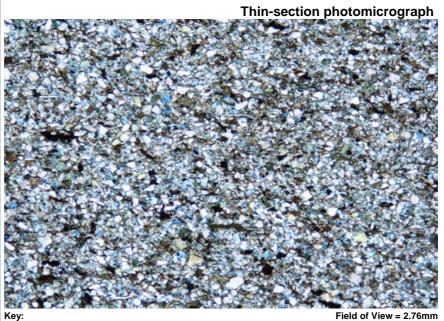
Sample Descriptions



Grain Size: Classification: Well: Fish Creek 0.043mm (csiltL) LS 3014.00ft DD Depth: Sorting: 0.501Ø (mws)



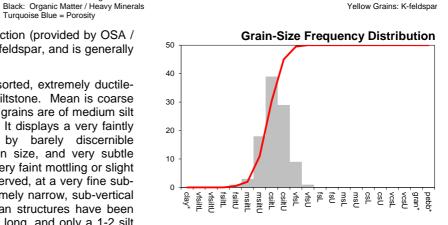
Field of view= 24.5mm



The thin-section is a legacy thin-section (provided by OSA / Santos). It has been stained for K-feldspar, and is generally of good quality.

White Grains: Quartz / Plagioclase

This sample is a moderately well sorted, extremely ductilerich (41.5% total ductile material) siltstone. Mean is coarse silt Lower, although most of the silt grains are of medium silt grade (mode grain size is msiltU). It displays a very faintly laminated fabric, characterised by barely discernible (extremely slight) changes in grain size, and very subtle changes in ductile abundance. A very faint mottling or slight churning of the fabric is locally observed, at a very fine submm scale. In addition, a few extremely narrow, sub-vertical (relative to bedding) unusually clean structures have been identified. These are up to 1.3mm long, and only a 1-2 silt



Green / Brown Grains: Ductile Grains + Lithic Grains

Yellow Grains: K-feldspar

grains wide, and possibly represent burrow-fills. This suggests that the subtle mottling / disruption evident throughout the sample is biogenic in origin, rather than related to soft sediment deformation.

FRAMEWORK GRAINS (45.0%)

- Monocrystalline quartz (23.0%):
- Polycrystalline quartz (2.5%):
- Chert (0.5%):
- Feldspar (9.5%):
- Extrabasinal Rigid rock fragments (9.0%): almost exclusively comprises metamorphic clasts (foliated schist, with rarer massive, hornfels-like grains), with minor altered / undifferentiated clasts mainly undifferentiated as they are so small, that they are difficult to resolve in thin-section).
- Heavy minerals (0.5%):

DUCTILE COMPONENTS (41.5%)

- Ductile rock fragments (28.5%): dominated by intrabasinal mudclasts, which are often, but not always, notably larger than the adjacent rigid silt grains.
- Mica (6.0%):
- Detrital clay (4.0%): grain-coating detrital clay is markedly scarce in this sample, compared to all the preceding samples from this well. The minor detrital clay point-counted mainly represent undifferentiated clay matrix, where it is difficult to tell whether the clayey material represent "real" pore-filling detrital matrix clay, or plastically deformed mudclasts (i.e. pseudo-matrix). The latter is most likely, given that mudclasts are abundant in this sample, and that no actual / definitive pore-filling detrital clay has been observed.
- Organic matter (3.0%):



page 2 of 2

Well: Fish Creek Depth: 3014.00ft DD

AUTHIGENIC COMPONENTS (13.5%)

This sample has been unusually overprinted by relatively abundant microcrystalline siderite (12.5%), with very minor undifferentiated authigenic clay (1.0%) completing the authigenic assemblage. The siderite crystals do not appear to form well defined lozenges, rather more ragged rhombs, and are typically only ~2-6µm in diameter (a few appear subtly larger). They preferentially appear to have precipitated within primary macropores, mainly at pore margins, although locally they completely choke primary macropores (smaller macropores). In fact, the siderite appears to have more of a grain-coating habit, than pore-lining habit.

The siderite also notably replaces ductile material (mainly mudclasts, but also more rarely micaceous schist grains, mica plates and grain-coating detrital clay)

The siderite crystals are trapped along elongated grain contacts, and thus pre-date compaction.

RESERVOIR POTENTIAL

Porosity Data: \varnothing_{He} = naPermeability Data: K_h = naMacroporosity Data: \varnothing_{PRIM} = 2.9% \varnothing_{SIM} = 0.5% \varnothing_{SOM} = trace \varnothing_{MICRO} = na

This sample contains only minor, extremely small, isolated to very poorly interconnected primary macropores, as it is exceptionally fine-grained (mainly medium silt grade), comprises extremely abundant plastically deformed mudclasts (which act as a patchy pseudo-matrix), and has been relatively highly cemented by microcrystalline siderite. The siderite significantly reduces the size of already exceptionally small primary pores (due to the silt grain size), as well as chokes pore throats. The siderite also locally completely occludes primary pores (smaller pores).

Reservoir quality is likely to be very poor.

Fish Creek 3014.00 TSD Brief.docx

Sample Descriptions

page 1 of 2

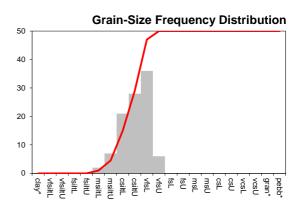


Well: Fish Creek Grain Size: 0.057mm (csiltU) Classification: LS Depth: 3025.90ft DD Sorting: 0.535Ø (mws)



The thin-section is a legacy thin-section (provided by OSA / Santos). It has been stained for K-feldspar, and is generally of good quality.

This sample is a moderately well sorted, highly lithic siltstone, which displays a very faintly laminated fabric, characterised by extremely subtle, sub-mm scale changes in ductile abundance (ductile material is relatively abundant throughout, but in some exceptionally thin laminae, only 0.1-0.2mm thick, ductile material is subtly less abundant). It is similar to adjacent siltstone samples, except that despite having a similar grain size, is overall cleaner (this siltstone sample contains 32.0% total ductile material, whereas as samples 3014.0ft and 3026.0ft above and below it, of similar coarse silt grain size, have 41.5% and 48.5%%, respectively, total ductile material).



Cementation is exceptionally light, whereas compaction is moderate, with significant plastic deformation of ductile material facilitating compaction (intrabasinal mudclasts demonstrate moderate to pronounced plastic deformation).

FRAMEWORK GRAINS (67.0%)

- Monocrystalline quartz (28.0%): angular to sub-rounded in shape, although most are sub-angular.
- **Polycrystalline quartz** (4.5%): fabrics are difficult to determine, as these grains are very small, and often contain only a few crystals of quartz.
- Chert (3.5%): grains are often very clay-rich / dirty, and rarely, if ever, show corrosion.
- **Feldspar** (14.0%): overwhelmingly dominated by plagioclase, with only very minor K-feldspar. The feldspar grains, particularly the K-feldspar grains, are notably more angular in shape compared to the quartz grains. They also locally demonstrate partial corrosion (complete corrosion is extremely rare), generating very minor volumes of secondary macroporosity and secondary microporosity (some feldspar grains are spongy in appearance).
- Extrabasinal rigid rock fragments (16.5%): dominated by metamorphic clasts (foliated schist, with rarer
 massive, hornfels-like grains), with minor altered / undifferentiated clasts (mainly undifferentiated as they are so
 small, that they are difficult to resolve in thin-section, although some are simply highly altered, making
 determination of their origin impossible to gauge). Extremely rare, small grains of dolomite have also been
 observed.
- **Heavy minerals** (0.5%): rounded zircon, opaque and rutile grains.



page 2 of 2

Well: Fish Creek Depth: 3025.90ft DD

DUCTILE COMPONENTS (32.0%)

- **Ductile rock fragments** (21.0%): these dominate the ductile assemblage, and as with most of the other Fish Creek samples, principally comprise intrabasinal mudclasts, with subordinate, mica-rich extrabasinal clasts (mainly mica schist). These all display plastic deformation, although the mudclasts have generally deformed more highly than the grains of micaceous schist.
- Mica (6.0%): dominated by small, highly degraded / altered flakes of indeterminate composition. A few very long flakes of fresh muscovite and partially altered biotite have also been observed.
- **Detrital clay** (4.5%): volumetrically minor, and comprises a sub-equal mixture of undifferentiated, pore-filling clay matrix and grain-coating detrital clay. The undifferentiated matrix clay probably represents highly plastically deformed mudclasts (i.e. pseudo-matrix), rather than actual / real pore-filling detrital matrix clay. The detrital clay rims are significantly more poorly developed (very thin and highly discontinuous clay coats) in this sample compared to the samples above.
- Organic matter (0.5%): very minor, small, angular to more rarely sub-rounded particles of organic material are scattered throughout the sample.

AUTHIGENIC COMPONENTS (1.0%)

The primary pore network of this sample has been almost completely unaffected by diagenesis, with only very minor undifferentiated authigenic clay noted (1.0%). This clay is extremely difficult to resolve in thin-section, due to its exceptionally finely crystalline nature, and the extremely small size of the pores within which it resides. Trace ductile-replacive, microcrystalline pyrite has also been observed (cubes and pyritohedra, rather than framboids are observed).

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 4.7\%$ $\varnothing_{SIM} = 1.4\%$ $\varnothing_{SOM} = trace$ $\varnothing_{MICRO} = na$

Primary interparticle macropores would have been extremely small on deposition, due to the medium to coarse silt size of the framework grains. However, they have been greatly reduced in size further, as well as in number and connectivity, by ductile facilitated compaction. The abundant plastically deformed ductile grains (mainly intrabasinal mudclasts) also occlude primary macropores, where highly plastically deformed. Remnant primary interparticle macropores are therefore exceptionally small (most are <10µm in diameter, with very few extending up to 20µm in diameter), and overall minor in abundance, and where connected, have exceptionally narrow pore throats. Secondary macroporosity produced by the localised dissolution of feldspar grains is very minor, and has little impact on reservoir quality (most secondary pores are held within partially corroded feldspar grains).

Whilst porosity is likely to be good, and mainly microporous in nature (with microporosity being held principally within abundant clayey ductile grains [including altered micaceous schist fragments], and more rarely within detrital + authigenic clay and spongy, partially corroded feldspar grains), permeability is likely to be poor.

Fish Creek 3025.90 TSD Full.docx

Sample Descriptions

page 1 of 1

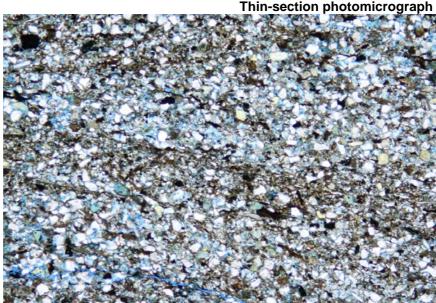


Well: Fish Creek Grain Size: 0.054mm (csiltU) Classification: LS Depth: 3026.00ft DD Sorting: 0.574Ø (mws)

Thin-section scan



Field of view= 24mm

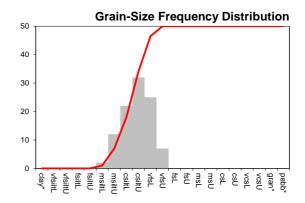


Key:White Grains: Quartz / Plagioclase
Black: Organic Matter / Heavy Minerals
Turquoise Blue = Porosity

Field of View = 2.76mm Green / Brown Grains: Ductile Grains + Lithic Grains Yellow Grains: K-feldspar

The thin-section is a legacy thin-section (provided by OSA / Santos). It has been stained for K-feldspar, and is generally of good quality.

This sample is a moderately well sorted, highly lithic, extremely ductile-rich, coarse siltstone. It appears to have been originally finely laminated, with lamination defined by relatively subtle changes in grain size, and relatively marked changes in ductile abundance (the finer grained laminae appear to have been fine to medium silt grade, whereas the coarser grained laminae appear to have been coarse silt to more rarely very fine sand (Lower) grade). The primary lamination has been greatly modified, post-deposition, by significant churning / disruption of the sediment, resulting in its deformed, wavy appearance. The cleaner siltstone



material is now somewhat inter-mixed with the more ductile-rich material, forming lens-like realms, rather than laterally continuous laminae, which float within, or are truncated by, the more ductile-rich material.

The origin of the churning / deformation is difficult to ascertain, although is more likely (possibly) of biogenic origin, rather than related to soft sediment deformation.

RESERVOIR POTENTIAL

Porosity Data: \varnothing_{He} = naPermeability Data: K_h = naMacroporosity Data: \varnothing_{PRIM} = 2.9% \varnothing_{SIM} = 1.4% \varnothing_{SOM} = 0% \varnothing_{MICRO} = na

This ductile-rich siltstone contains only minor, extremely small, poorly interconnected remnant primary interparticle macropores, which occur mainly / solely within what were the cleaner laminae of the sample. As these cleaner laminae have been disrupted, and somewhat intermixed / churned with the more ductile-rich / mud-prone laminae, they have been truncated, and form mm-scale lenses, cut-off from one another by the more volumetrically abundant, more ductile-rich, mud-prone laminae / realms (where primary macropores tend to absent). Permeability, therefore, is likely to be negligible to very poor.

Fish Creek 3026.00 TSD Review.docx

Sample Descriptions

page 1 of 1

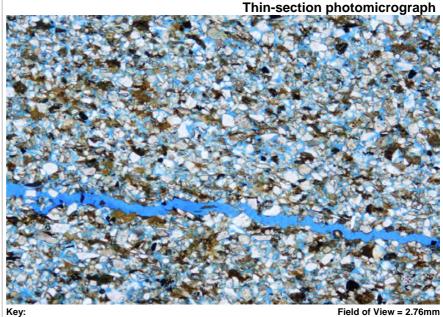


Well: Fish Creek Grain Size: 0.058mm (csiltU) Classification: LS Depth: 3032.90ft DD Sorting: 0.473Ø (ws)

Thin-section scan



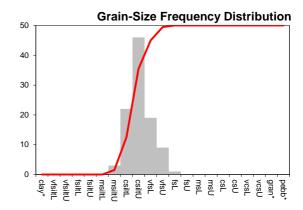




Field of View = 2.76mm Green / Brown Grains: Ductile Grains + Lithic Grains Yellow Grains: K-feldspar

The thin-section is a legacy thin-section (provided by OSA / Santos). Although it has been stained for K-feldspar, the staining is poor, and hence it has not been possible to always differentiate untwinned K-feldspar grains from untwinned plagioclase grains during modal analysis.

This sample is a well sorted, highly lithic, ductile-rich, coarse siltstone, which has been poorly overprinted by authigenic cements. The abundant ductile material varies in abundance, defining a finely laminated fabric, comprising sub-mm thick clean laminae (minor), laminae with prominent, but not abundant, ductile material (dominant) and extremely ductile-rich laminae (subordinate). Unusually, the clean laminae are notably finer grained than the ductile-rich and extremely ductile-rich laminae. At the very edge of the



sample (left hand side), large particles of organic material are evident, and appear to define an organic-rich laminae.

The ductile material has facilitated notably compression of the grain fabric, with abundant, brown intrabasinal mudclasts (which dominate the ductile suite) showing moderate to more typically pronounced plastic deformation.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 13.7\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0.4\%$ $\varnothing_{MICRO} = na$

Black: Organic Matter / Heavy Minerals Turquoise Blue = Porosity

Primary interparticle macropores are overall extremely small, and connected by exceptionally narrow pore throats, due mainly to the silt grain size, and also moderate ductile-facilitated compaction. They are notably more abundant, as well as slightly larger, in the laminae that contain prominent, rather than highly abundant, ductile material. In the more ductile-rich laminae, macropores have been greatly reduced in size and number by ductile-facilitated compaction, as well as the clayey ductile material [mudclasts] acting as a pore-filling pseudo-matrix). Within the minor, clean laminae, primary macropores are prominent, but exceptionally small (due to the fine to medium silt grain size).

Reservoir quality is likely to be moderate to possibly good.

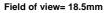
page 1 of 1

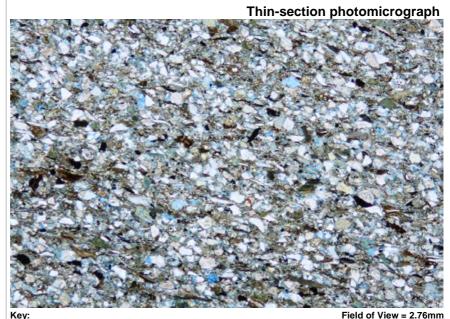


Well: Fish Creek Grain Size: 0.060mm (csiltU) Classification: LW Depth: 3033.30ft DD Sorting: 0.521Ø (mws)

Thin-section scan







Field of View = 2.76mm
Green / Brown Grains: Ductile Grains + Lithic Grains
Yellow Grains: K-feldspar

The thin-section is a legacy thin-section (provided by OSA / Santos). It has been stained for K-feldspar, and is generally of good quality.

This sample is a very finely laminated, moderately well sorted, highly lithic, ductile-rich, coarse siltstone. The lamination. The lamination / fabric, as well as grain size and mineralogy, vary across the thin-section, from left to right:

• At the far left of the thin-section, the lamination is angled (at approximately 20-25 degrees) relative to the flatlying lamination to the right of it (note: it is not possible to determine the "way-up" of the sample, although it appears more likely that the angled lamination underlies, and is thus truncated by, the horizon of flat / ?horizontal laminated siltstone). The angled laminated Grain-Size Frequency Distribution

50

40

30

20

10

0

wsl.

w

siltstone to the far left of the thin-section is still ductile-rich, but is subtle coarser grained and overall cleaner, than the siltstone material to the right of (?over-lying) it.

- In the middle, and forming the main bulk of the sample, is very finely laminated, ductile-rich siltstone (lamination
 is typically subtle, sub-mm scale, and defined by slight changes in ductile abundance and grain size the finer
 grained laminae are more ductile-rich). The thin-section photomicrograph above has been taken from this
 horizon.
- At the far left of the thin-section is a thin horizon of mud-prone, organic-rich, laminated siltstone (silt grains float within a dominant matrix of brown, detrital clay). A large, oversized quartz grain (csL grade) occurs at what is probably the base of this horizon.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 2.9\%$ $\varnothing_{SIM} = 0.5\%$ $\varnothing_{SOM} = 0\%$

White Grains: Quartz / Plagioclase Black: Organic Matter / Heavy Minerals

Turquoise Blue = Porosity

This heterogeneous siltstone sample has negligible to poor reservoir quality. Primary macropores are absent in the matrix-dominated, organic-rich siltstone horizon, and rare / isolated in the main, thicker horizon (due to the presence of abundant ductile grains and matrix clay). They are minor, and poorly interconnected in the somewhat cleaner (albeit still ductile-rich) siltstone material in the far right of the thin-section.

Fish Creek 3033.35 TSD Review.docx

Sample Descriptions



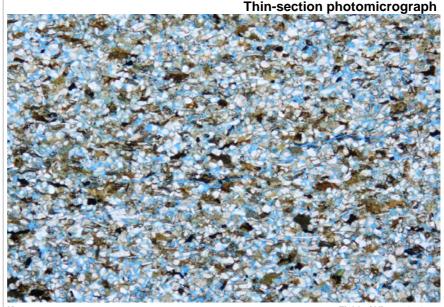
Grain Size: Classification: Well: Fish Creek 0.047mm (csiltU) LS 3042.80ft DD Depth: Sorting: 0.360Ø (ws)

Thin-section scan





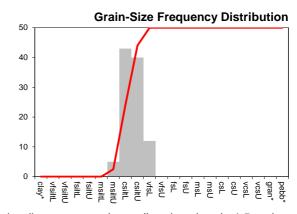
Field of view= 12mm



Field of View = 2.76mm Green / Brown Grains: D ctile Grains + Lithic Grains Yellow Grains: K-feldspar

The thin-section is a legacy thin-section (provided by OSA / Santos). It has been stained for K-feldspar, and is generally of good quality. The material mounted in thin-section represents a narrow piece of rock. However, it is still wide enough to make out the laminated fabric, thankfully because lamination is very fine (sub-mm) scale.

This sample is a very finely laminated, well sorted, coarse siltstone. It is notable better sorted than the majority of the preceding siltstone samples, with lamination characterised by subtle changes in ductile abundance (no grain size lamination is apparent). The framework grain assemblage is highly lithic (30.0% total rigid framework grains [with a further 9.5% lithic grains point-counted as ductile rock fragments). Ductile material is also abundant, and has facilitated



compaction - where ductile grains are minor / lacking (within subordinate, extremely small realms, barely 4-5 grains in diameter), grain contacts are tangential, and compaction is relatively weak, but elsewhere (the majority of the sample), ductile grains have plastically deformed, resulting in a notable reduction in primary intergranular volume).

te Grains: Quartz / Plagioclase

Black: Organic Matter / Heavy Minerals

FRAMEWORK GRAINS (55.5%)

- Monocrystalline quartz (20.0%):
- Polycrystalline quartz (1.5%):
- Chert (1.0%):
- Feldspar (8.0%):
- Extrabasinal Rigid rock fragments (27.5%): unusually for the Nanushuk sample set from this study, carbonate grains are extremely abundant (18.0%) and dominate the rigid rock fragment assemblage. The carbonate grains appear to comprise non-ferroan dolostone, which is typically monocrystalline (the dolomite grains are mainly represented by single crystals). These detrital dolomite grains often retain their rhombic shape. This suggests that they have not been as reworked as the quartz grains and other lithic grains, and as dolomite is "softer" than the other lithic grains and quartz grains, this further suggests that they may not have been transported as far, and thus are possibly derived from a more localised source compared to the quartz grains and lithic grains.
- Heavy minerals (0%):

DUCTILE COMPONENTS (40.0%)

- Ductile rock fragments (28.5%): dominated by brown mudclasts (intrabasinal), with subordinate micaceous schist grains (extrabasinal). The micaceous schist fragments are often elongated in form, and show less plastic deformation relative to the mudclasts.
- Mica (8.5%):



page 2 of 2

Well: Fish Creek Depth: 3042.80ft DD

• Detrital clay (3.0%):

• Organic matter (0%):

AUTHIGENIC COMPONENTS (2.0%)

Diagenetic overprinting is minor, and comprises mainly dolomite (1.5%), which principally forms small overgrowths / outgrowths off host dolomite grains. The dolomite is unstained, and assuming that carbonate-staining was also applied to the thin-section, along with K-feldspar staining, suggests that the authigenic dolomite, as with its host detrital dolomite grains, is non-ferroan. The minor abundance of the dolomite means that it has little or no impact on reservoir quality. Very minor / scarce undifferentiated authigenic clay (0.5%) has also been observed, possibly replacing grain-coating detrital clay.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 13.8\%$ $\varnothing_{SIM} = trace$ $\varnothing_{SOM} = trace$ $\varnothing_{MICRO} = na$

This sample retains relatively abundant, yet small primary interparticle macropores (most are less than 30µm in diameter), which are variably, although typically moderately well, interconnected, albeit via extremely narrow pore throats. Reservoir quality is potentially moderate, to possibly good.

Fish Creek 3042.80 TSD Brief.docx

Sample Descriptions

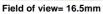
page 1 of 1

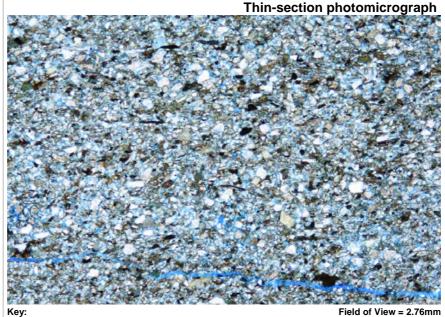


Well: Fish Creek Grain Size: 0.045mm (csiltU) Classification: LS Depth: 3043.30ft DD Sorting: 0.693Ø (mws)

Thin-section scan







White Grains: Quartz / Plagioclase Black: Organic Matter / Heavy Minerals Turquoise Blue = Porosity

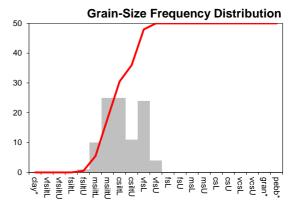
Field of View = 2.76mm

Green / Brown Grains: Ductile Grains + Lithic Grains

Yellow Grains: K-feldspar

The thin-section is a legacy thin-section (provided by OSA / Santos). Although it has been stained for K-feldspar, the staining is poor, and hence it has not been possible to always differentiate untwinned K-feldspar grains from untwinned plagioclase grains during modal analysis.

This sample is heterogeneous, comprising a thin horizon (or thick laminae), approximately 1.6-1.8mm thick, cleaner, relatively clean (albeit with prominent ductile rock fragments), very fine-grained Lower sand, adjacent to an even thinner interval (approximately 1.1mm thick) of extremely ductile-rich siltstone, adjacent to a thick interval of cleaner, albeit still ductile-rich, siltstone, which represents the main body of the sample.



This latter interval is relatively poorly sorted, with grains ranging in size from fine silt through to fine sand (Lower), and shows a very finely laminated fabric. The ductile-rich interval is also relatively poorly sorted, whilst the clean laminae is well sorted. Lamination is not apparent in the ductile-rich and clean horizons (possibly because they are so thin, and represent thick individual laminae).

The most important feature of this sample is the presence of extremely abundant dolomite grains (17.5%). Whilst dolomite grains are prominent in the coarser grained, clean laminae / horizon, they are markedly more abundant in the finer grained, more ductile-rich intervals.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 4.9\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0\%$ $\varnothing_{MICRO} = na$

Primary macropores are extremely small, and very poorly interconnected (and often isolated) in the thick ductile-rich, siltstone interval (they rarely exceed 5µm in diameter, although some are locally up to 10µm in diameter). They are lacking in the most ductile-rich horizon. However, they are abundant and well interconnected in the thin, clean laminae / horizon. Reservoir quality is therefore highly variable throughout the sample.

Fish Creek 3043.30 TSD Review.docx

Sample Descriptions

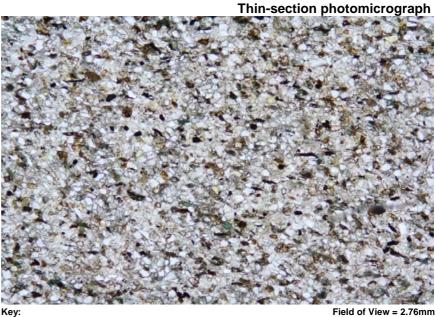
page 1 of 2



Well:Fish CreekGrain Size:0.046mm (csiltU)Classification:LSDepth:3171.00ft DDSorting:0.391Ø (ws)



Field of view= 24mm

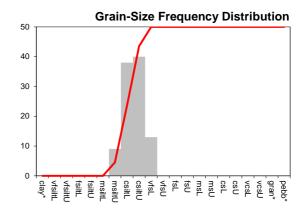


Key: Field of View = 2.76mm
White Grains: Quartz / Plagioclase
Black: Organic Matter / Heavy Minerals
Beige Pore-filling Material = Carbonate

Field of View = 2.76mm
Grey / Brown Grains: Ductile Grains + Lithic Grains
Yellow Grains: K-feldspar

The thin-section is a legacy thin-section (provided by OSA / Santos). It has been stained for K-feldspar, but it is unclear whether the abundant, pervasive carbonate species present has been stained or not (see below).

This sample is a well sorted, lithic, coarse siltstone, which has been pervasively cemented / overprinted by carbonate. Whilst ductile material was probably somewhat more abundant upon deposition, with some since being overprinted carbonate, overall it appears that ductile material was not very abundant, and this siltstone sample was possibly markedly cleaner than most of the other siltstone samples from this well. In fact, the primary pore network of this sample appears relatively clean, with the carbonate appearing colourless, and relatively clay-free. This sample is therefore different to the pervasively carbonate-cemented



sample at 3004.7ft, where the carbonate appears to have replaced abundant ductile material. As will be demonstrated below, the carbonate in this sample is not the same as the carbonate in the sample at 3004.7ft.

A very faintly laminated fabric is observed, and the grain framework appears relatively open, although some localised grain contact elongation is locally apparent (this was not apparent in the sample at 30047ft, where the carbonate clearly pre-dated compaction, and possibly precipitated relatively early).

FRAMEWORK GRAINS (56.0%)

- **Monocrystalline quartz** (27.0%): principally unstrained (straight extinction), and predominantly sub-angular in shape.
- Polycrystalline quartz (2.0%): very finely crystalline, with sub-equigranular to equigranular textures.
- Chert (0.5%): rare, clean and dirty chert grains have been observed. Their scarcity is probably due to the exceptionally fine grain size rather than any replacement by the carbonate (other siltstone samples from this well, with similar grain size, and which lack carbonate cement, also contain scarce chert grains).
- Feldspar (6.5%): as noted elsewhere in this well, and the other wells from this study, plagioclase is the dominant feldspar grain type, with only very minor volumes of K-feldspar evident. The lower abundance of feldspar in this sample compared to texturally equivalent samples in this well suggest that the carbonate replaces a minor volume of feldspar grains in this sample.
- Extrabasinal rigid rock fragments (19.0%): the rigid rock fragment suite comprises a sub-equal mixture of small metamorphic clasts (mainly quartz-rich, quartz / mica schist) and carbonate grains. The carbonate grains range from rhombic shaped through to sub-angular shaped, and show notable oxidation (reddening), suggesting that they may be / have been ferroan in composition. It is unknown whether the thin-section has been stained for carbonate, and hence it is not possible to determine whether these carbonate grains comprise siderite (which

Fish Creek 3171.00 TSD Full.docx Sample Descriptions



page 2 of 2

Well: Fish Creek Depth: 3171.00ft DD

does not stain), or whether they comprise ferroan dolomite (which should stain blue, only if stain is applied). The carbonate grains also lack overgrowths, which have been noted in the samples from 3032.9ft to 3043.3ft from this well (here the detrital carbonate grains were definitely dolomite, and comprise minor dolomite overgrowths).

• Heavy minerals (1.0%): small, rounded grains of rutile, undifferentiated opaques and zircon.

DUCTILE COMPONENTS (11.5%)

- Ductile rock fragments (8.5%): ductile rock fragments occur in relatively low abundances, although a minor
 percentage have been replaced by carbonate, and thus point-counted as replacive carbonate, rather than ductile
 rock fragments. The ductile rock fragment suite comprises a mixture of brown mudclasts, micaceous schist
 grains, unusual bright green grains, and highly altered / undifferentiated grains. Green ductile grains, were
 rarely, if ever, encountered in the samples above this sample (they are minor in this sample, and the 2 samples
 directly below it).
- Mica (2.5%): altered / undifferentiated mica plates, along with rarer fresh plates of muscovite and biotite.
- **Detrital clay** (0.5%): rare brown detrital grain coats noted on some grain surfaces.
- Organic matter (0%):

AUTHIGENIC COMPONENTS (32.5%)

The primary pore network of this sample has been pervasively cemented by authigenic carbonate, which also to a much lesser extent, appears to replace ductile grains, lithic grains and feldspar grains (26.0% cement and 6.0% replacive undifferentiated carbonate has been point-counted). It is not clear whether the carbonate has been stained or not. It is possible that all the carbonate represents non-ferroan dolomite and / or siderite (or a combination of both), both of which do not stain. It may also be possible that this carbonate represents calcite and / or ferroan dolomite, and that staining has not been applied.

Scarce microcrystalline siderite (0.5%), with a much stronger pleochroism than the majority of the carbonate present, has been definately identified, and is of similar character as seen elsewhere in this well, and the other wells included in this study (i.e. microcrystalline, and preferentially replacive of mudclasts, and more rarely micaceous rock fragments, and more rarely lines pores).

The pervasive carbonate in this sample differs to that noted in the sample at 3004.7ft. Not only does it appear to have precipitated later (it post-dates some grain contact elongation, which was not noted for carbonate in sample 3004.7ft), it is also markedly more coarsely crystalline, forming large, poikilotopic masses (some are definitely large rhombs, others may simple represent crystals which are in optical continuity with one another) – the carbonate in sample 3004.7ft appears very finely to finely crystalline. The later paragenesis of the carbonate in this sample, combined with its poikilotopic habit, and the fact that it appears to have preferentially cemented the cleanest sample in this well, are all consistent with features that were shown by calcite in previously studied Nanushuk wells. Therefore, the pervasive carbonate in this sample is most likely calcite and not dolomite, and has not been stained.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 0\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0\%$ $\varnothing_{MICRO} = na$

This sample has no reservoir potential, as it has been pervasively cemented by carbonate.

Fish Creek 3171.00 TSD Full.docx

Sample Descriptions

page 1 of 2

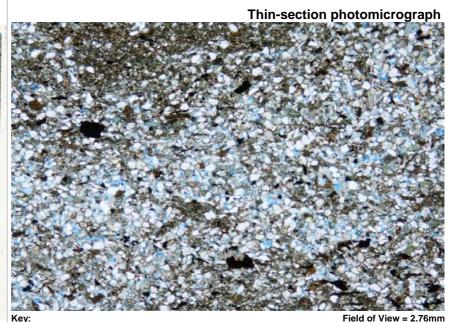


Well: Fish Creek Grain Size: 0.048mm (csiltU) Classification: LW Depth: 3171.50ft DD Sorting: 0.446Ø (ws)

Thin-section scan



Field of view= 23.5mm

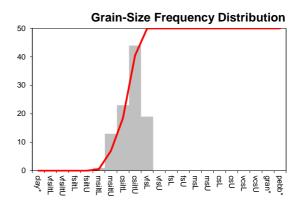


White Grains: Quartz / Plagioclase
Black: Organic Matter / Heavy Minerals
Turquoise Blue = Porosity

Field of View = 2.76mm Green / Brown Grains: Ductile Grains + Lithic Grains Yellow Grains: K-feldspar

The thin-section is a legacy thin-section (provided by OSA / Santos). Whilst the K-feldspar grains have been stained, the staining is very poor, and therefore it has not been possible to differentiate K-feldspar from plagioclase during modal analysis. Overall, however, the quality of the thin-section is good.

This sample is a highly bioturbated, extremely ductile-rich / mud-prone siltstone. The original depositional fabric of this siltstone has been significantly churned, resulting in the intermixing of cleaner (albeit still ductile-rich) silt and what may have been originally intercalated layers of mudstone / silty mudstone. The mudstone material is highly micaceous, and contains prominent finely particulate organic material.



The deformation / churning is consistent with bioturbation, and distinct biogenic structures are commonly distributed throughout the thin-section. These include: sub-vertical, elongated, tube-like, clean, mm-scale burrow fills within the mudstone material; spherical, organic-rich, sub-mm scale burrow-fills within the mudstone material; clusters of rounded to oval-shaped mud-filled burrows within the cleaner siltstone material; large (possibly cm-scale), clean, oval to elongated shaped burrow-fills. The notable variation in biogenic structures suggests numerous biogenic species lived / fed within the sediment.

FRAMEWORK GRAINS (45.5%)

- Monocrystalline quartz (22.0%):
- Polycrystalline quartz (2.5%):
- Chert (0.5%):
- Feldspar (6.0%):
- Extrabasinal Rigid rock fragments (14.5%):
- Heavy minerals (0%):

DUCTILE COMPONENTS (45.5%)

- **Ductile rock fragments** (13.5%): these are abundant in the cleaner (detrital clay-poor) siltstone material / realms, and comprise intrabasinal mudclasts, extrabasinal micaceous schist fragments, altered / undifferentiated clayey grains and green, possibly chloritic grains, in order of decreasing relative abundance. Notable plastic deformation of the ductile rock fragments is often evident.
- Mica (8.0%):



page 2 of 2

Well: Fish Creek Depth: 3171.50ft DD

• **Detrital clay** (21.5%): abundant, brown, pore-filling matrix clay, which was probably originally present within discrete mudstone laminae / intervals, but which is now patchily distributed throughout the sample, due to biogenic modification.

• Organic matter (2.5%):

AUTHIGENIC COMPONENTS (9.0%)

Microcrystalline siderite (7.0%) is prominent in this sample, although is preferentially concentrated within mudstone / mud-prone silt material in the lowermost part of thin-section. Here it pervasively replaces the abundant, patchily distributed matrix clay, as well as all the mud-filled burrow structures. Immediately adjacent to these, the siderite lines pores, forming exceptionally small crystals, barely a micron in diameter. Elsewhere, the siderite forms a very minor replacement of intrabasinal mudclasts.

Minor undifferentiated authigenic clay (1.5%) is locally seen lining to partially pore-filling pores. Scarce microcrystalline anatase (0.5%) has also been observed.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 2.0\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0\%$ $\varnothing_{MICRO} = na$

Despite containing only minor detrital clay, the cleaner siltstone realms of this sample in fact contain abundant ductile rock fragments, which plastically deform, tightening the grain framework (i.e. facilitating compaction) and resulting in them forming a patchy pseudo-matrix. The result is a significant destruction of primary macroporosity. Remnant primary macropores are extremely small, overall minor in abundance, and very poorly interconnected. Reservoir quality is therefore estimate to be very poor to poor.

Fish Creek 3171.50 TSD Brief.docx
Sample Descriptions

page 1 of 2

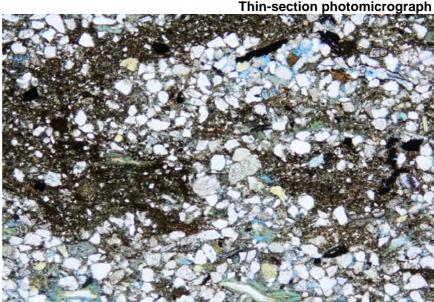


Well: Fish Creek Grain Size: 0.091mm (vfsU) Classification: LW Depth: 3373.30ft DD Sorting: 0.559Ø (mws)

Thin-section scan



Field of view= 22mm



Field of View = 2.76mm
Beige Grains: Lithic Grains
Yellow Grains: K-feldspar
Turquoise Blue = Porosity

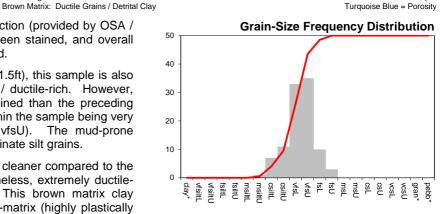
The thin-section is a legacy thin-section (provided by OSA / Santos). K-feldspar grains have been stained, and overall the quality of the thin-section is good.

Key:

Black: Organic Matte

As with the preceding sample (3171.5ft), this sample is also highly bioturbated and mud-prone / ductile-rich. However, this sample is notably coarser grained than the preceding sample, with the cleaner realms within the sample being very fine-grained (mean grain size is vfsU). The mud-prone realms contain only minor to subordinate silt grains.

Although the sandstone realms are cleaner compared to the mudstone realms, they are, nonetheless, extremely ductilerich, with abundant matrix clay. This brown matrix clay appears to mainly comprise seudo-matrix (highly plastically deformed mudclasts), with subordinate pore-filling detrital clay.



Most of the distinct biogenic structures present represent mm-scale mud-filled burrows, ranging in form (some are oval / rounded in shape, although most are elongated, and are mainly horizontal relative to bedding, although some are vertical / sub-vertical). However, some cleaner, larger scale burrow-fill structures are apparent, although overall the biogenic modification is simply diffuse (significant churning and re-churning of the sediment by biogenic organisms).

FRAMEWORK GRAINS (41.5%)

- Monocrystalline quartz (17.5%):
- Polycrystalline quartz (3.5%):
- Chert (2.5%):
- Feldspar (8.0%):
- Extrabasinal Rigid rock fragments (9.0%):
- Heavy minerals (1.0%):

DUCTILE COMPONENTS (56.5%)

• Ductile rock fragments (29.0%): overwhelmingly dominated by highly plastically deformed, brown (?illitic) mudclasts. However, prominent, albeit overall minor, unusual green grains are scattered throughout the thin-section (within the sandy realms). These grains have been highly altered (?chlorite), and it is not possible to definitively ascertain whether the alteration is derived (occurred before deposition), or whether it represents an in-situ replacement (i.e. is diagenetic). Although at first glance these grains appear to be the same, on closer inspection, they appear to have originally been derived from a variety of sources, including: mica stacks, possible volcanic grains and mudclasts (in order of decreasing relative importance).



page 2 of 2

Well: Fish Creek Depth: 3373.30ft DD

• Mica (2.5%):

- Detrital clay (22.5%):
- Organic matter (2.5%):

AUTHIGENIC COMPONENTS (2.0%)

Only minor microcrystalline siderite (2.0%) has been locally observed replacing intrabasinal mudclasts.

RESERVOIR POTENTIAL

Porosity Data: $\emptyset_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\emptyset_{PRIM} = trace$ $\emptyset_{SIM} = 0.5\%$ $\emptyset_{SOM} = 0\%$ $\emptyset_{MICRO} = na$

Only trace, extremely small, isolated primary macropores are evident within a few scattered, extremely small, cleaner realms. Elsewhere (almost the entire sample), the primary pore network is filled within detrital matrix clay and plastically deformed mudclasts (pseudo-matrix). This sample therefore is likely to have a negligible reservoir quality.

Fish Creek_3373.30TSD_Brief.docx

Sample Descriptions

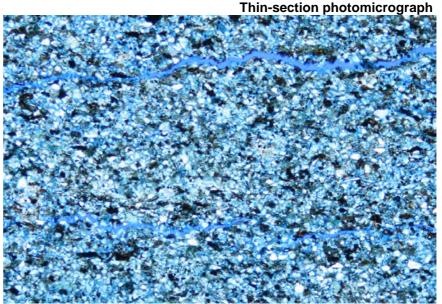
page 1 of 1



Well: J W Dalton Grain Size: 0.052mm (csiltU) Classification: LS Depth: 3503.00ft DD Sorting: 0.511Ø (mws)

Thin-section scan



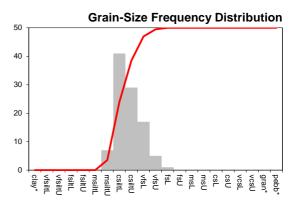


Key: White Grains: Quartz / Feldspar Black Grains: Pyrite (+ Rarer Organic Matter) Turquoise Blue = Porosity

Field of View = 2.76mm
Green / Brown Grains: Ductile Grains + Lithic Grains
Brown Matrix: Detrital Clay +/- Deformed Ductile Grains

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has not been stained for K-feldspar. In addition, it contains many patches which have been poorly impregnated with resin, and where material has been plucked out (these represent the lighter patches that can be clearly seen dotting the thin-section in the scan above).

This sample is a finely laminated, ductile-rich, highly lithic siltstone. Despite its extremely fine (silt) grain size, lithic material is still highly abundant (29.5%), although a significant proportion of the lithic grains are represented by exceptionally small micaceous schist clasts – these border on, and grade into, individual plates of mica, which are also relatively abundant in this sample (9.0%).



The lamination is defined by subtle, to locally pronounced, changes in ductile abundance (ductile rock fragments, mica plates and more rarely pore-filling matrix clay).

The most important feature of this sample is the presence of relatively abundant microcrystalline pyrite (8.5%), which preferentially replaces ductile material. The pyrite mainly forms euhedral cubes, typically 5-10µm in diameter, although framboids have locally been observed.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 7.0\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0\%$ $\varnothing_{MICRO} = na$

Primary interparticle macropores preferentially occur within the cleaner (albeit still relatively ductile-rich) laminae, where they are exceptionally small (<10µm in diameter, with many being <5µm in diameter), which are very poorly to poorly interconnected. Reservoir quality is expected to be poor.

J W Dalton 3503.00 TSD Review.docx

Sample Descriptions

page 1 of 1

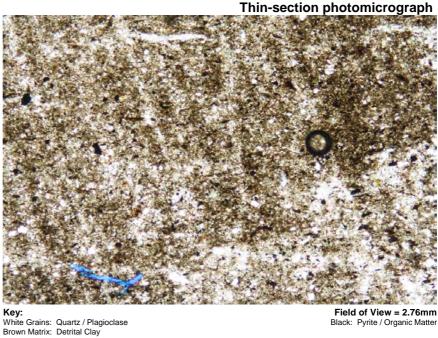


Well:J W DaltonGrain Size:naClassification:naDepth:3514.0ft DDSorting:na

Thin-section scan



Field of view= 24mm



The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has not been stained for K-feldspar or carbonate, and is of overall poor quality – significant areas of the sample have been plucked-out during thin-section preparation, and the grinding / polishing of the finished surface is poor (in fact, the thin-section shows significant scratches across most of the surface).

No textural or modal analysis has been undertaken upon this sample, as it is a mudstone.

Despite the poor quality of the thin-section, it is still obvious that this sample is a silty mudstone, which displays a significantly churned or deformed fabric, with irregular shaped realms that are cleaner or siltier, mixed with larger (more abundant) realms that are muddier or less siltier. The fabric appears more consistent with biogenic reworking, rather than soft sediment deformation, but is not definitive, due to the poor quality of the thin-section.

Organic material and mica appear minor, and the dominant mud matrix clay is brown, with birefringence suggestive of a predominantly illitic composition. However, the notable plucking / removal of material during thin-section preparation would suggest the presence of water sensitive clays (i.e. smectite).

RESERVOIR POTENTIAL

Porosity Data: \varnothing_{He} = naPermeability Data: K_h = naMacroporosity Data: \varnothing_{PRIM} = na \varnothing_{SIM} = % \varnothing_{SOM} = na \varnothing_{MICRO} = na

No routine core analysis data is available for this sample, but given that it is a mudstone, it is expected to have negligible reservoir quality (non-reservoir).

J W Dalton 3514.0 TSD Review.docx

Sample Descriptions

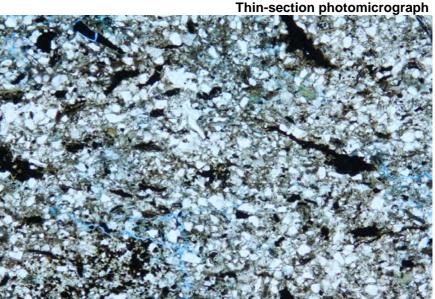
page 1 of 2



Well: J W Dalton Grain Size: 0.082mm (vfsL) Classification: LW Depth: 3529.00ft DD Sorting: 0.371Ø (ws)



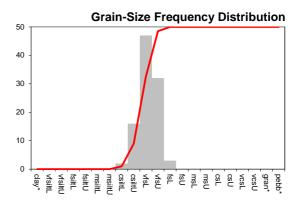




Key:White Grains: Quartz / Feldspar
Black Grains: Organic Matter
Turquoise Blue = Porosity

Field of View = 2.76mm
Green / Brown Grains: Ductile Grains + Lithic Grains
Brown Matrix: Detrital Clay +/- Deformed Ductile Grains

The thin-section is a legacy thin-section (provided by OSA / Santos). It has not been stained for K-feldspar (and therefore also probably not for carbonate as well [although there is very little carbonate present, apart from scarce reworked carbonate grains). A significant proportion of the sample has been plucked out / removed during thin-section preparation (some areas are extremely large, and are clearly visible in the thin-section scan above (these represent the large white patches that are dotted all over the thin-section). Resin impregnation is variable, and overall poor. The sample is also strewn with small to large cracks, probably related to clay shrinkage, suggesting that the clay is somewhat water sensitive (this would also explain the notable plucking of material and poor resin impregnation).



This sample appears to be a well sorted, highly lithic, extremely ductile-rich, very fine-grained (Lower) sandstone, bordering on siltstone (mode grain size [i.e. the predominant size of the grains measured] is coarse siltstone). The fabric appears contorted / churned, with irregular intermixing of more clay / ductile-rich material and cleaner (albeit still ductile-rich) material. The fabric is consistent with notable / pervasive bioturbation, which is further supported by the presence of a few distinct, very small (sub mm-scale), rounded, clean burrow-fill structures, and the presence of a few elongated burrows that have been lined by organic matter (most of which has been replaced by pyrite).

FRAMEWORK GRAINS (47.0%)

- Monocrystalline quartz (16.0%): angular to predominantly sub-angular in shape.
- Polycrystalline quartz (3.0%): due to the very fine to silt grain size, polycrystalline quartz grains are minor in this sample. Predominantly equigranular, comprising only 2-4 crystallites.
- Chert (2.5%): clean, small, well rounded grains, showing no signs of corrosion.
- **Feldspar** (10.0%): K-feldspar has not been stained. However, where possible to tell (i.e. where twinning is evident), most grains show plagioclase twinning, with only rare K-feldspar twinning observed. The feldspar grains rarely show signs of corrosion.
- Extrabasinal rigid rock fragments (15.0%): dominated by metamorphic clasts, with minor plutonic fragments and highly altered and / or exceptionally finely crystalline / cryptocrystalline clasts (undifferentiated lithic material). A few grains of carbonate (?dolostone) and green (highly altered, possibly chloritic grains) have also been observed. The metamorphic clasts are dominated by schist, which are relatively mica-rich (quartz is still dominant, but mica forms a major component [the more highly micaceous schist fragments tend to show plastic deformation, and therefore have been point-counted as extrabasinal ductile rock fragments]). The plutonic clasts mainly comprise grains with 2-4 crystals of quartz, with rarer feldspar, although some of these grains also include minor to subordinate chlorite.
- Heavy minerals (0.5%): zircon

J W Dalton 3529.00 TSD Full.docx

Sample Descriptions



page 2 of 2

Well: J W Dalton Depth: 3529.00ft DD

DUCTILE COMPONENTS (49.5%)

- Ductile rock fragments (18.5%): at first glance, it appears that most of the ductile-rock fragments comprise
 micaceous schist (some grains do contain minor / subordinate quartz). These fragments are typically very small,
 and there is clear gradation between what is a micaceous schist ductile fragment and individual mica plates.
 Minor intrabasinal mudclasts have been point-counted. However, on closer inspection, much of the abundant
 undifferentiated clay matrix point-counted, in fact represents highly plastically deformed mudclasts, rather than
 actual real pore-filling detrital clay matrix.
- Mica (5.0%): most of the extremely small mica plates appear altered / degraded (alteration is probably derived), with only rare fresh(er) plates of chlorite and muscovite observed.
- Detrital clay (19.5%): abundant, near-pervasive, pore-filling clay / clayey matrix. Whilst a significant proportion
 of this matrix clay / clayey material has been point-counted as pore-filling detrital clay, most has been pointcounted as undifferentiated matrix (where is it is difficult to determine whether the compacted matrix represent
 pore-filling detrital clay or highly plastically deformed mudclasts, and in some cases, highly plastically deformed,
 altered (and hence clayey) mica / mica schist grains). On closer inspection, much of the undifferentiated matrix
 appears to represent pseudo-matrix (highly plastically deformed ductile grains, mainly mudclasts see above).
- **Organic matter** (6.5%): occurs as irregular shaped particles / grains, and more rarely elongated strands or sheets, that are patchily scattered throughout the sample, and locally filling / lining biogenic structures. The organic matter has been significantly replaced by pyrite.

AUTHIGENIC COMPONENTS (3.5%)

The only authigenic phase identified is minor microcrystalline, framboidal pyrite (3.5%). The pyrite framboids principally replace ductile material, preferentially organic matter, although also matrix clay, mudclasts and more rarely mica. The framboids typically range in size from ~2-25µm in diameter.

RESERVOIR POTENTIAL

Porosity Data: \varnothing_{He} = naPermeability Data: K_h = naMacroporosity Data: \varnothing_{PRIM} = trace \varnothing_{SIM} = 0.5% \varnothing_{SOM} = 0% \varnothing_{MICRO} = na

This sample has no reservoir potential, as it is dominated by realms that contain pervasive pore-filling matrix clay (both actual pore-filling detrital matrix clay, as well as pseudo-matrix [i.e. highly plastically deformed ductile rock fragments]). Although subordinate cleaner realms are apparent, they still contain abundant ductile material, which has facilitated compaction, with no remnant primary macropores being preserved. Only a few (volumetrically very minor) clean realms are apparent, containing small, poorly interconnected primary macropores. These which represent sub mm-scale burrow-fills, and thus are exceptionally small, and are completely encased within surrounding ductile-rich / mud-prone material (i.e. they do not connect to one another, are volumetrically insignificant, and thus have no effect on permeability or porosity).

J W Dalton 3529.00 TSD Full.docx Sample Descriptions



Grain Size: Classification: Well: J W Dalton 0.067mm (vfsL) Depth: 4667,40ft DD Sorting: 0.384Ø (ws)





Field of view= 23.5mm

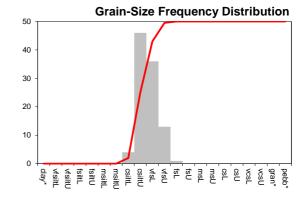
Thin-section photomicrograph

White Grains: Quartz / Feldspar Black: Organic Matter

Field of View = 2.76mm

The thin-section is a legacy thin-section (provided by OSA / It has not been stained for K-feldspar (and therefore also possibly not carbonate). The surface finish, whilst not very good, is acceptable, permitting reliable data collection and observation. However, the sample has clearly been over-ground / polished during thin-section preparation, resulting in the significant removal of sample material, in long, thin streaks (one can clearly see these abundant streaks, where sand / silt material has been "gouged" out note the abundant pale / white streaks or scratches on the thin-section scan above).

This sample is an exceptionally ductile-rich or mud-prone siltstone to very fine-grained sandstone (mean grain size is close to the coarse silt / vfsL boundary, with grain size



varying between thick, discrete horizons). Ductile content and grain size vary up through the thin-section, with a thick mud-prone / ductile-rich siltstone layer, followed by a thinner horizon of somewhat cleaner (but still very clay / ductilerich), very fine-grained sandstone, then a layer of silty mudstone, then another layer of very fine-grained sandstone, and finally a layer of mud-prone siltstone. The depositional fabric appears laminated within all layers / horizons, and some slight deformation is also often apparent, particularly at the margins / boundaries between the different layers. The deformation is more consistent with bioturbation than dewatering.

FRAMEWORK GRAINS (50.0%)

- Monocrystalline quartz (15.0%):
- Polycrystalline quartz (2.0%):
- Chert (2.0%):
- Feldspar (10.0%):
- Extrabasinal Rigid rock fragments (20.0%): the minor carbonate grains (probably dolomite) generally show reworking, with retained rhombic shapes rarely being observed.
- Heavy minerals (1.0%):

DUCTILE COMPONENTS (50.0%)

- Ductile rock fragments (20.5%): highly micaceous extrabasinal schist fragments (with little if any crystalline quartz) dominated the ductile rock fragment suite. They show moderate to locally pronounced plastic deformation.
- Mica (4.0%):
- Detrital clay (23.0%): pore-filling detrital clay is abundant and pervasive within the mud-prone siltstone and silty mudstone horizons. Within the very fine sand (Lower) horizons, much of the pervasive, pore-filling clay matrix

Sample Descriptions



page 2 of 2

Well: J W Dalton Depth: 4667.40ft DD

has been point-counted as undifferentiated. On closer examination, most of this undifferentiated matrix appears to be "real" pore-filling detrital matrix, and is more rarely represented by pseudo-matrix (highly plastically deformed mudclasts).

• Organic matter (2.5%):

AUTHIGENIC COMPONENTS (trace)

Extremely rare replacement of mudclasts by microcrystalline siderite.

RESERVOIR POTENTIAL

Porosity Data: \emptyset_{He} = naPermeability Data: K_h = naMacroporosity Data: \emptyset_{PRIM} = 0% \emptyset_{SIM} = 0% \emptyset_{MICRO} = na

This sample is devoid of macroporosity, as all layers comprise abundant, pervasive, pore-filling clay / clayey matrix (detrital clay in most cases, but highly plastically deformed ductile rock fragments also act as an abundant pseudomatrix). It therefore has no reservoir potential.

J W Dalton_4667.40 TSD_Brief.docx

Sample Descriptions

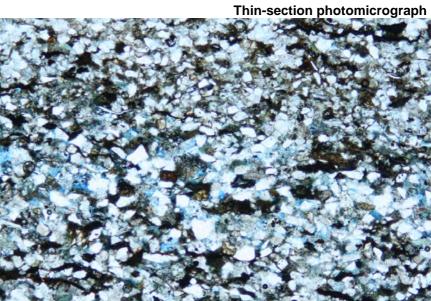
page 1 of 1



Well: J W Dalton Grain Size: 0.097mm (vfsU) Classification: LS Depth: 4681.00ft DD Sorting: 0.400Ø (ws)







Key:White Grains: Quartz / Feldspar
Black Grains: Organic Matter
Turquoise Blue = Porosity

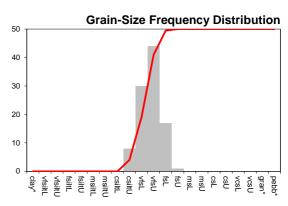
Field of View = 2.76mm

Brown Grains: Ductile Grains + Lithic Grains

Brown Matrix: Detrital Clay +/- Deformed Ductile Grains

The thin-section is a legacy thin-section (provided by OSA / Santos). It has not been stained for K-feldspar (and therefore also possibly not carbonate). The quality of this thin-section better than all / most of the others from this well, with plucking of material only locally being evident.

This sample is a very finely laminated, well sorted, highly lithic, very fine-grained (Upper) sandstone. The lamination is characterised by subtle changes in grain size, and more significant changes in ductile abundance — the slightly coarser grained laminae tend to be cleaner compared to the finer grained laminae. However, the coarser / cleaner laminae are markedly thinner (subordinate) relative to the more ductile-rich laminae, and still contain abundant, plastically deformed ductile material, and hence have only trace macroporosity preserved.



The composition / nature of the detrital components and scarce authigenic phases are similar to those described in the other samples from this well.

RESERVOIR POTENTIAL

Porosity Data: \varnothing_{He} = naPermeability Data: K_h = naMacroporosity Data: \varnothing_{PRIM} = trace \varnothing_{SIM} = trace \varnothing_{SOM} = 0% M_{ICRO} = na

Macropores are overall extremely scarce in this sample, and only occur within a few of the intercalated, coarser grained, cleaner laminae. However, even here ductile material (mainly plastically deformed ductile rock fragments) is abundant, and has facilitated compaction, with primary macropores therefore being extremely small, and isolated to very poorly interconnected. Within the dominant ductile-rich laminae, no macroporosity is evident (these laminae comprise pervasive, pore-filling, clayey matrix (most is in fact pseudo-matrix [deformed mudclasts and other ductile grains]).

Reservoir quality is anticipated to be very poor.

page 1 of 2



Well: J W Dalton Grain Size: 0.107mm (vfsU) Classification: LS Depth: 4689.00ft DD Sorting: 0.401Ø (ws)



The thin-section is a legacy thin-section (provided by OSA / Santos). It has not been stained for K-feldspar (and therefore also probably not carbonate, although this is of little consequence, as apart from a scarce ductile-replacive microcrystalline phase [most likely siderite], no authigenic carbonate has been identified). Unfortunately, within the more mud-prone horizons / realms, large areas have been removed / plucked-out during thin-section preparation. Within the cleaner laminae / realms, significant material also appears to have been removed, but on a much finer scale, often representing only single grains and / pore-occluding material that has been removed. However, these plucked grains / material are extremely abundant, and with the overall very poor resin impregnation, it has not been possible

Grain-Size Frequency Distribution

50

40

30

20

10

0

Grain-Size Frequency Distribution

pebby

residuate

to collect reliable modal macroporosity data for this sample, or to confidently assess its reservoir potential.

This sample is a highly lithic, well sorted, ductile-rich sandstone, which displays a very finely laminated fabric. Lamination is characterised by changes in ductile abundance, which are sometimes, but not always, associated within changes in ductile abundance. There are 2 discrete, thick laminae of mud-prone silt, which are notably finer grained than the surrounding, dominant, overall cleaner sandstone material (which is principally very fine-grained). The cleaner sandstone material is still ductile-rich, although there is notable variability in ductile abundance between the very fine scale (sub mm scale) laminae, with some finer grained (very fine-grained Lower) laminae being extremely ductile-rich. Lamination is also defined by the localised concentration of organic matter.

The lamination locally changes angle, suggesting some localised current rippling. In addition, a large mud-lined burrow structure is evident at the top of the thin-section, suggesting some minor, localised biogenic reworking.

Compaction is significant, with ductile rock fragments and strands of organic matter showing pronounced plastic deformation (many of the highly deformed mudclasts form a pore-filling, pseudo-matrix). Where framework grains are in contact with one another, these contacts are typically elongated.

FRAMEWORK GRAINS (58.0%)

- Monocrystalline quartz (21.5%): principally sub-angular in shape.
- **Polycrystalline quartz** (4.5%): very finely crystalline, and principally equigranular, grading into (over-lapping with) chert grains.
- Chert (2.0%): some grains exhibit deformation (or rather concavo-convex grain contacts), and chemical compaction (stylolitisation) is locally apparent.
- **Feldspar** (11.5%): although K-feldspar grains have not been stained, it appears that most of the twinned and untwinned feldspar grains comprise plagioclase.

J W Dalton 4689.00 TSD Full.docx Sample Descriptions



page 2 of 2

Well: J W Dalton Depth: 4689.00ft DD

 Extrabasinal rigid rock fragments (18.5%): dominated by metamorphic clasts (mostly quartz-rich, quartz / mica schist), with subordinate crystalline grains of quartz and feldspar, some of which also contain chlorite. Minor carbonate grains and very minor green, altered (?chloritic) grains have also been observed. The minor carbonate grains (probably dolomite) generally show reworking, with retained rhombic shapes only locally being observed.

• Heavy minerals (0%):

DUCTILE COMPONENTS (41.0%)

- **Ductile rock fragments** (21.5%): dominated by highly micaceous schist grains (extrabasinal, metamorphic clasts), related to the quartz / mica schist fragments that dominate the rigid extrabasinal rock fragments suite, but which show notable plastic deformation, because of their highly micaceous nature (and also sometimes somewhat clayey nature, as some of the mica shows notable alteration [derived]). Small, highly plastically deformed intrabasinal mudclasts are also common.
- Mica (3.0%): minor, very small, fresh plates of muscovite and more rarely chlorite. Most of the mica plates are highly altered and of ambiguous original composition.
- **Detrital clay** (7.5%): principally occurs as small patches of pore-filling clay, which are highly compacted (plastically deformed), and of ambiguous origin (it is difficult to determine whether these represent compacted mudclasts, that have been squeezed into primary macropores by the plastic deformation, or whether they represent actual / "real" pore-filling detrital matrix clay).
- **Organic matter** (9.0%): organic material is relatively abundant in this sample, and tends to be preferentially concentrated within thin, discrete, organic-rich laminae. Most of the organic matter forms thin, elongated strands, of varying size, although some irregular shaped grains / particles of organic material are also observed.

AUTHIGENIC COMPONENTS (1.0%)

This sample has been very poorly overprinted by authigenic phases, comprising only very minor volumes (0.5%) of kaolinite and siderite. The kaolinite locally occludes single primary macropores, and is replacive of plagioclase grains. The siderite is microcrystalline, and locally replaces mudclasts,

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = na$ $\varnothing_{SIM} = na$ $\varnothing_{SOM} = na$ $\varnothing_{MICRO} = na$

It has not been possible to collect reliable modal porosity data for this sample, and it is extremely difficult to assess the abundance, size and distribution of any macroporosity that might be present (see above for the reasons why). Whilst undoubtedly cleaner than the mud-prone / ductile-rich laminae / layers, the cleaner laminae / layers still contain abundant ductile material, which demonstrates significant plastic deformation, resulting in pronounced compaction in these laminae / layers. Where possible to tell (i.e. where grain / material plucking is less pronounced), it appears that remnant primary macropores are very small and scarce, and show very poor interconnectivity.

The more ductile-rich / mud-prone laminae / layers are clearly devoid of macropores, and contain abundant, tightly compressed clay matrices / pseudo-matrices.

J W Dalton 4689.00 TSD Full.docx Sample Descriptions

page 1 of 2

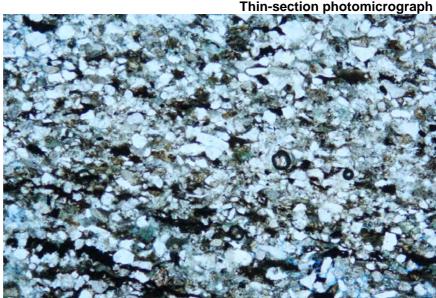


Well: J W Dalton Grain Size: 0.105mm (vfsU) Classification: LS Depth: 4690.50ft DD Sorting: 0.427Ø (ws)

Thin-section scan



Field of view= 23.5mm

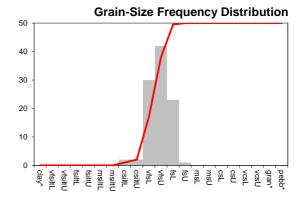


Key:White Grains: Quartz / Feldspar
Black Grains: Organic Matter
Turquoise Blue = Porosity

Field of View = 2.76mm Green / Brown Grains: Ductile Grains + Lithic Grains Brown Matrix: Detrital Clay +/- Deformed Ductile Grains

The thin-section is a legacy thin-section (provided by OSA / Santos). It has not been stained for K-feldspar (and therefore also probably not carbonate, although this is of little consequence, as apart from a scarce ductile-replacive microcrystalline phase [most likely siderite], no authigenic carbonate has been identified). A large patch of material has been plucked out of the thin-section during thin-section preparation, and material is also poorly preserved in the silty mudstone horizon at the base of the thin-section.

This sample is heterogeneous, and comprises a slightly thicker interval of well sorted, very fine-grained (Upper), highly lithic, very finely laminated sandstone, which sits above / below (way up is impossible to determine from such a small sample) an interval of finely laminated, silty



mudstone. The top part of the mudstone interval and the base of the sandstone interval show pronounced biogenic reworking, with sandstone material being incorporated into the mudstone horizon within mm-scale, to almost cm-scale, elongated / oval shaped burrow structures. The biogenic modification in the base of the sandstone interval is more diffuse (irregularly churned), although a mud-filled burrow is evident at the edge of the thin-section (and has been truncated by the edge of the thin-section).

As with the adjacent sample at 4689.0ft, compaction is pronounced in this sample, with ductile rock fragments and strands of organic matter being exceptionally highly plastically deformed, and framework grains showing highly elongated contacts. The pronounced compaction has near pervasively destroyed the primary pore network.

FRAMEWORK GRAINS (57.5%)

- Monocrystalline quartz (21.0%):
- Polycrystalline quartz (5.0%):
- Chert (3.0%):
- Feldspar (9.5%):
- Extrabasinal Rigid rock fragments (19.0%): the extrabasinal, rigid rock fragment suite is similar to that described in the adjacent sample (4689.0ft), except that carbonate grains are somewhat more abundant in this sample. As with sample 4689.0ft, the carbonate grains comprise monocrystalline and polycrystalline dolostone, and show pronounced oxidation (reddening), suggesting that the dolomite is possibly ferroan.
- Heavy minerals (trace):



page 2 of 2

Well: JW Dalton Depth: 4690.50ft DD

DUCTILE COMPONENTS (42.0%)

- **Ductile rock fragments** (23.0%): dominated by highly micaceous schist clasts, which show significant plastic deformation. The subordinate mudclasts present show even greater plastic deformation, and form patchy pseudo-matrix.
- Mica (2.0%):
- Detrital clay (11.5%):
- Organic matter (5.5%):

AUTHIGENIC COMPONENTS (0.5%)

Only scarce microcrystalline, ductile-replacive siderite has been identified.

RESERVOIR POTENTIAL

Porosity Data: \varnothing_{He} = naPermeability Data: K_h = naMacroporosity Data: \varnothing_{PRIM} = 0.5% \varnothing_{SIM} = trace \varnothing_{SOM} = 0% \varnothing_{MICRO} = na

The silty mudstone portion of this sample is clearly non-reservoir. The sandstone portion is relatively ductile-rich (abundant ductile rock fragments), and has been highly compacted, resulting in a near complete destruction of primary macroporosity. Only a very minor volume of exceptionally small, remnant primary macopores are preserved (most are <10µm in diameter, with a few up to ~20µm in diameter), which preferentially occur within cleaner burrow-fill structures (within the top of the mudstone horizon and base of the sandstone horizon). These are very poorly interconnected, and the burrow-fill structures that they occur in are isolated within more ductile-rich material, that lack macroporosity. Therefore, this sample is likely to have negligible to very poor reservoir quality.

J W Dalton 4690.50 TSD Brief.docx Sample Descriptions



Well: J W Dalton **Grain Size:** Classification: na 4694.5ft DD Depth: Sorting: na





Field of view= 19.5mm

Key:
White Grains: Quartz / Plagic

The thin-section is a legacy thin-section (provided by OSA / Santos). No textural or modal analysis has been undertaken upon this sample, as it is a silty mudstone. The thin-section has not been stained for K-feldspar, although otherwise it is of good quality.

This sample is a very finely laminated silty mudstone. It contains minor / highly subordinate, exceptionally thin, cleaner siltier / siltstone laminae (although cleaner they are still mud-prone in nature), most of which are barely 0.1-0.2mm thick (some are just a few grains thick). The siltstone laminae are thicker in the middle of the thin-section, where intercalated, exceptionally thin surfaces / laminae of organic-rich mudstone / mud-prone siltstone are also observed. Very finely particulate organic material is also relatively abundant throughout the dominant mudstone intervals.

The matrix clays are brown, with typically moderate birefringence, and are possibly principally illitic.

RESERVOIR POTENTIAL

Permeability Data: Porosity Data: $K_h = na$ $\emptyset_{He} = na$ **Macroporosity Data:** $\emptyset_{PRIM} = na$ Øsim = % Ø_{MICRO} = na \emptyset som = na

This sample has no reservoir potential, as it represents a mudstone (non-reservoir).

Sample Descriptions J W Dalton 4694.5 TSD Review.docx

page 1 of 2



Well: Kaolak Grain Size: 0.237mm (fsU) Classification: LS

Depth: 937.00ft DD Sorting: 0.644Ø (mws)

Thin-section scan

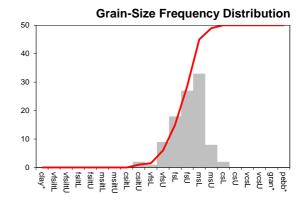




Field of view= 22mm

Key: Field of View = 2.76mm
White Grains: Quartz / Feldspar Beige / Brown / Black Grains: Ductile Grains + Lithic Grains
Dark Brown / Black Strands / Coatings: Detrital Clay + Stylolites

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section does not appear to have been stained for K-feldspar or carbonate. The resin has not been dyed, and is of poor quality, obscuring authigenic clays within primary pores, and grinding medium is locally observed obscuring mineral phases. The surface of the sample has not been polished / finished well, or evenly, and some grains, as well as finely particulate pore-filling material and pores, are difficult to resolve, with poor definition of some grain boundaries. This has made it difficult in some cases to differentiate deformed / compacted chert grains from pore-filling / replacive kaolinite (if there was an ambiguity, these area / patches were ignored during modal analysis). Overall, therefore, the quality of the thin-section is relatively poor.



This sample is a highly lithic, moderately well sorted, relatively clean, fine-grained (Upper) sandstone, which displays a broad / wide grain size laminated fabric. It is not too dissimilar to the sample at 2453.0ft, despite the ~1500ft gap between them, although this sample lacks organic matter (which is locally abundant in sample 2453.0ft), and despite having almost identical abundances of lithic grains (a whopping 65% in this sample and 66% in sample 2453.0ft), the abundance / proportion of chert in this sample is markedly higher, balanced by a notable decline in dolostone grains. In addition, this sample is more poorly sorted (wider range in grain size) than sample 2453.0ft, because it shows notable changes in grain size between the laminae (sample 2453.0ft is weakly foliated, with no grain size lamination evident).

As with sample 2453.0ft, this sample has also been intensely compacted (highly elongated grain contacts dominate, with subordinate sutured to stylolitised grain contacts). However, compaction is slightly weaker / less pronounced in this sample, and thus it preserves a slightly higher current intergranular volume (11%) and subtly more remnant primary macroporosity (3.4%) compared to sample 2453.0ft (which has an IGV of 6% and only 1.0% primary macroporosity).

FRAMEWORK GRAINS (78.0%)

- Monocrystalline quartz (18.0%):
- Polycrystalline quartz (15.5%):
- Chert (23.5%): exceptionally abundant in this sample, representing almost a quarter of the bulk mineralogy. The chert grains often, but not always, show concavo-convex grain contacts, with locally minor stylolitisation.
- Feldspar (5.5%):
- Extrabasinal Rigid rock fragments (15.5%):
- Heavy minerals (0%):



page 2 of 2

Well: Kaolak Depth: 937.00ft DD

DUCTILE COMPONENTS (16.0%)

- Ductile rock fragments (12.0%): as with all the Kaolak samples, the ductile rock fragments principally comprise
 highly micaceous schist fragments, which show moderate to notable plastic deformation. Although micadominated, these schist fragments still contain prominent (albeit highly subordinate relative to mica) quartz.
- Mica (0.5%):
- **Detrital clay** (3.5%):
- Organic matter (0%):

AUTHIGENIC COMPONENTS (6.0%)

Cementation is relatively light, with only minor pore-filling kaolinite (2.5%), microcrystalline, ductile-replacive siderite (1.5%), poorly developed quartz overgrowths (1.0%; forming very small, irregular projections on monocrystalline quartz grain surfaces) and microcrystalline, replacive rhombs of dolomite (1.0%; mostly replacive of chert grains) having been identified.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 3.4\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0\%$ $\varnothing_{MICRO} = na$

This sample contains minor, small, very irregular shaped, remnant primary macropores, which typically appear to be isolated relative to one another. There are little / no signs of corrosion, and hence secondary porosity, although the poor quality of the thin-section may have precluded identification. As alluded to above, the primary pore network of this sample has been significantly degraded, with most primary interparticle macropores being destroyed, by intense compaction (facilitated by the high abundance of lithic grains, in particular chert). Reservoir quality is expected to be negligible to possibly very poor.

Kaolak 937.00 TSD Brief.docx Sample Descriptions

page 1 of 2

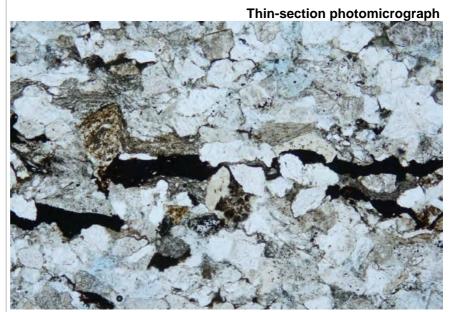


Well: Kaolak Grain Size: 0.261mm (msL) Classification: LS Depth: 2453.00ft DD Sorting: 0.498Ø (ws)

Thin-section scan



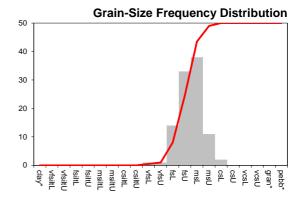




Key:White Grains: Quartz / Feldspar
Dark Brown / Black Strands / Coatings: Detrital Clay + Stylolites

Field of View = 2.76mm
Beige / Brown Grains: Ductile Grains + Lithic Grains
Black: Organic Matter

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section does not appear to have been stained for K-feldspar or carbonate. The resin has not been dyed, and is of poor quality, obscuring authigenic clays within primary pores, and grinding medium is locally observed obscuring mineral phases. The surface of the sample has not been polished / finished well, or evenly, and some grains, as well as finely particulate pore-filling material and pores, are difficult to resolve, with poor definition of some grain boundaries. This has made it difficult in some cases to differentiate deformed / compacted chert grains from pore-filling / replacive kaolinite (if there was an ambiguity, these area / patches were ignored during modal analysis). Overall, therefore, the quality of the thin-section is relatively poor.



This sample is a well sorted, extremely highly lithic (almost two thirds of the bulk mineralogy of this sample is represented by extrabasinal lithic grains), medium-grained (Lower) sandstone, and is the coarsest grained of the entire sample set from this study. It displays a weakly foliated fabric, although some lamination is evident by the presence of 2 extremely thin, organic-rich horizons. One of these organic-rich horizons show disruption of the organic material. Two extremely large intraclasts are evident (refer to ductile rock fragments below).

The most striking feature of this sample is its intensely compacted fabric. Grain contacts range from highly elongated to more rarely concavo-convex, although in the case of chert grains, common sutured to stylolitised grain contacts (chemical compaction) are observed (often with small, thin clay stylolites preserved). The abundant extrabasinal ductile rock fragments have been highly plastically deformed. Overall this sandstone sample appears to have lost approximately 80% of its original intergranular volume via compaction (the current measured primary intergranular volume is 6%, down from an original or depositional primary intergranular volume of ~34%).

FRAMEWORK GRAINS (71.5%)

- Monocrystalline quartz (11.5%); principally sub-angular in shape.
- **Polycrystalline quartz** (14.0%): these grains show a wide variation in crystallite size, mainly between individual grains (which range from coarsely crystalline through to very finely crystalline, and often grade into / overlap with chert grains), and more rarely within individual grains (most polycrystalline quartz grains are equigranular, but some show ineguigranular textures, with widely ranging crystallite size).
- Chert (18.5%): the chert grains, which are often better rounded in shape compared to all other framework grain types, range from relatively clean (dominant), through to somewhat clayey (minor) to highly clayey / dirty (subordinate). The chert grains show little signs of corrosion, but clearly show prominent chemical compaction (stylolitised grain contacts).

Kaolak 2453.00 TSD Full.docx Sample Descriptions

page 2 of 2



Well: Kaolak Depth: 2453.00ft DD

- **Feldspar** (5.0%): notably minor in this sample, and much rarer than noted in most of the other Nanushuk samples from this study. This is probably due to the coarser grain size of this sample compared to all the other samples from this study.
- Extrabasinal rigid rock fragments (22.5%): predominantly comprise a mixture of quartz-rich schist grains (metamorphic grains) and angular, to more typically to sub-rounded grains of dolomite / dolostone (monocrystalline and polycrystalline). Minor crystalline composites of feldspar and quartz (plutonic grains [note these lack chlorite, as noted in other wells from this study) and reworked sandstone clasts (very fine-grained, welded and most likely of extrabasinal, rather than intrabasinal, origin) have also been observed. The rigid rock fragment assemblage is completed by minor, highly altered / undifferentiated grains (indeterminate composition and origin).
- Heavy minerals (0%):

DUCTILE COMPONENTS (24.0%)

- **Ductile rock fragments** (15.5%): dominated by extrabasinal, metamorphic clasts, which are somewhat elongated in form (although this elongation has been extenuated by pronounced plastic deformation). These metamorphic clasts comprise mica-dominated quartz/mica schist and mica schist. Intrabasinal mudclasts are rare, with the minor abundance point-counted mainly representing the 2 large intraclasts in the top left hand corner of the thin-section. The smaller clast (~4mm in diameter) comprises mainly mudstone, with a few floating silt and sand grains. The larger clast (~10.5mm in diameter) comprise abundant very fine to fine grained sand grains, floating within a mud matrix. The matrix clays in both of these clasts is highly reddened (oxidised).
- **Mica** (0.5%): rare, partially altered flake of biotite.
- **Detrital clay** (1.5%): most of the minor grain-coating detrital clay point-counted actually represents stylolites (thin clay seams associated with stylolitised grain contacts).
- Organic matter (6.5%): organic material is typically scarce to very minor throughout most the sample, but is locally concentrated within 2 discrete, thin horizons. Here the organic matter forms extremely large / long strands (mm-scale, with some being up to 6mm long), which locally preserve a cellular (woody) structure. The organic material demonstrates significant plastic deformation.

AUTHIGENIC COMPONENTS (4.5%)

Although cementation is relatively light, as stated above, pronounced compaction has nearly completely destroyed the primary pore network of this sample (compactional porosity loss has been calculated at 28%, whilst cementational porosity loss has been calculated at only 4%). Most notably, quartz overgrowths are poorly developed in this sample (1.5% [small patchy overgrowths]), in contrast to the adjacent sample, at 4078.0ft, which has 13.5% quartz overgrowths, and although relatively highly compacted, is significantly less compacted compared to this sample (compactional porosity loss is 15.4% in sample 4078.0ft), despite being approximately 0.5km more deeply buried.

The most likely reason for the lower abundance of quartz cement and markedly greater compaction in this sample, compared to sample 4078.ft, are that this sample is exceptionally more highly lithic, and in particular chertiferous, and hence has markedly less monocrystalline quartz grains, compared to the sample at 4078.0ft (i.e. this sample is less chemically mature, and has markedly less surfaces [monocrystalline quartz grains] upon which quartz overgrowths could have nucleated – this sample has only 11.5% monocrystalline quartz grains, whereas sample 4078.0ft has 31.0% monocrystalline quartz grains, almost 3 times more in fact). The high abundance chert grains, and to a lesser extent highly micaceous extrabasinal rock fragments, has also facilitated greater compaction in this sample. Therefore, possibly the amount, or rather lack, of available space in which quartz could have precipitated may have also been a contributing factor as to why this sample is less quartz-cemented (i.e. if quartz overgrowths precipitated after the main phase of compaction).

Minor kaolinite (2.0%) and dolomite (1.0%) complete the authigenic assemblage. As with sample 4078.0ft, the dolomite is represented by small, subhedral rhombic projections, which precipitate off host dolomite grains, with rare microcrystalline, euhedral rhombs noted replacing chert grains. Due to a lack of staining, it is impossible to determine whether the dolomite is ferroan or non-ferroan. The kaolinite forms a patchy, coarsely crystalline primary pore-fill, and more rarely is replacive of framework grains (?feldspar grains). Paragenetic relationships are rarely observed, apart from kaolinite appearing to pre-date compaction (it shows significant compression [i.e. is highly compacted]), and some minor quartz overgrowths appearing to post-date tangential to slightly elongated grain contacts, but are inhibited by highly elongated / sutured grain contacts.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 1.0\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0\%$ $\varnothing_{MICRO} = na$

Remnant primary macropores are very minor and isolated, having been near completely destroyed by pronounced compaction. Reservoir quality is expected to be negligible.

Kaolak_2453.00 TSD_Full.docx

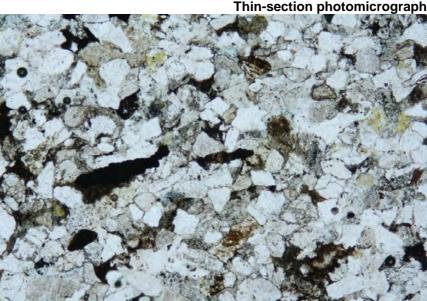
Sample Descriptions

page 1 of 1



Well: Kaolak Grain Size: 0.169mm (fsL) Classification: LS Depth: 3187.00ft DD Sorting: 0.484Ø (ws)

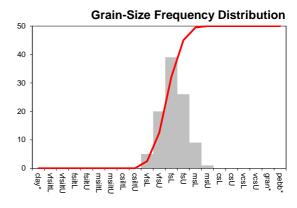




Field of view= 25mm

Key: Field of View = 2.76mm
White Grains: Quartz / Feldspar Beige / Brown / Black Grains: Ductile Grains + Lithic Grains
Dark Brown / Black Strands / Coatings: Detrital Clay + Stylolites
Pale Yellow Grains: K-feldspar (poorly stained)

The thin-section is a legacy thin-section (provided by OSA / Santos). Although K-feldspar grains The resin has not been dyed, and is of poor quality, obscuring authigenic clays within primary pores, and grinding medium is locally observed obscuring mineral phases. The surface of the sample has not been polished / finished well, or evenly, and some grains, as well as finely particulate pore-filling material and pores, are difficult to resolve, with poor definition of some grain boundaries. This has made it difficult in some cases to differentiate deformed / compacted chert grains from pore-filling / replacive kaolinite (if there was an ambiguity, these area / patches were ignored during modal analysis). Overall, therefore, the quality of the thin-section is relatively poor.



This sample is a well sorted, extremely highly lithic, relatively clean, fine-grained (Lower) sandstone, which displays a very weakly foliated fabric, defined by the preferred long axis orientation of elongated lithic and ductile grains. This sample is similar to the preceding samples, although is finer grained and slightly less lithic. As with the preceding samples, this sample has only minor authigenic cements.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 1.5\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0.5\%$ $\varnothing_{MICRO} = na$

Remnant primary macropores are minor, small and isolated, having been near completely destroyed by pronounced compaction. Reservoir quality is expected to be negligible.

Kaolak_3187.00 TSD_Review.docx
Sample Descriptions

page 1 of 2

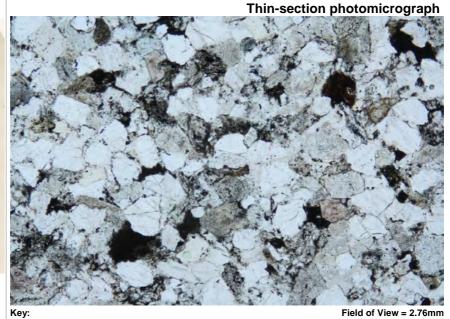


Well: Kaolak Grain Size: 0.194mm (fsU) Classification: LS
Depth: 4078ft DD Sorting: 0.400Ø (ws)

Thin-section scan

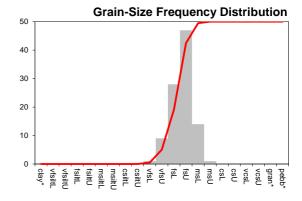


Field of view= 19mm



Key: Field of View = 2.76mm
White Grains: Quartz / Feldspar Beige / Brown / Black Grains: Ductile Grains + Lithic Grains
Dark Brown / Black Strands / Coatings: Detrital Clay + Stylolites

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section does not appear to have been stained for K-feldspar or carbonate. The resin has not been dyed, and is of poor quality, obscuring authigenic clays within primary pores. Also, some grains appear to have been plucked from the thin-section, and grinding / polishing medium (exceptionally finely particulate "dust") commonly obscures lithic grains and clays. It is, therefore, extremely difficult to observe / differentiate real holes (pores) from artefact holes (grain plucking), and differentiate grinding medium from microcrystalline oxide(s) that are also locally present overprinting grain-coating clay (both appear as very finely granular, opaque material). Overall, therefore, the quality of the thin-section is relatively poor.



This sample is a well sorted, extremely lithic, relatively clean, fine-grained (Upper) sandstone, which demonstrates a predominantly massive fabric. The prominent ductile grains (which are highly micaceous and mainly of extrabasinal origin) are patchily scattered throughout the sample, although appear to be subtly more abundant in the lower half of the thin-section, where slight churning / mottling is evident (the lower half of the thin-section appears slightly darker in colour than the upper half of the thin-section – refer to the thin-section scan above).

The most striking feature of this sample is its notably compacted fabric. Most rigid grain contacts are elongated (some are only partially elongated, through to others which are highly elongated), and ductile rock fragments show extremely pronounced plastic deformation. Overall this sandstone sample appears to have lost at least 50% of its original intergranular volume via compaction (the current measured primary intergranular volume is 19%, down from an original or depositional primary intergranular volume of ~34%).

FRAMEWORK GRAINS (67.0%)

- Monocrystalline quartz (31.0%): sub-angular to principally sub-rounded grains (a few are rounded in shape).
 Monocrystalline quartz grains are unusually abundant in this sample.
- Polycrystalline quartz (8.0%): these grains show a wide variation in crystallite size, mainly between individual
 grains (which range from coarsely crystalline through to very finely crystalline, and often grade into / overlap with
 chert grains), and more rarely within individual grains (most polycrystalline quartz grains are equigranular, but
 some show ineguigranular textures, with widely ranging crystallite size). There is also a clear gradation from
 quartzite (equigranular polycrystalline quartz grains) into quartz-schist (with minor / subordinate mica [pointcounted as metamorphic rigid rock fragments]).
- Chert (9.0%): predominantly clean, non-corroded grains, although some are quite dirty in nature. Grain contacts between chert and other rigid framework grains are often concavo-convex, and a few are sutured / crenulated (chert grains are more susceptible to chemical compaction than quartz grains and other lithic grains).

Kaolak 4078.00 TSD Full.docx Sample Descriptions

page 2 of 2



Well: Kaolak Depth: 4078ft DD

- **Feldspar** (8.0%): although the thin-section has not been stained for K-feldspar, most of the grains appear to comprise plagioclase, which often shows minor to moderate sericitisation. A very minor volume of twinned K-feldspar grains have been observed, along with a few grains of myrmekite (plagioclase inter-grown with thin strands of quartz). There are no signs of feldspar corrosion.
- Extrabasinal rigid rock fragments (11.0%): comprise a mixture of quartz-rich schist grains (metamorphic grains), crystalline composites of feldspar and quartz (plutonic grains), dolomite / carbonate grains (monocrystalline and polycrystalline) and altered / undifferentiated grains. Rare reworked sandstone clasts have also been observed. Rigid rock fragments are not as abundant as one might expect for the grain size of this sample, and in fact are noticeably rarer in this sample compared to all the others from this well (which have lower abundances of monocrystalline quartz).
- Heavy minerals (trace): extremely rare rounded grains of zircon.

DUCTILE COMPONENTS (17.5%)

- **Ductile rock fragments** (13.5%): dominated by highly micaceous quartz-mica schist fragments, which display notable plastic deformation. In most of the other wells in this study, these extrabasinal ductile rock fragments comprise mica-schist, with little if any quartz, rather than highly micaceous quartz-mica schist, as noted here.
- Mica (0%):
- **Detrital clay** (3.5%): minor, patchy, poorly developed (highly discontinuous) granular coatings on many, but by no means all, grain surfaces. The granular material forms particles / crystals that are typically sub-micron in size, and which possibly represent oxides (?anatase) which are replacive of precursor grain-coating detrital clay.
- Organic matter (0.5%): rare, extremely highly deformed particles / strands of organic material.

AUTHIGENIC COMPONENTS (15.5%)

This sandstone has been significantly overprinted by the following authigenic phases:

- Relatively abundant syntaxial **quartz overgrowths** (13.5%). These overgrowths are discontinuous, and appear more like outgrowths, which often precipitate or "balloon" outwards, occluding nearly every single remnant primary macropore (i.e. many resemble out-growths, rather than overgrowths). Most of the overgrowths / outgrowths are inhibited by elongated grain contacts, and post-date compaction in this sample. However, some overgrowths appears to have formed during, rather than after, compaction (the presence of abundant quartz overgrowths appears to have inhibited compaction. Note: compaction fabrics / compaction is more pronounced in the other Kaolak samples, compared to this sample, despite these samples having similar ductile abundances to this sample. This appears to be because the other Kaolak samples have markedly less quartz cement (only minor quartz overgrowths are present in these samples), which in turn appears to be in response to their significantly more lithic and less quartzose nature the other samples comprise between ~58.5-62.0% lithic grains and only ~11.0-17.5% monocrystalline quartz grains, whereas this sample has 36.5% lithic grains and 30.5% monocrystalline quartz grains (i.e. there are less quartz grain surfaces upon which quartz overgrowths could precipitate in the other samples). The other samples are also significantly more shallowly buried.
- Minor **dolomite** (0.5%). Represented by small, subhedral rhombic projections, up to approximately 20µm long, which precipitate off host dolomite grains, and are locally seen engulfed by quartz overgrowths. However, a few microcrystalline, euhedral rhombs have been noted replacing ductile and chert grains. Due to a lack of staining, it is impossible to determine whether the dolomite is ferroan or non-ferroan.
- Minor kaolinite (1.5%). This mainly primary pore-filling phase is very difficult to observe in this poor quality thin-section. In plane polarised light, the booklets and verms are almost invisible due to the poor quality of the resin. Whilst they are slightly more visible in cross polarised light, they are still difficult to resolve, and it has not been possible to capture any decent images of the kaolinite. Where possible to tell, the kaolinite appears relatively coarsely crystalline (booklets are possibly between 7-15µm in diameter), and forms small verms, which patchily occlude single / isolated primary pores. Locally the kaolinite is also seen completely replacing rigid framework grains (no remnant grain material is left, although they were most likely feldspar grains). The kaolinite verms and booklets are locally seen to be engulfed by quartz overgrowths.
- Trace anatase / oxides. Most of the oxide material seen in thin-section forms thin, discontinuous, minor
 granular coatings on grain surfaces, which appear to be replacive of precursor detrital clay (and as such have
 been point-counted as grain-coating detrital clay). However, a few slightly larger crystals of anatase (still
 microcrystalline in form) are locally seen residing at pore margins. These are completely engulfed by quartz
 overgrowths.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 0.5\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0\%$ $\varnothing_{MICRO} = na$

Remnant primary macropores are extremely rare and isolated (they represent rare pores which have not been occluded by quartz), as this sample has been highly compacted and quartz-cemented. Reservoir quality is expected to be negligible.

Kaolak 4078.00 TSD Full.docx Sample Descriptions

page 1 of 2



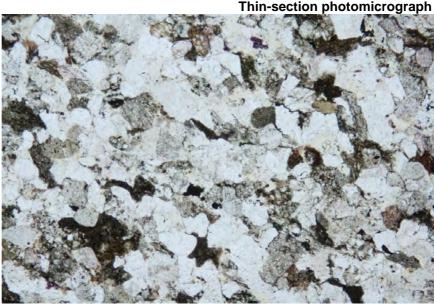
 Well:
 Meade
 Grain Size:
 0.174mm (fsL)
 Classification:
 LS

 Depth:
 2953.00ft DD
 Sorting:
 0.350Ø (ws)

Thin-section scan



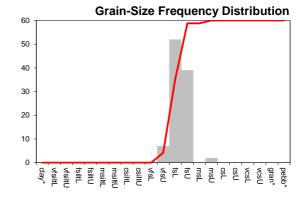
Field of view= 22mm



Key: Field of View = 2.76mm
White Grains: Quartz / Feldspar Beige / Brown / Black Grains: Ductile Grains + Lithic Grains
Dark Brown / Black Strands / Coatings: Detrital Clay + Stylolites

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section does not appear to have been stained for K-feldspar or carbonate. The resin has not been dyed, and is of poor quality, obscuring authigenic clays within primary pores. Also, some grains appear to have been plucked from the thin-section. It is, therefore, extremely difficult to observe / differentiate real holes (pores) from artefact holes (grain plucking). Overall, therefore, the quality of the thin-section is relatively poor.

This sample is a well sorted, clean, highly lithic, fine-grained (Lower bordering on Upper) sandstone, which demonstrates an essentially massive depositional fabric. Compaction is significant, although has clearly been stabilised somewhat by the presence of relatively abundant quartz cement. Where



quartz overgrowths are more poorly developed, grain contacts are highly elongated. Ductile grains are highly plastically deformed.

FRAMEWORK GRAINS (77.5%)

- Monocrystalline quartz (36.0%): sub-angular to sub-rounded grains. Monocrystalline quartz grains are unusually
 abundant in this sample, and notably abundant than in sample 4133.0ft from this well (which consequently also
 has less quartz cement than this sample, probably due to the lower abundance of host grains upon which to
 precipitate).
- **Polycrystalline quartz** (10.5%): these grains show a wide variation in crystallite size, mainly between individual grains (which range from coarsely crystalline through to very finely crystalline, and often grade into / overlap with chert grains), and more rarely within individual grains (most polycrystalline quartz grains are equigranular, but some show ineguigranular textures, with widely ranging crystallite size).
- Chert (10.5%): typically clean, although some grains are quite clayey / dirty. The chert grains are notably better rounded compared to the quartz grains.
- Feldspar (7.5%): although the thin-section has not been stained for K-feldspar, most of the grains appear to comprise plagioclase, which often shows minor to moderate sericitisation. A very minor volume of twinned K-feldspar grains have been observed. The feldspar grains rarely show signs of corrosion, and therefore the minor secondary oversized pores point-counted are more likely to represent holes (where grains have been plucked out during thin-section preparation) than actual real pores.
- Extrabasinal rigid rock fragments (13.0%): dominated by metamorphic schist fragments (quartz-dominated, with minor to subordinate mica), with minor volumes of crystalline quartz / feldspar composite grains (of indeterminate igneous / metamorphic derivation), volcanic grains, and extrabasinal sandstone clasts (welded / compacted silt to very fine-grained sandstone, with prominent ductile material).
- Heavy minerals (0%):



page 2 of 2

Well: Meade Depth: 2953.00ft DD

DUCTILE COMPONENTS (6.5%)

- **Ductile rock fragments** (4.5%): intrabasinal mudclasts only occur in very minor abundance in this sample. Most of the ductile rock fragments point-counted are of extrabasinal origin, and represent more highly micaceous quartz / mica schist grains (relative to their extrabasinal rigid counterparts), which show moderate plastic deformation. The mica-dominated schist fragments are not as highly micaceous as those seen in the other finer grained wells from this study (here the micaceous schist fragments tend to comprise 100% mica, with little, if any, quartz).
- Mica (0.5%): rare, small, highly altered flakes of mica.
- Detrital clay (1.0%): very poorly developed, exceptionally thin, discontinuous, brown clay coats.
- Organic matter (0.5%): very minor, scattered, irregular shaped particles, which show notable plastic deformation.

AUTHIGENIC COMPONENTS (164.0%)

The primary pore network of this sample has been significantly occluded by quartz cement (13.5%). The quartz forms thick, but typically discontinuous, syntaxial overgrowths, on the surface of monocrystalline quartz grains, which tend to balloon-outwards, filling adjacent primary macropores. The overgrowths appear to be inhibited by partially / moderately elongated overgrowths, but have inhibited further grain contact elongation, suggesting that they formed. Within small realms (only 3-4 grains), where monocrystalline quartz grains are se overgrowths are discontinuous, grain contacts are more highly elongated. The overgrowths, therefore, appear to have stabilised / inhibited more pronounced compaction. Very minor, thin, more poorly developed plagioclase overgrowths are also locally observed around some plagioclase grains. The plagioclase overgrowths appear to be overlain / engulfed by the quartz overgrowths.

Minor coarsely crystalline, vermiform, pore-filling kaolinite (2.0%) has locally been observed. Unfortunately, due to the poor quality of the thin-section, it is very difficult to identify the kaolinite (which is barely observable), and so it is possible that this phase has been somewhat underestimated. Fortunately, it was possible to observe that the kaolinite is engulfed by quartz overgrowths.

RESERVOIR POTENTIAL

Porosity Data: $\emptyset_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\emptyset_{PRIM} = 3.3\%$ $\emptyset_{SIM} = 0\%$ $\emptyset_{SOM} = 1.0\%$ $\emptyset_{MICRO} = na$

As noted above, the poor resin impregnation, combined with the localised plucking of grains / material from the thinsection, has often meant that it is difficult / impossible to differentiate real macropores (primary and secondary) from holes (artefact). Where possible to tell, it appears that remnant primary macropores are minor, isolated to poorly interconnected, and have been reduced significantly in size by compaction. They appear to be preserved where quartz overgrowths have not completely occluded adjacent pores, and they are therefore relatively small and irregular in shape.

The combination of pronounced compaction and abundant quartz cementation has resulted in the significant destruction of primary macroporosity, and hence reservoir quality. Reservoir quality is expected to be poor.

Meade 2953.0 TSD Full.docx Sample Descriptions

page 1 of 2



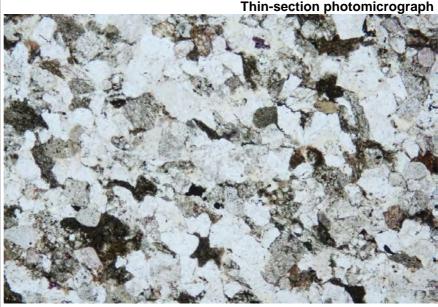
 Well:
 Meade
 Grain Size:
 0.191mm (fsU)
 Classification:
 LS

 Depth:
 4133.00ft DD
 Sorting:
 0.459Ø (ws)

Thin-section scan



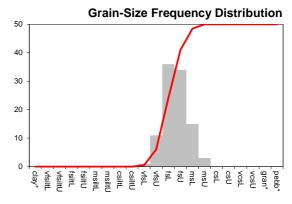
Field of view= 22mm



Key: Field of View = 2.76mm
White Grains: Quartz / Feldspar Beige / Brown / Black Grains: Ductile Grains + Lithic Grains
Dark Brown / Black Strands / Coatings: Detrital Clay + Stylolites

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section does not appear to have been stained for K-feldspar or carbonate. The resin has not been dyed, and is of poor quality, obscuring authigenic clays within primary pores. Also, some grains appear to have been plucked from the thin-section. It is, therefore, extremely difficult to observe / differentiate real holes (pores) from artefact holes (grain plucking). Overall, therefore, the quality of the thin-section is relatively poor.

This sample is a well sorted, clean, highly lithic, fine-grained (Upper) sandstone, which demonstrates an essentially massive depositional fabric. Compaction is pronounced, with a current estimated primary intergranular volume of 11%, down from an original / depositional primary intergranular



volume of ~39% (i.e. this sample has lost approximately 75% of its original intergranular volume through compaction). Grain contacts range from highly elongated to more rarely concavo-convex, although in the case of chert grains, common sutured to stylolitised grain contacts (chemical compaction) are locally observed (often with small, thin clay stylolites preserved). The prominent ductile rock fragments show pronounced plastic deformation, even the extrabasinal types (which are highly micaceous).

This sample is coarser grained, and consequently more highly lithic, than the other sample from this well (2953.0ft). It therefore is more highly compacted, and has less monocrystalline quartz grains, which probably account for the lower abundance of quartz overgrowths in this sample, compared to sample 2953.0ft.

FRAMEWORK GRAINS (75.0%)

- Monocrystalline quartz (23.5%): sub-angular to sub-rounded in shape.
- **Polycrystalline quartz** (10.0%): the polycrystalline quartz grains principally show equigranular / sub-equigranular textures, with minor inequigranular textures. There is a clear gradation into / overlap with chert, as well as with quartz schist fragments, suggesting that these framework grain types are all genetically related.
- Chert (8.0%): often show more rounded grain shapes compared to the monocrystalline quartz grains, and vary from clean through to clayey / dirty in form. Chemical compaction (styolitised clay coatings) is locally evident associated with chert grain contacts.
- Feldspar (9.5%): most of the twinned feldspar grains show plagioclase twinning, and where untwinned, show moderate alteration to sericite (which is a common feature of plagioclase, rather than K-feldspar). Therefore, feldspar grains are readily discernible from quartz grains, and principally comprise plagioclase. A few of the feldspar grains, however, show cross-hatch twinning, and so very minor volumes of the feldspar comprises K-feldspar.
- Extrabasinal rigid rock fragments (24.0%): characteristically for the Nanushuk, the rigid extrabasinal rock fragment suite in this sample is dominated by metamorphic clasts, mainly quartz-dominated quartz / mica schist,

Meade 4133.0 TSD Full.docx Sample Descriptions



page 2 of 2

Well: Meade Depth: 4133.00ft DD

with rarer exceptionally finely crystalline, welded metasedimentary clasts (some are slate, others appear more hornfels like). Minor plutonic (indeterminate igneous / metamorphic) grains quartz + feldspar +/- chlorite are also observed, along with reworked sedimentary grains (welded sandstone and dolostone). The dolostone grains are predominantly monocrystalline, and more rarely polycrystalline, and do not show reddening, as they do in sample 2953.0ft from this well. The monocrystalline dolostone grains often, but not always, retain their original rhombic shapes (but are clearly detrital grains). Trace highly altered volcanic grains (possibly basaltic) and volcanic glass have been observed, along with scarce, green highly altered (?chloritised) grains.

• Heavy minerals (0%):

DUCTILE COMPONENTS (13.0%)

- Ductile rock fragments (10.5%): intrabasinal mudclasts only occur in minor abundance in this sample. Most of
 the ductile rock fragments point-counted are of extrabasinal origin, and represent more highly micaceous quartz /
 mica schist grains (relative to their extrabasinal rigid counterparts), which show moderate to pronounced plastic
 deformation. The mica-dominated schist fragments are not as highly micaceous as those seen in the other finer
 grained wells from this study (here the micaceous schist fragments tend to comprise 100% mica, with little, if any,
 quartz).
- Mica (1.5%): dominated by biotite and highly altered flakes (possibly originally biotite). No muscovite has been
 identified.
- **Detrital clay** (0.5%): scarce, dark / black coatings around the surface of a few framework grains. The granular nature of the coatings suggest the material, if originally clay, has subsequently been replaced by some form of oxide.
- Organic matter (0.5%): rare, irregular shaped, highly plastically deformed particles of organic material.

AUTHIGENIC COMPONENTS (12.0%)

Although prominent, syntaxial quartz overgrowths (9.0%) are more irregular-shaped in this sample compared to the other Meade sample (2953.0ft). In sample 2953.0ft, quartz overgrowths were more continuous in form. Here they tend to cover much smaller surface areas of their host monocrystalline quartz grains, although are thick, and tend to balloon-outwards, occluding nearly every remnant primary macropore (i.e. they have a pore-filling habit, rather than a pore-reducing habit). Comparatively, the quartz overgrowths appear to post-date greater grain contact elongation in this sample than they do in sample 2953.0ft. Therefore, compaction appears to have been somewhat more advanced in this sample prior to quartz cementation compared to sample 2953.0ft. This probably reflects a combination of the greater depth of burial of this sample, and its more lithic / ductile nature (this sample has 10.5% ductile grains, whereas sample 2953.0ft has only 4.5% ductile grains).

The minor siderite present (2.0%) forms dense clusters of extremely small (microcrystalline) crystals, which preferentially replace micas and micaceous-rich lithic grains. The siderite appears reddened (oxidised).

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 0.5\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0\%$ $\varnothing_{MICRO} = na$

The primary pore network in this sample has been near-pervasively destroyed by pronounced compaction, and to a lesser extent prominent quartz cementation (approximately 75% of the primary macroporosity has been destroyed by compaction, with approximately 25% of the primary macroporosity being destroyed by quartz cementation). The scarce to very minor remnant primary macropores are very small and isolated. No secondary macroporosity has been observed.

Reservoir quality is therefore expected to be negligible to very poor.

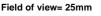
Meade 4133.0 TSD Full.docx Sample Descriptions

page 1 of 1



Well:Oumalik Test Well-1Grain Size:naClassification:naDepth:525.0ft DDSorting:na





Thin-section photomicrograph

Key:White Grains: Quartz / Plagioclass
Brown Matrix: Detrital Clay

Field of View = 2.76mm Black: Pyrite / Organic Matter

The thin-section is a legacy thin-section (provided by OSA / Santos). No textural or modal analysis has been undertaken upon this sample, as it is a mudstone.

This sample is a mudstone (possibly dolomitised mudstone [see below]), which contains subordinate silt grains (mainly fine to medium silt, with rare coarse silt grains). The silt grains are preferentially concentrated within cleaner, albeit still mud-prone), irregular shaped realms, which clearly represent biogenic structures. In fact, the whole fabric of the mudstone material in thin-section appears highly churned, with the disruption consistent with biogenic reworking of the sediment. Very small particles of organic material occur throughout the mudstone (these too are fine to medium silt grade), although are overall of minor abundance. A few thin, elongated strands of organic material are also locally evident.

The matrix clay / mud appears pale brown in colour at low magnification. At higher magnification, this pale colour is attributable to the fact that clay / mud matrix has been pervasively overprinted by microcrystalline carbonate, which forms a tight mosaic of extremely small crystals, that are only a few microns in diameter, up to 10 microns in diameter. It is not known if the thin-section has been stained for carbonate, and therefore it is not possible to tell whether the carbonate represents calcite, siderite or dolomite, although given its pale colour and weakly pleochroic nature, suggests either calcite or dolomite, in preference to siderite. Dolomite is considered most likely.

The sample is cross-cut by a single series of parallel, enechelon (slightly over-lapping) micro-fractures, running the entire length of the thin-section, that are pervasively cemented by carbonate. The micro-fractures are only ~150-200µm in width, and the tightly crystalline carbonate filling them forms microcrystalline to very finely crystalline, subhedral, to more rarely euhedral rhombs (most range in size from ~10-60µm in diameter). The colourless carbonate in the micro-fractures is weakly to moderately pleochroic, suggesting that it is either calcite or dolomite.

At the very base of the thin-section is a nodule of carbonate, with similar properties to the carbonate noted in the microfractures. Unfortunately much of the nodule has been truncated by the edge of the thin-section. The carbonate rhombs at the edge of the nodule, which form a thin outer margin, are markedly more finely crystalline (mainly microcrystalline) compared to the carbonate rhombs that form the nodule (here the rhombs are up to 250µm in diameter, and much better crystalline, often forming euhedral rhombs). The shape of the rhombs is more consistent with dolomite than calcite. Very little matrix clay is apparent within the nodule, with the carbonate crystals appearing pristine / clean, although a few floating masses of matrix clay do occur towards to the edge of the nodule. These appears to have been replaced by microcrystalline carbonate (identical to that noted in the bulk of the mudstone), which is engulfed by the more coarsely crystalline, nodule-fill carbonate, suggesting that the carbonate phases are paragenetically different, and maybe unrelated to one another.

RESERVOIR POTENTIAL

Porosity Data: $\emptyset_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\emptyset_{PRIM} = na$ $\emptyset_{SIM} = \%$ $\emptyset_{SOM} = na$ $\emptyset_{MICRO} = na$

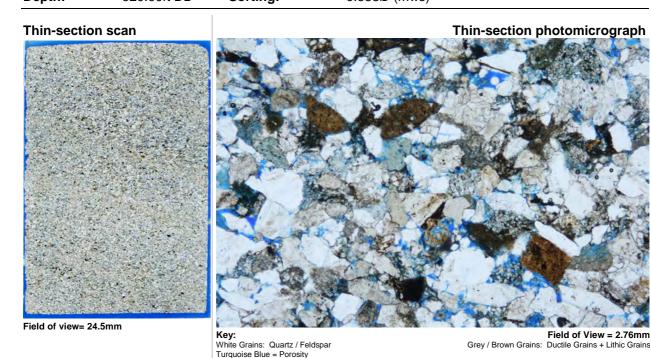
This sample has no reservoir potential, as it is a tightly carbonate-cemented mudstone.

Oumalik 525.0 TSD Review.docx Sample Descriptions

page 1 of 2

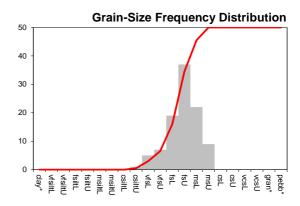


Well: Oumalik Grain Size: 0.217mm (fsU) Classification: LS Depth: 920.00ft DD Sorting: 0.638Ø (mws)



The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section does not appear to have been stained for K-feldspar or carbonate, but is otherwise of good quality.

This sample is a moderately well sorted, overall fine-grained (Upper), highly lithic, relatively clean sandstone (ductile grains are prominent, but not abundant, and mainly of extrabasinal / lithic origin, with no detrital clay, mica plates or organic particles evident). The depositional fabric appears to be broadly grain size laminated (mm-scale to almost cm-scale changes in grain size). The wide difference in grain size between the laminae is primarily responsible for the wide range in grain size (coarse silt to medium sand), with most individual laminae appearing relatively well sorted.



Compaction is moderate, with most grains demonstrating elongated grain contacts. Overall this sample appears to have lost approximately 40% of its original primary intergranular volume through compaction of the grain framework. Chert grains locally demonstrate some minor chemical compaction (small, clayey stylolites), and ductile grains tend to demonstrate moderate to pronounced plastic deformation.

FRAMEWORK GRAINS (62.5%)

- Monocrystalline quartz (17.5%): predominantly sub-angular in shape.
- **Polycrystalline quartz** (3.5%): most of the polycrystalline grains in this sample are chert grade. Those point-counted as polycrystalline quartz are notably more coarsely crystalline compared to the chert grains, and often, but not always, demonstrate inequigranular, rather than equigranular, textures.
- Chert (13.5%): principally demonstrate sub-rounded to rounded shapes. Some chert grains show replacement by euhedral, microcrystalline carbonate rhombs, which share similar properties to the detrital polycrystalline carbonate grains (which appear dolomitic / dolostone). This microcrystalline carbonate is not seen replacing any other detrital grain type, and is commonly seen replacing chert grains in all wells which also contain reworked, detrital dolomite grains. These carbonate / dolomite replaced chert grains (which are overall a highly subordinate / minor component of the total chert grains present) therefore possibly represent chertiferous material genetically related to the dolostone material (e.g. chertiferous dolostone, chertiferous dolomitised mudstone, etc.). The chert grains are typically clean, although more clayey / dirty-looking chert grains are common. The chert grains locally demonstrate spongy textures (partially corroded, generating secondary microporosity).
- **Feldspar** (9.5%): K-feldspar twinning is commonly seen, although overall plagioclase appears to be the dominant feldspar type. Both K-feldspar, but in particular plagioclase, grains locally demonstrate partial to advanced corrosion, generating minor secondary macroporosity (mostly intraparticle, and more rarely oversized).

Oumalik 920.00 TSD Full.docx Sample Descriptions

page 2 of 2



Well: Oumalik Depth: 920.00ft DD

 Extrabasinal rigid rock fragments (18.5%): predominantly comprise metamorphic schist fragments and sedimentary dolostone grains (polycrystalline > monocrystalline). Minor crystalline quartz / feldspar + chlorite composite grains (plutonic) and highly altered (often spongy) volcanic grains have also been identified. A few reworked siltstone / sandstone grains have also been observed, some of which have had their matrices corroded / removed.

• Heavy minerals (0%):

DUCTILE COMPONENTS (12.0%)

- **Ductile rock fragments** (12.0%): dominated by more highly micaceous extrabasinal schist clasts (quartz is subordinate, but is still often present in these mica-dominated clasts), whose high mica contents means that they are susceptible to plastic deformation.
- Mica (0%):
- Detrital clay (0%):
- Organic matter (0%):

AUTHIGENIC COMPONENTS (25.5%)

This sample has been significantly diagenetically modified, predominantly by carbonate (18.5%), with minor kaolinite (4.0%), quartz overgrowths (2.0%) and undifferentiated authigenic clay (1.0%). Trace replacive microcrystalline siderite has also been observed.

The **carbonate** forms a patchy, but overall quite abundant, pore-filling cement, which is more rarely replacive of detrital grains. It often forms more finely crystalline fringes around many of the detrital dolomite grains. However, it also patchily forms a coarsely crystalline, poikilotopic, pore-filling cement. The coarse, poikilotopic habit is more consistent with calcite, whereas the grain-fringing habit is more consistent with dolomite. However, in the absence of carbonate staining, it is not possible to determine whether this phases comprises calcite, dolomite or a mixture of the 2 species.

The **kaolinite** is vermiform, with individual plates within the verms ranging widely in size from ~5µm to ~20µm in diameter. The verms are extremely loosely packed (highly microporous in nature), and preferentially occlude primary pores, although are also seen replacing plagioclase grains.

The minor **quartz overgrowths** are syntaxial, and typically poorly developed (small and discontinuous), although a few overgrowths are seen covering more than 50% of their host monocrystalline grain surfaces. Exceptionally small (few microns diameter) incipient quartz overgrowths are locally seen around the surfaces of some chert and polycrystalline quartz grains.

The minor **undifferentiated** authigenic clay appears green and spongy in thin-section (the green colour is probably due to resin impregnation within the intercrystalline microporosity). It is so finely crystalline, that crystals are barely perceptible in thin-section. This has made it impossible to determine its composition. It preferentially replaces highly corroded detrital grains and micas, and is of unknown composition.

The following paragenetic relationships have been observed:

- Quartz overgrowths are overlain by pore-filling undifferentiated carbonate.
- The pore-filling, undifferentiated carbonate appears to overlie pore-filling kaolinite, and is inhibited by elongated grain contacts.
- Quartz overgrowths engulf kaolinite booklets / verms.
- The pore-filling carbonate appears to post-date grain contact elongation, although in some areas, where the carbonate is better developed, the grain fabrics appear slightly more open (suggests that although the carbonate precipitated later during burial, post-dating some compaction, it possibly inhibited later / further compaction).

RESERVOIR POTENTIAL

Porosity Data: \emptyset_{He} = naPermeability Data: K_h = naMacroporosity Data: \emptyset_{PRIM} = 1.9% \emptyset_{SIM} = 2.8% \emptyset_{SOM} = 0.5% \emptyset_{MICRO} = na

Remnant primary macropores are minor in overall volume, extremely small, and range from isolated to poorly interconnected. A few are locally enlarged by advanced corrosion of feldspar / chert grains, generating very minor secondary oversized pores. However, most of the secondary porosity is intraparticle in nature (very small pores trapped within the non-corroded remnants of the host grain). Reservoir quality is expected to be relatively poor, and has been severely degraded by notable cementation (mainly carbonate) and moderate compaction.

Oumalik_920.00 TSD_Full.docx
Sample Descriptions

page 1 of 1



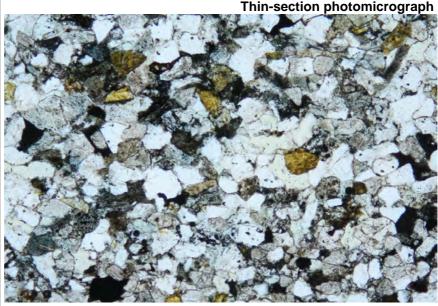
Well: Oumalik Grain Size: 0.163mm (fsL) Classification: LS

Depth: 979.00ft DD Sorting: 0.418Ø (ws)

Thin-section scan



Field of view= 21mm



Key:White Grains: Quartz / Plagioclase Yellow Grains: K-feldspar

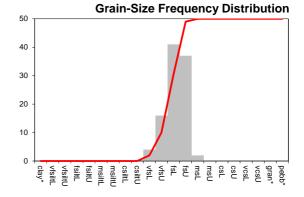
Field of View = 2.76mm

Dark Grey / Brown Grains: Ductile Grains + Lithic Grains

Black: Organic Matter

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has been stained for K-feldspar, but poorly. Carbonate staining has been applied, but again the quality is poor (some grains, which do not appear to be carbonate in composition, have been intensely pink stained, with the staining completely obscuring the composition / nature of the grains). The resin has not been dyed, and it is extremely difficult to observe porosity in this sample. The quality of the thin-section is overall relatively poor (this thin-section is clearly made by a different contractor to the previous thin-section [920.0ft], and looks much older in nature).

This sample is a very weakly laminated, well sorted, finegrained (Lower), exceptionally highly lithic sandstone, which



locally contains thin, variably continuous organic-rich laminae. This sandstone is notably finer grained relative to the previous sample from this well, and consequently has more ductile material (organic matter and ductile grains). However, despite being finer grained, it is more highly lithic, and in particular contains more abundant polycrystalline quartz and extrabasinal metamorphic schist fragments (both rigid and ductile [this sample has a total of 18.0%, whereas the previous sample has a total of 14.0%]).

This sample has been intensely compacted (it has lost approximately 85% of its original primary intergranular volume through compaction), with ductile material showing pronounced plastic deformation, rigid grains showing highly elongated, to more rarely concavo-convex, contacts, and small stylolites developed along chert grain contacts (some chemical compaction appears to be associated with chert grains). This sample is significantly more highly compacted relative to the previous sample. This could be due in part to its more highly lithic and ductile nature. However, it is also likely due to the absence of carbonate cement (which is abundant in the previous sample, but scarce in this sample).

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 2.4\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0.5\%$ $\varnothing_{MICRO} = na$

This sample has been intensely compacted, and contains only minor, poorly interconnected primary interparticle macropores. Reservoir quality is likely to be relatively poor.

Oumalik 979.00 TSD Review.docx Sample Descriptions

page 1 of 2



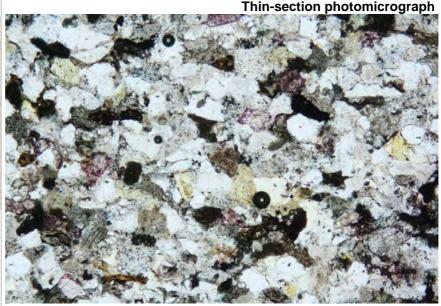
Well: Oumalik Grain Size: 0.160mm (fsL) Classification: LS

Depth: 1606.00ft DD Sorting: 0.462Ø (ws)

Thin-section scan



Field of view= 21mm



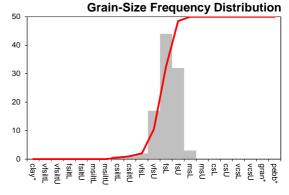
Key:White Grains: Quartz / Plagioclase Yellow Grains: K-feldspar

Field of View = 2.76mm

Dark Grey-Black / Brown Grains: Ductile Grains + Lithic Grains

Black: Organic Matter

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has been stained for K-feldspar, but very poorly (some K-feldspar grains remain unstained, and with others the staining has "dragged-over" onto non-K-feldspar grains). Therefore, it has not been possible to point-count K-feldspar accurately in this sample (all feldspar has been point-counted together as undifferentiated). Carbonate staining has been applied, but again the quality is poor (some grains, which do not appear to be carbonate in composition, have been intensely pink stained, with the staining completely obscuring the composition / nature of these grains). The resin has not been dyed, and the surface of the sample has been very poorly polished, with notable inclusion of grinding medium within pores, and hence it is



extremely difficult to observe porosity and any authigenic clays that maybe present within pores. Overall the quality of the thin-section is poor.

This sample is a well sorted, fine-grained (Lower), exceptionally highly lithic sandstone, which displays an apparently massive fabric (Note: the darker patches / streaks observable on the thin-section scan above are artefact, representing poor surface preparation and scratches / cracks caused during polishing). Despite being finer grained than sample 920.0ft from this well, it is markedly more highly lithic, and in particular contains significantly more abundant chert, polycrystalline quartz and metamorphic schist clasts.

This sample has been intensely compacted (it has lost over 80% of its original primary intergranular volume through compaction), with ductile material showing pronounced plastic deformation and rigid grains showing highly elongated to concavo-convex contacts (particularly in relation to grain contacts associated with chert grains). Small stylolites are locally developed along chert grain contacts (some chemical compaction appears to be associated with chert grains). This sample is significantly more highly compacted relative to sample 920.0ft. This could be due in part to its more highly lithic / chertiferous nature. However, it is also likely due to the scarcity of carbonate cement (which is abundant in sample 920.0ft).

FRAMEWORK GRAINS (80.0%)

- Monocrystalline quartz (18.0%): sub-angular to more rarely sub-rounded in shape.
- **Polycrystalline quartz** (9.5%): principally finely crystalline and equigranular to sub-equigranular in form (with rarer inequigranular textures). Some of the polycrystalline quartz grains are very finely crystalline and grade into (overlap with) chert.
- Chert (19.0%): extremely abundant in this sample, and the grains show more pronounced grain contact elongation, as well as often cancavo-convex contacts, compared to their more rigid framework grain counterparts. The grains range from clean through to dirty, and rarely show signs of corrosion.

Oumalik 1606.00 TSD Full.docx Sample Descriptions



page 2 of 2

Well: Oumalik Depth: 1606.00ft DD

- **Feldspar** (9.5%): dominated by plagioclase, which often shows some degree of alteration / sericitisation (minor to pronounced [derived]), with minor K-feldspar. The feldspar grains rarely appear corroded, although resin impregnation and quality is poor, making it very difficult to identify small secondary pores.
- Extrabasinal rigid rock fragments (23.5%): characteristically for the Nanushuk, the rigid extrabasinal rock fragment suite in this sample is dominated by metamorphic clasts, mainly quartz-dominated quartz / mica schist, with rarer exceptionally finely crystalline, welded metasedimentary clasts (some are slate, others appear more hornfels like). Minor plutonic (indeterminate igneous / metamorphic) grains of quartz + feldspar are also observed, along with reworked sedimentary grains (welded sandstone and dolostone). The dolostone grains are predominantly polycrystalline, and more rarely monocrystalline.
- **Heavy minerals** (0.5%): rare, very small grains of garnet noted.

DUCTILE COMPONENTS (14.0%)

- **Ductile rock fragments** (12.0%): dominated by more highly micaceous extrabasinal schist clasts (quartz is subordinate, but is still often present in these mica-dominated clasts), whose high mica contents means that they are susceptible to plastic deformation. Minor, highly plastically deformed, brown intrabasinal mudclasts have also been observed.
- Mica (1.0%): very minor flakes of biotite and undifferentiated, highly altered mica.
- Detrital clay (0%):
- Organic matter (1.0%): scattered, small, irregularly shaped particles of organic material.

AUTHIGENIC COMPONENTS (6.0%)

This sample has been poorly overprinted by authigenic cements, containing only minor volumes of quartz (2.5%) and kaolinite (2.5%), with relatively scarce (0.5%) carbonate and anatase:

- The authigenic quartz forms minor, small, highly discontinuous, syntaxial overgrowths.
- **Kaolinite** is difficult to resolve in this thin-section, due to its poor quality (surface finishing is poor, grinding medium significantly coats the kaolinite, and the quality of the resin is poor). Where kaolinite is identified, therefore, its morphology and characteristics are difficult to resolve. It is possible, however, to determine that this phase principally occludes primary macropores, and is a minor component of the sample.
- The poorly stained, undifferentiated carbonate forms small outgrowths and thin discontinuous fringes around host detrital carbonate grains. The authigenic carbonate has been completely obscured by thick, cracked staining material, and it is impossible to gain any petrographical properties from the carbonate (e.g. it is impossible to identify pleochroism, birefringence, relief, cleavage and colour). Given that universally in the Nanushuk the detrital carbonate grains comprise dolomite, and that in other wells from this study the authigenic carbonate that precipitates off host detrital dolomite grains also appears to be dolomite, would suggest that the authigenic carbonate here is also dolomite. However, it is not possible to definitively determine whether this authigenic carbonate is dolomite, and hence one cannot rule out the possibility that it is calcite.
- Anatase locally forms isolated / single, microcrystalline crystals at pore margins.

Due to their scarce / minor abundance and the poor quality of the thin-section, it has not been possible to identify any paragenetic relationships.

RESERVOIR POTENTIAL

Porosity Data: \varnothing_{He} = naPermeability Data: K_h = naMacroporosity Data: \varnothing_{PRIM} = 1.5% \varnothing_{SIM} = 0% \varnothing_{SOM} = 0% \varnothing_{MICRO} = na

This sample has been intensely compacted, and contains only minor, small, poorly interconnected remnant primary interparticle macropores. Reservoir quality is likely to be poor.

Oumalik_1606.00 TSD_Full.docx
Sample Descriptions

page 1 of 2

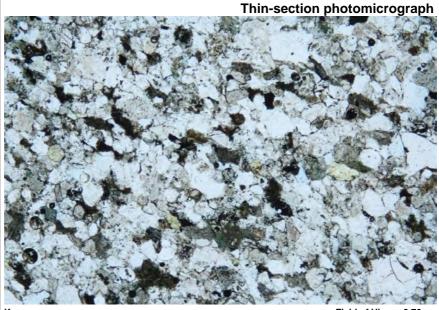


Well: Oumalik Grain Size: 0.121mm (vfsU) Classification: LS

Depth: 3260.00ft DD Sorting: 0.504Ø (mws)

Thin-section scan

Field of view= 21mm

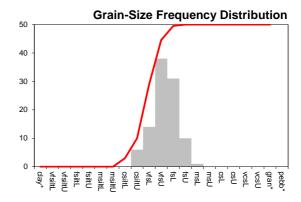


Key:White Grains: Quartz / Plagioclase
Pale Yellow Grains: K-feldspar (poorly stained)

Field of View = 2.76mm

Dark Grey-Black / Brown Grains: Ductile Grains + Lithic Grains

The thin-section is a legacy thin-section (provided by OSA / Santos). The section has been stained for K-feldspar and carbonate, but the staining is inadequate and poor (many K-feldspar grains lack staining, and where stained, the staining is so weak, it is often almost imperceptible. Carbonate grains and cement has often not been stained, and where stained, the staining is so intense, and of unusual [non-diagnostic] colour, that the carbonate it stains is impossible to view under the stain). The resin has not been dyed, and the surface of the sample has been very poorly polished, with notable inclusion of grinding medium within pores, and hence it is extremely difficult to observe porosity and any authigenic clays that maybe present within pores. Overall the quality of the thin-section is poor.



This sample is a moderately well sorted, very fine-grained (Upper), highly lithic sandstone, which is relatively clean, although does contain prominent, highly micaceous schist fragments (which are prone to ductile deformation). A relatively massive fabric is shown throughout, and the sample is locally dotted with notably larger (over-sized) grains, up to msU (to almost csL) grade. Compaction is variable, although overall pronounced. In very small realms (submm scale), where monocrystalline quartz grains are adjacent to one another, compaction is less pronounced, and grain contacts, whilst elongated, are not as highly elongated as they are within more lithic-rich realms. In these more quartz-rich realms, quartz overgrowths are well / better developed, and appear to post-date some grain contact elongation, but clearly inhibit further grain contact elongation.

This sample has notably more monocrystalline quartz grains and quartz overgrowths, and significantly less chert grains, compared to the sample at 1606.0ft, and therefore, is overall less compacted – this sample has lost approximately 62% of its original porosity via compaction, whereas sample 1606.0ft has lost approximately 82% of its original porosity via compaction.

FRAMEWORK GRAINS (73.5%)

- Monocrystalline quartz (26.5%):
- Polycrystalline quartz (7.5%):
- Chert (6.5%):
- Feldspar (10.0%):
- Extrabasinal Rigid rock fragments (22.5%): the rigid rock fragment assemblage is similar to that described in sample 1606.0ft, and is again dominated by metamorphic clasts, mainly quartz-dominated quartz/mica schist. The metamorphic schist fragments which are more highly micaceous in nature, and which consequently show notable plastic deformation, have been point-counted as extrabasinal ductile rock fragments.
- Heavy minerals (0.5%): garnet.



page 2 of 2

Well: Oumalik Depth: 3260.00ft DD

DUCTILE COMPONENTS (15.5%)

- Ductile rock fragments (11.0%):
- Mica (1.5%):
- Detrital clay (3.0%):
- Organic matter (0%):

AUTHIGENIC COMPONENTS (11.0%)

This sample is more highly quartz-cemented (8.5%) compared to the previous sample described from this well (sample 1606.0ft contains only minor quartz overgrowths [2.5%]). This is possibly related to the greater abundance of host monocrystalline quartz grains in this sample compared to sample 1606.0ft. The quartz overgrowths here are variably developed, but are never highly continuous (they have more of a pore-filling habit), as they appear to be inhibited by moderate grain contact elongation. The fact that within small realms, where they are better developed, more significant grain contact elongation is not seen (as seen elsewhere in the sample), suggests that quartz precipitated during burial, but before maximum burial.

Minor authigenic carbonate (1.0%) is locally seen forming a pore-filling, patchy cement, and is more rarely seen precipitated on / around host detrital dolomite grains. Whilst detrital dolomite grains are seen within the patches of carbonate cement, they are not in optical continuity with the cement. The cement is also locally coarsely crystalline, and bordering on poikilotopic. These features are consistent with pore-filling calcite seen in previously studied Nanushuk wells, but in the absence of staining (or rather reliable staining), it is impossible to definitively determine whether this cement represents calcite or dolomite.

Scarce (0.5% each) pore-filling kaolinite, grain-replacive anatase and thin, discontinuous plagioclase overgrowths have also been observed.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 0\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0\%$ $\varnothing_{MICRO} = na$

This sandstone has no visible macroporosity. The entire primary pore network has been destroyed, mainly by pronounced compaction, and to a lesser extent prominent quartz cementation (which pervasively occludes primary pores that have already been significantly reduced in size by compaction). This sample, therefore, is expected to have negligible reservoir quality.

Oumalik 3260.00 TSD Brief.docx Sample Descriptions

page 1 of 1



Well: Oumalik Grain Size: 0.044mm (csiltU) Classification: LW Depth: 4685.00ft DD Sorting: 0.499Ø (ws)



Thin-section photomicrograph

Field of view= 23mm

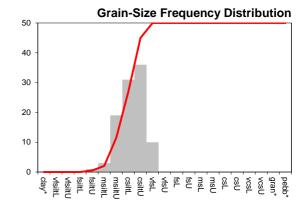
Key: White Grains: Quartz / Feldspar Black: Organic Matter

Field of View = 2.76mm Brown Matrix: Detrital Clay

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has not been stained for K-feldspar or carbonate. However, the quality of the thin-section is good.

This sample is a laminated, mud-prone siltstone. The lamination is defined by subtle to locally significant changes in grain size and ductile / mud content, although even the slightly coarser grained siltstone laminae are still ductile-rich / mud-prone, and devoid of macroporosity. The abundant, pervasive, pore-filling matrix clay is brown, with mainly moderate birefringence, suggestive of a predominantly illitic composition.

Extremely small carbonate (?dolomite) grains are relatively abundant, and dominate the rigid lithic grain assemblage.



RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 0\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0\%$ $\varnothing_{MICRO} = na$

This mud-prone siltstone is devoid of macroporosity, and thus has no reservoir potential.

Oumalik_4685.00 TSD_Review.docx

Sample Descriptions

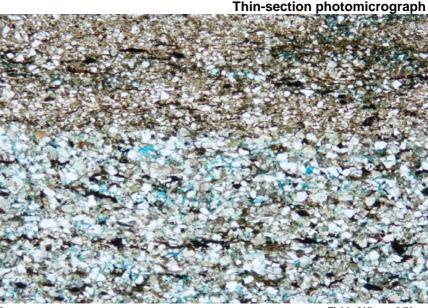
page 1 of 2



Well: Oumalik Grain Size: 0.050mm (csiltU) Classification: LW Depth: 6670.00ft DD Sorting: 0.0483Ø (ws)

Thin-section scan





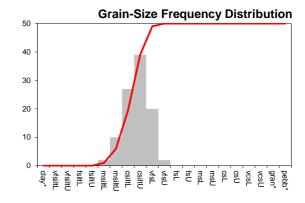
Key:White Grains: Quartz / Feldspar
Black: Organic Matter
Turquoise Blue = Porosity

Field of View = 2.76mm
Grey / Brown Grains: Ductile Grains + Lithic Grains
Brown Matrix: Detrital Clay

Field of view= 19mm

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section does not appear to have been stained for K-feldspar or carbonate, but is otherwise of good quality.

This sample is a laminated, well sorted, mud-prone, coarse siltstone, which. The lamination is characterised by changes in grain size and ductile (typically detrital clay) abundance, with the finer grained laminae (medium to coarse Lower siltstone) being more mud-prone than the coarser grained laminae (coarse siltstone Upper to very fine sand Lower). Organic material is locally concentrated within a few thin horizons. Although most of the lamination is flat-lying, the mud-prone siltstone laminae to the far left of the thin-section shows a wavy outline, and the cleaner coarse siltstone to



very fine-grained sandstone material to the left of this is angled, suggesting current rippling.

FRAMEWORK GRAINS (47.5%)

- Monocrystalline quartz (21.5%):
- Polycrystalline quartz (3.0%):
- Chert (0.5%):
- Feldspar (8.0%):
- Extrabasinal Rigid rock fragments (13.0%):
- Heavy minerals (1.5%):

DUCTILE COMPONENTS (48.5%)

- **Ductile rock fragments** (10.0%): principally occur within the coarser grained (coarse silt Upper to very fine sand Lower) laminae, and are locally concentrated here within discrete ductile-rich laminae. Dominated by extrabasinal mica schist fragments. Intrabasinal mudclasts are very minor in this sample.
- Mica (6.5%)
- **Detrital clay** (27.5%): pore-filling, brown detrital matrix clay dominates the ductile assemblage. It preferentially occurs within the finer grained siltstone laminae, but is also prominent within many of the coarser grained, cleaner laminae, except those to the far left of the thin-section (which are the coarsest grained in the sample).

Oumalik 6670.00 TSD Brief.docx Sample Descriptions



page 2 of 2

Well: Oumalik Depth: 6670.00ft DD

• Organic matter (4.5%):

AUTHIGENIC COMPONENTS (4.0%)

This sample has been poorly overprinted by authigenic cements. However, the authigenic assemblage is unusual as it comprises almost solely authigenic clay, which occludes most of the remnant primary macroporosity. The clay mainly comprises spongy (highly microporous), finely crystalline plates / fibres of ambiguous (undifferentiated) composition (3.5%). The greenish colour is probably related to resin impregnation, rather than the actual colour of the clay. This clay also locally replaces lithic grains. The pore-filling undifferentiated clay occurs only within the cleaner laminae, and may possibly be replacive of precursor detrital clay.

Scarce finely crystalline, pore-filling, to more rarely grain-replacive kaolinite (0.5%) has also been observed, along with rare (trace), small, syntaxial quartz overgrowths (which engulf kaolinite and the undifferentiated authigenic clay).

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 1.0\%$ $\varnothing_{SIM} = trace$ $\varnothing_{SOM} = 0\%$ $\varnothing_{MICRO} = na$

This sample is likely to have very poor to neglible reservoir quality. The mud-prone, fine to medium siltstone laminae have no visible porosity (completely occluded by pervasive, pore-filling detrital clay). The coarser grained laminae are cleaner, but still have abundant matrix clay and / or abundant ductile grains, mica plates and authigenic clay, as well as have been moderately compacted. Remnant primary macropores are evident in the coarser grained, cleaner laminae, but they are extremely small, very minor, and typically isolated to more rarely very poorly interconnected.

Oumalik 6670.00 TSD Brief.docx Sample Descriptions

page 1 of 1



Well:Oumalik Test Well-1Grain Size:naClassification:naDepth:6981.0ft DDSorting:na



The thin-section is a legacy thin-section (provided by OSA / Santos). No textural or modal analysis has been undertaken upon this sample, as it is a mudstone.

This sample is a mudstone, which comprises thick intercalated layers of silt-poor mudstone and more silty mudstone (mm-scale to almost cm-scale intercalation). At the far left of the thin-section, a thin interval of mud-prone siltstone is apparent. Within the variably silty mudstone horizons, the fabric appears laminated, with some localised mottling / disruption.

The lamination is faint / subtle, and is somewhat wavy in nature. The waviness of the lamination is highlighted by the presence of exceptionally abundant hairline cracks, that criss-cross the entire sample, and which run parallel to (matching) the wavy lamination. The resin has impregnated significantly into the mudstone adjacent to each crack, forming a dark halo around the cracks. Resin impregnation beyond the cracks is poor, resulting in the mudstone appearing lighter in colour between the cracks (i.e. the colour change is nothing to do with mineralogical changes, and is simply the result of variable resin impregnation). These cracks are most likely induced (i.e. not real in-situ cracks formed at depth), and formed via clay shrinkage. This suggests that they clay maybe somewhat water sensitive in nature (i.e. somewhat smectitic), although the birefringence of the clay suggests a significant, if not dominant, illitic component is present.

The waviness of the lamination is possibly the result of subtle biogenic reworking, as the mudstone horizons often show patchy distribution of silt grains, resembling narrow / thin burrow-fills.

RESERVOIR POTENTIAL

Porosity Data: $\emptyset_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\emptyset_{PRIM} = na$ $\emptyset_{SIM} = \%$ $\emptyset_{SOM} = na$ $\emptyset_{MICRO} = na$

Oumalik 6981.0 TSD Review.docx Sample Descriptions

page 1 of 1



Well:S MeadeGrain Size:naClassification:naDepth:600.0ft DDSorting:na



The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has not been stained for K-feldspar or carbonate, and is of overall good quality.

No modal or textural analysis has been conducted on this sample.

This sample is a dolomitised mudstone. The entire sample has been replaced by microcrystalline dolomite (a lack of staining makes it impossible to determine whether the dolomite is non-ferroan or ferroan). No silt grains are apparent, although if any were originally present, they may have been replaced by the dolomite. Exceptionally small (<8µm diameter), very minor particles of organic matter are scattered throughout the dolomitised mud matrix.

There are distinct differences in the amount of brown, mudstone matrix preserved between the dolomite rhombs, as well as the size of the dolomite rhombs, across the sample. The darker areas on the thin-section scan above have significant volumes of preserved matrix clay between the microcrystalline dolomite rhombs, which tend to between ~10-25µm in diameter. The paler areas have less matrix clay preserved, and the dolomite rhombs, whilst still microcrystalline grade, are markedly larger (most are between ~25-50µm in diameter).

The shape / forms of the variations in colour (reflecting the differences in % preserved mud matrix and size of dolomite rhombs noted above) appears reminiscent of biogenic reworking / bioturbation.

RESERVOIR POTENTIAL

Porosity Data: \varnothing_{He} = naPermeability Data: K_h = naMacroporosity Data: \varnothing_{PRIM} = na \varnothing_{SIM} = na \varnothing_{SOM} = na

This dolomitised mudstone is clearly non-reservoir.

S Meade_600.0 TSD_Review.docx

Sample Descriptions

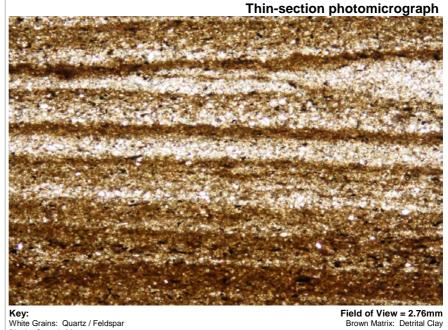


Well: **Grain Size:** Classification: S Meade na Depth: 2366.0ft DD Sorting: na

Thin-section scan



Field of view= 14.5mm



Field of View = 2.76mm

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has not been stained for Kfeldspar or carbonate, and is of overall good quality.

No modal or textural analysis has been conducted on this sample.

This sample represents an extremely finely laminated silty mudstone. The lamination is sub-mm scale, with the thinnest laminae being only 40µm thick, and the thickest laminae only ~450µm thick. The lamination is defined by marked changes in mud versus silt content, and is predominantly flat-lying. However, some minor biogenic reworking is apparent, in the form of four rounded to oval shaped, very small burrows (filled with cleaner silt). Also present is a syndepositional slump structure, with some slight off-setting of lamination (see white arrow on the thin-section scan above).

The silty laminae contain appreciable carbonate, which mainly appears to be of detrital origin (silt grade carbonate grains). Very finely particulate organic is minor, and the abundant matrix clays appear illitic (at least in part).

RESERVOIR POTENTIAL

Porosity Data: $\emptyset_{\mathsf{He}} = \mathsf{na}$ **Permeability Data:** $K_h = na$ **Macroporosity Data:** \emptyset PRIM = na \emptyset MICRO = na \emptyset sıм = na \emptyset som = na

Black: Organic Matter

The sample has no reservoir potential, as it represents a mudstone.

Sample Descriptions S Meade 2366.0 TSD Review.docx

page 1 of 1



Well:S MeadeGrain Size:naClassification:naDepth:3010.0ft DDSorting:na



Field of view= 19.5mm



Key:
White Grains: Quartz / Feldspar
Black: Organic Matter

Field of View = 2.76mm Brown Matrix: Detrital Clay

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has not been stained for K-feldspar or carbonate, and is of overall good quality. Three thin-sections with the same depth (3010.0ft) were provided. This sample differs somewhat to the other two, and thus has been described separately.

No modal or textural analysis has been conducted on this sample.

This sample is a silty mudstone. It is finely laminated, with subtle changes in grain size, corresponding with notable changes in silt versus mud (brown matrix clay) content – the finer grained laminae are markedly more mud-prone and less silty than the coarser grained laminae. However, the lamination in many places is disrupted by biogenic modification, and there are some very large (relative to the thin-section scale), horizontal, cleaner / siltier burrow fill structures, comprising elongated lenses of cleaner silt encased within silty mudstone – one of the structures / burrows is almost 2cm in diameter).

The silt grains are dominated by quartz (mainly monocrystalline), with subordinate feldspar and lithic grains. Very small mica plates are prominent, but not abundant, and very small particles of organic matter are relatively minor.

RESERVOIR POTENTIAL

Porosity Data: \emptyset_{He} = naPermeability Data: K_h = naMacroporosity Data: \emptyset_{PRIM} = na \emptyset_{SIM} = na \emptyset_{SOM} = na \emptyset_{MICRO} = na

This sample has no reservoir potential, as it is a silty mudstone.p

S Meade 3010.0 A TSD Review.docx Sample Descriptions

page 1 of 1

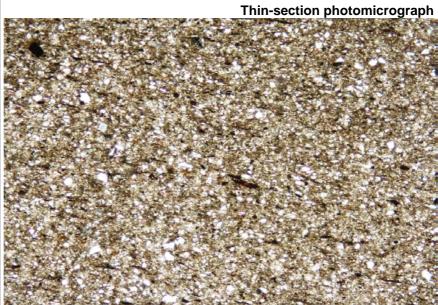


Well:S MeadeGrain Size:naClassification:naDepth:3010.0ft DDSorting:na

Thin-section scan







Key:White Grains: Quartz / Feldspar
Black: Organic Matter

Field of View = 2.76mm Brown Matrix: Detrital Clay

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has not been stained for K-feldspar or carbonate, and is of overall good quality. Three thin-sections with the same depth (3010.0ft) were provided. This sample is identical to one of the other thin-sections, but differs to the third thin-section, which has been described separately.

No modal or textural analysis has been conducted on this sample.

This sample is a silty mudstone. The main body of the sample appears fairly homogeneous, with only a very subtle / weak lamination evident, and comprises significantly silty mudstone (silt grains are fine to coarse grade, and represent on average approximately 20% of the bulk mineralogy). However, at the top of the thin-section, the lamination becomes more pronounced, with distinct changes in silt versus mud content. The more mud-prone laminae at the top of the thin-section (which are thicker / dominant here) contain only minor, very fine silt grains, and are intercalated with exceptionally thin mud-prone silt laminae, where the silt grains are medium to coarse silt grade. Disruption is locally evident, and appears biogenic in nature.

RESERVOIR POTENTIAL

Porosity Data: \emptyset_{He} = naPermeability Data: K_h = naMacroporosity Data: \emptyset_{PRIM} = na \emptyset_{SIM} = na \emptyset_{SOM} = na \emptyset_{MICRO} = na

This sample has no reservoir potential, as it is a mudstone.



Grain Size: Classification: Well: S Meade 0.048mm (csiltU) 4950.00ft DD Depth: Sorting: 0.704Ø (mws)

Thin-section scan



Field of view= 21.5mm

Thin-section photomicrograph

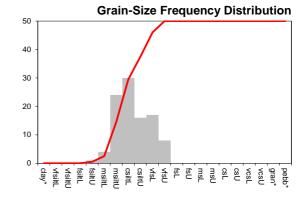
Field of View = 2.76mm White Grains: Quartz / Feldspar Black: Organic Matter

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has not been stained for Kfeldspar or carbonate, and is of overall good quality.

Key:

This sample is a mud-prone siltstone / silty mudstone. It is siltier in nature compared to the previous mudstone sample described above, and hence has been selected for modal and textural analysis.

The detrital grains are predominantly silt grade (range fine to coarse silt, with most being medium silt grade), although a minor proportion are coarser, and of very fine sand (Lower) grade. Almost without exception, and even within the siltier biogenic (burrow-fill) structures that occur throughout the thin-section, the silt grains float within a pervasive mud matrix).



The sample appears to have been originally laminated, although the lamination has been significantly disrupted, and is now only locally preserved intact. The disruption has resulted in a mixing / churning of silty mudstone and cleaner (albeit still extremely ductile-rich / mud-prone) muddy siltstone. Distinct biogenic structures are apparent, and overall the churning appears biogenic in nature.

FRAMEWORK GRAINS (42.0%)

- Monocrystalline quartz (24.0%):
- **Polycrystalline quartz** (0.5%):
- Chert (2.5%):
- Feldspar (9.5%): dominated by plagioclase, which shows no evidence of corrosion.
- Extrabasinal Rigid rock fragments (5.5%):
- Heavy minerals (trace):

DUCTILE COMPONENTS (58.0%)

- **Ductile rock fragments (4.5%):**
- Mica (6.0%):
- Detrital clay (42.5%): extremely abundant, pervasive, brown mud matrix. The colour and birefringence of the clay suggests a predominantly illitic composition.
- Organic matter (5.0%):



page 2 of 2

Well: S Meade Depth: 4950.00ft DD

AUTHIGENIC COMPONENTS (trace)

Extremely rare microcrystalline pyrite (trace) replacing organic matter and matrix clay.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 0\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0\%$ $\varnothing_{MICRO} = na$

This sample has no reservoir potential as it is a mud-prone siltstone, dominated by pervasive, pore-filling detrital matrix clay. No macroporosity is visible.

S Meade_4950.00 TSD_Brief.docx
Sample Descriptions

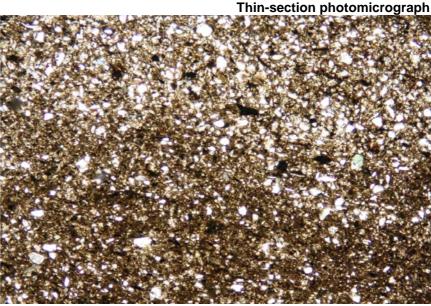
page 1 of 2



Well: S Meade Grain Size: 0.051mm (csiltU) Classification: LS Depth: 4950.70ft DD Sorting: 0.543Ø (mws)

Thin-section scan





Key:White Grains: Quartz / Feldspar
Black: Organic Matter

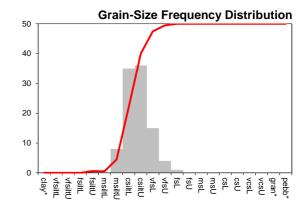
Field of View = 2.76mm
Brown Matrix: Detrital Clay

Field of view= 22mm

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has not been stained for K-feldspar or carbonate, and is of overall good quality.

This sample is extremely similar to the previous / adjacent sample at 4950.0ft. It therefore also represents a mudprone siltstone / silty mudstone, comprising a dominant, pervasive mud matrix, within which float abundant, albeit subordinate relative to the mud matrix, medium to coarse silt grains (+ minor very fine sand grains). This sample is weakly laminated, and comprises notable disruption caused by biogenic modification. However, churning / disruption is not as pronounced in this sample as it is within the adjacent sample at 4950.0ft.

Due to its extremely fine, silty grain size, lithic material (grains) are only minor in this sample.



FRAMEWORK GRAINS (36.0%)

- Monocrystalline quartz (21.5%):
- Polycrystalline quartz (0.5%):
- Chert (0.5%):
- **Feldspar** (10.5%): although not stained, twinned feldspar grains predominantly comprise plagioclase, and untwinned grains show partial sericitisation, suggestive of plagioclase.
- Extrabasinal Rigid rock fragments (2.5%):
- Heavy minerals (0.5%):

DUCTILE COMPONENTS (64.0%)

- Ductile rock fragments (0%):
- Mica (4.0%):
- **Detrital clay** (54.0%): extremely abundant, pervasive, brown mud matrix. The colour and birefringence of the clay suggests a predominantly illitic composition.
- Organic matter (6.0%): organic material is prominent, but not abundant, and comprises extremely small (silt grade), irregular shaped particles, scattered throughout the abundant / pervasive mud matrix.



page 2 of 2

Well: S Meade Depth: 4950.70ft DD

AUTHIGENIC COMPONENTS (trace)

Extremely rare microcrystalline pyrite (trace) replacing organic matter and matrix clay.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 0\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0\%$ $\varnothing_{MICRO} = na$

This sample has no reservoir potential as it is a mud-prone siltstone, dominated by pervasive, pore-filling detrital matrix clay. No macroporosity is visible.

S Meade_4950.70 TSD_Brief.docx
Sample Descriptions

page 1 of 1



Well:S MeadeGrain Size:naClassification:naDepth:4958.6ft DDSorting:na





Thin-section photomicrograph

Key:White Grains: Quartz / Feldspar Black: Organic Matter

Field of View = 2.76mm Brown Matrix: Detrital Clay

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has not been stained for K-feldspar or carbonate, and is of overall good quality.

No modal or textural analysis has been conducted on this sample.

This sample is a very finely laminated, silty mudstone. The lamination is characterised by subtle to distinct changes in grain size, clay / mud content and silt content, and is generally sub-mm scale, to more rarely mm-scale. The silt grains are typically relatively minor to more rarely prominent (typically <20% of the bulk volume within most laminae), although locally dominate within the minor, silt-prone laminae observed. The lamination is patchily subtly disturbed / distorted, probably by biogenic modification.

RESERVOIR POTENTIAL

Porosity Data: $\emptyset_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\emptyset_{PRIM} = na$ $\emptyset_{SIM} = na$ $\emptyset_{SOM} = na$ $\emptyset_{MICRO} = na$

This sample has no reservoir potential, as it represents a silty mudstone.

Sample Descriptions

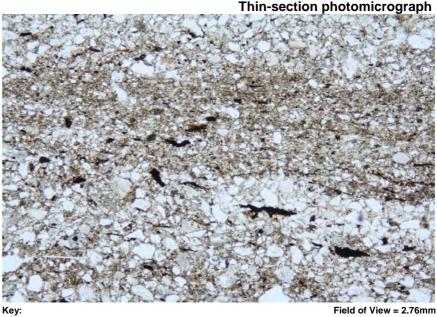
page 1 of 2



Well: S Meade Grain Size: 0.068mm (vfsL) Classification: FW Depth: 4959.00ft DD Sorting: 0.664Ø (mws)

Thin-section scan

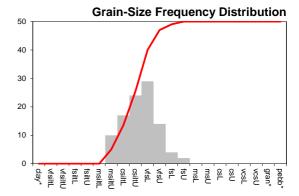
Field of view= 19mm



Key: Field of View = 2.76mm
White Grains: Quartz / Feldspar Brown Matrix: Detrital Clay
Black: Organic Matter

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has not been stained for K-feldspar or carbonate, and is of overall good quality.

This sample is extremely heterogeneous in nature. It comprises finely intercalated laminae / layers of siltstone (which are typically mud-prone), silty mudstone and ductile-rich / mud-prone, very fine-grained, to more rarely almost fine-grained, sandstone, in order of decreasing relative abundance. The laminae / layers therefore show significant variation in both grain size (grains range in size from fine silt through to fine sand) and mud / ductile content. Significant bioturbation is evident in the lower, more silty / sandy part of the sample / thin-section.



Overall this sample is moderately well to moderately sorted (0.664), with a mean grain size that is very fine sand Lower, bordering on coarse silt Upper (0.068mm). However, textural analysis has focussed on the siltstone and sandstone laminae, and when one looks at the grain size distribution (see above), it is clear than median and mode grain size (i.e. most of the grains) are coarse silt Upper.

Pore-filling detrital matrix clay is exceptionally abundant and pervasive, and this sample clearly lacked any primary macroporosity on deposition, and hence is non-reservoir.

FRAMEWORK GRAINS (55.0%)

- Monocrystalline quartz (26.0%): predominantly angular to sub-angular in shape.
- **Polycrystalline quartz** (6.0%): textures are often inequigranular, and more rarely equigranular, but crystal contacts are distinctly welded / sutured, and are more consistent with a metamorphic origin, than an igneous origin.
- Chert (5.0%): no signs of corrosion have been observed.
- **Feldspar** (13.0%): feldspar grains are relatively abundant in this sample, and although not stained, plagioclase appears to dominate, with minor volumes of K-feldspar. No signs of corrosion are evident.
- Extrabasinal rigid rock fragments (4.5%): dominated by metamorphic quartz/mica schist fragments, with rarer grains of monocrystalline to polycrystalline carbonate (?dolomite).
- **Heavy minerals** (0.5%): zircon, rutile and undifferentiated opaque grains, that are typically extremely small and quite well rounded.

DUCTILE COMPONENTS (45.0%)

• **Ductile rock fragments** (2.5%): ductile grains are minor in this sample, and principally occur in the coarser grained silt / sand laminae, where they are dominated by small intrabasinal mudclasts.

S Meade 4959.00 TSD Full.docx Sample Descriptions



page 2 of 2

Well: S Meade Depth: 4959.00ft DD

- **Mica** (6.5%): preferentially, but not exclusively, occurs in the finer grained, more mud-prone laminae. The mica plates are extremely small, and principally comprise fresh muscovite and altered / degraded plates of indeterminate composition. Rare flakes of relatively fresh chlorite and biotite have also been observed.
- **Detrital clay** (33.0%): abundant, pervasive, brown, pore-filling clay matrix. Even within the coarser grained laminae / layers, pore-filling matrix clay is abundant, and appears to have facilitated compaction. The birefringence of the matrix clay is consistent with an illitic composition.
- Organic matter (3.0%): variably sized (~5-200µm diameter), irregular shaped particles, and more rarely thin, wispy sheets, scattered throughout the abundant / pervasive mud matrix. A few thicker sheets are locally observed in the coarser grained laminae that are exceptionally large (long).

AUTHIGENIC COMPONENTS (trace)

This sample has only been overprinted by extremely scarce, ductile-replacive, microcrystalline pyrite (trace).

RESERVOIR POTENTIAL

Porosity Data: \emptyset_{He} = naPermeability Data: K_h = naMacroporosity Data: \emptyset_{PRIM} = 0% \emptyset_{SIM} = 0% \emptyset_{SOM} = 0% \emptyset_{MICRO} = na

This sample is a mud-prone siltstone / sandstone, and lacks any visible macroporosity. It therefore has a solely microporous pore system, with relatively abundant intramatrix microporosity held within the exceptionally abundant, pervasive clay matrix. The mud-prone nature of this sample means that it is non reservoir.

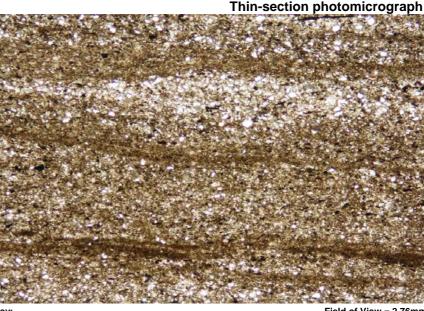
S Meade 4959.00 TSD Full.docx Sample Descriptions

page 1 of 1



Well:S MeadeGrain Size:naClassification:naDepth:4959.6ft DDSorting:na





Field of view= 23mm

Key:White Grains: Quartz / Feldspar
Black: Organic Matter

Field of View = 2.76mm
Brown Matrix: Detrital Clay

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has not been stained for K-feldspar or carbonate, and is of overall good quality.

No modal or textural analysis has been conducted on this sample.

This sample is very similar to the adjacent sample at 4958.6ft, and also comprises a very finely laminated, silty mudstone, with lamination characterised by subtle to more typically distinct changes in grain size, clay / mud content and silt content. Again, the lamination is generally sub-mm scale, to more rarely mm-scale. The silt grains are rarely abundant, except within a couple of thin, intercalated silt laminae. The lamination is patchily distorted by biogenic modification. Also observed are a couple of syn-depositional slump structures, with slight off-setting / dislocation of lamination.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = na$ $\varnothing_{SIM} = na$ $\varnothing_{SOM} = na$ $\varnothing_{MICRO} = na$

This sample has no reservoir potential, as it represents a mudstone.

S Meade 4959.60 TSD Review.docx Sample Descriptions

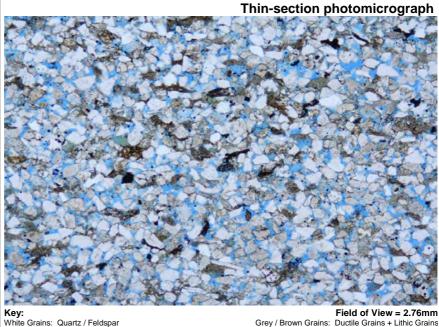
page 1 of 1



Well: Topagoruk Grain Size: 0.092mm (vfsU) Classification: LS Depth: 2087.00ft DD Sorting: 0.295Ø (vws)

Thin-section scan





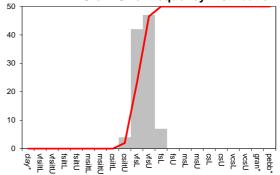
Field of view= 17.5mm

Field of View = 2.76mm Grey / Brown Grains: Ductile Grains + Lithic Grains Brown Matrix: Deformed Ductile Grains Turquoise Blue = Porosity

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has not been stained for K-feldspar or carbonate, but is otherwise of good quality.

This sample is an extremely well sorted, highly lithic, very fine-grained (Upper) sandstone. It contains prominent, but not abundant, ductile material (18.5%), mainly clayey / micaceous ductile grains, which demonstrate notable plastic deformation, facilitating moderate compaction (this sample has lost over half of its original intergranular volume via compaction). Diagenetic overprinting is light, and the depositional fabric appears weakly laminated.

Grain-Size Frequency Distribution



RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 10.8\%$ $\varnothing_{SIM} = 1.7\%$ $\varnothing_{SOM} = 1.3\%$ $\varnothing_{MICRO} = na$

Yellow Grains: K-feldspar Black: Pyrite / Organic Matter / Heavy Minerals

This sandstone contains relatively abundant macroporosity (13.8%). The macropores principally comprise relatively small primary interparticle macropores (most are <50µm in diameter [range 10-70µm diameter]), which are variably interconnected (poorly interconnected through to well interconnected). They have been significantly reduced in volume by moderate compaction. A minor volume of secondary macropores, produced via the partial to often advanced corrosion of feldspar grains, and more rarely chert, are also observed. These are mainly intraparticle in natures (i.e. trapped within the non-corroded remnants of their host grains), but some are oversized (near-complete to complete dissolution), and connected to adjacent primary macropores.

Overall this sandstone is expected to have moderate, to possibly good, reservoir quality.

page 1 of 2



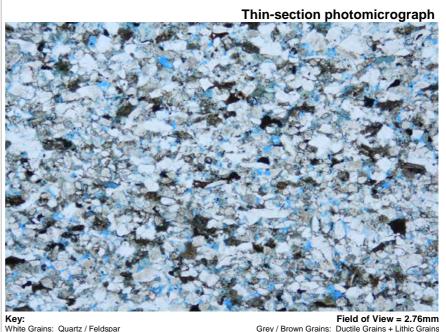
Brown Matrix: Deformed Ductile Grains

Grain-Size Frequency Distribution

Turquoise Blue = Porosity

Well: Topagoruk Grain Size: 0.101mm (vfsU) Classification: LS Depth: 3240.00ft DD Sorting: 0.465Ø (ws)





Field of view= 21.5mm

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has not been stained for K-feldspar or carbonate, but is otherwise of good quality.

Yellow Grains: K-feldspa

Black: Pyrite / Organic Matter / Heavy Minerals

This sample is a well sorted, highly lithic, very fine-grained (Upper) sandstone, which mostly displays a weakly laminated fabric, characterised by very subtle changes in grain size and ductile abundance. However, to the far right of thin-section, lamination is more distinct, with more notable changes in grain size and ductile abundance observed. Two extremely thin, discontinuous laminae containing abundant heavy minerals (heavy mineral lags) are evident in the top right hand corner of the thin-section.

peb onstrating pronounced plastic deformation. Overall this interpreparation will be compaction because in the compaction because of the compaction because in the compaction because of the compaction of the compaction because of the compaction of the compaction because of the compaction of

Compaction is pronounced, with rigid / framework grains demonstrating elongated contacts, and ductile grains demonstrating pronounced plastic deformation. Overall this sandstone has lost approximately 65% of its original primary intergranular volume via compaction. Compaction has been significantly facilitated by the presence of abundant ductile rock fragments (which facilitate compaction via plastic deformation).

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FRAMEWORK GRAINS (73.0%)

- Monocrystalline quartz (26.5%): predominantly sub-angular in shape.
- **Polycrystalline quartz** (8.5%): predominantly sub-equigranular to equigranular, with welded / sutured crystallite contacts (i.e. quartzite).
- Chert (2.5%): often show partial (spongy) corrosion.
- **Feldspar** (11.0%): K-feldspar grains have not been stained in this thin-section. However, minor orthoclase twinning is noted in some grains. Overall, however plagioclase (twinned and untwinned grains) appears to dominate.
- Extrabasinal rigid rock fragments (24.0%): extrabasinal rock fragments are extremely abundant in this sample. They mainly comprise metamorphic clasts, with subordinate, yet still relatively abundant, carbonate grains. The metamorphic clasts are dominated by quartz-rich quartz/mica schist, although welded, exceptionally finely crystalline, hornfels-like grains have also been observed. The carbonate grains are principally monocrystalline, and more rarely polycrystalline. Many of the monocrystalline grains retain euhedral rhombic outlines. The carbonate grains, although not stained, are possibly dolomite.
- **Heavy minerals** (0.5%): preferentially concentrated within 2, extremely small lags, although scarce, small rounded heavy mineral grains are also scattered throughout the sample. The assemblage comprises apatite, rutile, garnet and undifferentiated opaques.

Topagoruk 3240.00 TSD Full.docx Sample Descriptions



page 2 of 2

Well: Topagoruk Depth: 3240.00ft DD

DUCTILE COMPONENTS (23.0%)

- **Ductile rock fragments** (15.0%): dominated by highly micaceous schist fragments (some comprise minor / subordinate quartz, but most comprise solely different species of mica), with minor intrabasinal mudclasts. minor, green, possibly chloritic grains are evident, some of which may have possibly been glauconitic.
- **Mica** (2.0%): fresh plates of muscovite, biotite and chlorite, through to highly altered / degraded mica plates, of undifferentiated composition.
- **Detrital clay** (6.0%): forms minor, thin, brown, moderately birefringent (?illitic), discontinuous clay coats, and minor, patchy, spongy, pore-filling masses.
- Organic matter (trace): rare, small, irregular shaped particle of organic material.

AUTHIGENIC COMPONENTS (4.0%)

This sandstone has been overprinted by a relatively minor volume of diagenetic cements, although the authigenic assemblage is quite varied, comprising (in order of decreasing abundance): undifferentiated / unstained carbonate (1.5%), kaolinite (0.5%), undifferentiated authigenic clay (1.0%), anatase (0.5%), siderite (0.5%), quartz (0.5%) and pyrite (trace):

- The kaolinite occurs as very loosely packed, finely crystalline, small verms and booklets, which principally occlude scattered (patchy) primary macropores, although also locally appear to replace plagioclase grains. The kaolinite booklets are locally engulfed by quartz overgrowths.
- The undifferentiated carbonate principally occurs as coarsely crystalline, pore-filling masses, with no distinct rhombic shape (anhedral). The coarsely crystalline, pore-filling cement has characteristics similar to calcite seen in previous wells studied, but in the absence of carbonate staining, it is impossible to determine whether this cement is calcite or dolomite. Also present are small rhombic outgrowths on the surface of detrital dolomite grains.
- The undifferentiated authigenic clay forms spongy masses at pore margins. It is impossible to resolve the nature of this clay in thin-section, or to be sure that this clay is indeed authigenic in origin (it could possibly be detrital clay, although a vaguely crystalline nature is locally apparent in these green, spongy masses).
- The anatase occurs as extremely small (microcrystalline), isolated / single crystals at pore margins.
- The siderite is microcrystalline in form, and exclusively replaces intrabasinal mudclasts. The siderite is reddened (oxidised).
- The quartz forms variably developed syntaxial overgrowths on the surface of some monocrystalline quartz grains. Some overgrowths are incipient, and although the rest cover only small areas / volumes of their host grain surfaces, they in fact balloon-outwards, and occlude small adjacent primary pores (i.e. they have a pore-filling habit). The quartz overgrowths appear to post-date significant grain contact elongation.
- The pyrite forms rare microcrystalline cubes sitting at pore margins. A single pyrite crystal has been observed engulfed by coarsely crystalline carbonate.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 3.4\%$ $\varnothing_{SIM} = 1.0\%$ $\varnothing_{SOM} = 1.0\%$ $\varnothing_{MICRO} = na$

This sample contains only minor volumes of remnant primary interparticle macropores. The primary macropores are small (most are <30µm in diameter) and poorly interconnected, having been severely reduced in size and number by pronounced compaction. Minor volumes of secondary macroporosity are evident, produced by partial corrosion (generating small secondary intraparticle macropores) to locally advanced / complete corrosion (generating oversized macropores) of feldspar grains. Significant volumes of microporosity are evident within clayey ductile grains, and are more rarely associated with detrital clay, authigenic clays and spongy (partially corroded) feldspar grains.

This sandstone is likely to have a poor reservoir quality.

Topagoruk_3240.00 TSD_Full.docx

Sample Descriptions

page 1 of 1



Well:TunalikGrain Size:naClassification:naDepth:3288.50ft DDSorting:na

Thin-section scan



Field of view= 23.5mm

Thin-section photomicrograph

Key:White Grains: Quartz / Feldspar
Black / Orange: Organic Matter

Field of View = 2.76mm Brown Matrix: Detrital Clay

The thin-section is a legacy thin-section (provided by OSA / Santos). It does not appear to have been stained for carbonate or K-feldspar.

No textural or modal analysis has been undertaken on this sample.

The material mounted into the thin-section appears to be cuttings particles. Without exception, the small particles comprise mudstone. The mudstone particles vary from being relatively silt-free, to more typically containing minor fine to medium grade silt grains, with a few particles containing prominent silt grains, albeit still highly subordinate relative to the mud matrix within which they float. Very small, to locally extremely large, particles of organic material occur in every particle, although overall occur in relatively low volumes (estimate ~6% +/- 2%).

The small mudstone particles locally display relatively massive fabrics, although most particles show faint lamination. A few particles appear churned / disrupted, with one particle in particular containing distinct biogenic structures (siltier burrow-fills).

RESERVOIR POTENTIAL

Porosity Data: \varnothing_{He} = naPermeability Data: K_h = naMacroporosity Data: \varnothing_{PRIM} = na \varnothing_{SIM} = na \varnothing_{SOM} = na \varnothing_{MICRO} = na

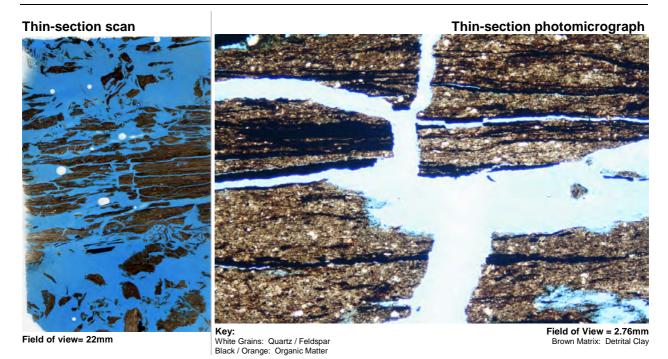
This sample is a mudstone, and is therefore non-reservoir.

Tunalik 3288.50 TSD Review.docx Sample Descriptions

page 1 of 1



Well:TunalikGrain Size:naClassification:naDepth:3296.00ft DDSorting:na



The thin-section is a legacy thin-section (provided by OSA / Santos). It does not appear to have been stained for carbonate or K-feldspar.

No textural or modal analysis has been undertaken on this sample.

The material mounted into the thin-section appears to be cuttings particles. The cuttings particles, without exception, comprise organic-rich mudstone. Some particles contain as much as ~20% organic matter, with most containing between ~10-20% organic matter.

The mudstone material is finely laminated, with large / long sheets of organic matter aligned parallel to lamination. Silicate grains (quartz > feldspar) are typically minor, and range in size from fine silt grade, through to fine sand Lower grade. The silt / sand grains are locally concentrated within sub-rounded structures, which possibly represent burrow.

The dominant mud matrix is brown, with moderate birefringence, and appears illitic, at least in part.

RESERVOIR POTENTIAL

Porosity Data: $\emptyset_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\emptyset_{PRIM} = na$ $\emptyset_{SIM} = na$ $\emptyset_{SOM} = na$ $\emptyset_{MICRO} = na$

This sample is a mudstone, and is therefore non-reservoir.

Tunalik 3296.00 TSD Review.docx Sample Descriptions

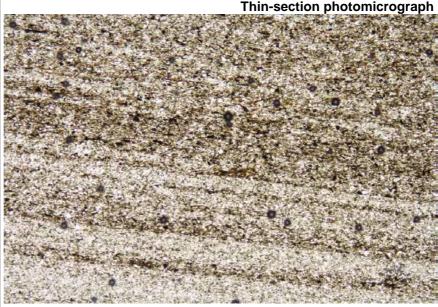
page 1 of 1



Well:TunalikGrain Size:naClassification:naDepth:3308.00ft DDSorting:na

Thin-section scan

Field of view= 23mm



Key: White Grains: Quartz / Feldspar Black / Orange: Organic Matter

Field of View = 2.76mm
Brown Matrix: Detrital Clay

The thin-section is a legacy thin-section (provided by OSA / Santos). It does not appear to have been stained for carbonate or K-feldspar.

No textural or modal analysis has been undertaken on this sample.

This sample is a very finely laminated, highly silty mudstone. The lamination is defined by subtle to more distinct changes in mud versus silt content, and is typically very fine, sub-mm scale (some laminae are <50µm thick) The silt grains are exceptionally small (fine silt grade), and rarely exceed 10µm in diameter. They dominate in the siltiest laminae, although are normally subordinate relative to the brown matrix clay in most laminae.

The lamination is often parallel and potentially flat-lying (?horizontal), but changes angle in parts of the thin-section, where distinct current rippling is evident. Some minor syn-depositional distortion of the laminae is locally evident, but it is not possible to determine whether the distortion is related to soft sediment deformation or biogenic reworking. However, a single, extremely small (~400µm wide) rounded, silty structure is evident cross-cutting lamination. This is probably a burrow-fill.

RESERVOIR POTENTIAL

Porosity Data: $\emptyset_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\emptyset_{PRIM} = na$ $\emptyset_{SIM} = na$ $\emptyset_{SOM} = na$ $\emptyset_{MICRO} = na$

This silty mudstone sample has no reservoir potential (non reservoir).

Tunalik 3308.00 TSD Review.docx

Sample Descriptions

page 1 of 1



Well:TunalikGrain Size:naClassification:naDepth:3825.30ft DDSorting:na



The thin-section is a legacy thin-section (provided by OSA / Santos). It does not appear to have been stained for carbonate or K-feldspar.

No textural or modal analysis has been undertaken on this sample.

The material mounted in thin-section is clearly from cuttings particles. The particles are typically relatively large, and are compositionally homogeneous (i.e. all the particles contain the same material). Many of the particles appear lighter coloured in their centres, with darker brown margins. This change in colour is artefact, and results from differential resin impregnation, as well as the fact that the thin-section is relatively thick, and the edges of many of the particles are set further within the resin, whilst the middle parts are higher up, and have experienced greater polishing during thin-section preparation.

The particles, without exception, comprise silty mudstone. The silt particles are typically fine to medium silt grade, and are markedly subordinate relative to the clay / mud matrix within which they float. The clay / mud matrix is brown, with moderate birefringence, suggestive of an illitic composition. The silty mudstone particles appear to have massive fabrics, with no lamination observed. As well as subordinate quartz (and more rarely feldspar) silt grains, minor volumes of exceptionally small (mainly fine silt grade) particles of organic matter are apparent. Mica plates are extremely scarce.

RESERVOIR POTENTIAL

Porosity Data: $\emptyset_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\emptyset_{PRIM} = na$ $\emptyset_{SIM} = na$ $\emptyset_{SOM} = na$ $\emptyset_{MICRO} = na$

This sample has no reservoir potential, as it represents a silty mudstone.

Tunalik_3825.30 TSD_Review.docx

Sample Descriptions

page 1 of 2



Well: Tunalik Grain Size: 0.120mm (vfsU) Classification: LS Depth: 5557.60ft DD Sorting: 0.434Ø (ws)

Thin-section scan

Field of view= 22mm

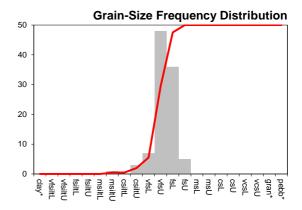




Field of View = 2.76mm
Grey / Brown Grains: Ductile Grains + Lithic Grains
Brown Matrix: Detrital Clay

The thin-section is a legacy thin-section (provided by OSA / Santos). It does not appear to have been stained for K-feldspar, and also possibly not carbonate either. However, overall the thin-section is of good quality.

This material in thin-section comprises only a thin slice of laminated sandstone, intercalated with a thin horizon of mudstone, with much of the latter (mudstone horizon) having detached away from the main body of sample material. The sandstone is well sorted, highly lithic, with relatively abundant ductile rock fragments, and is overall very fine-grained (mean and median grain size are vfsU, whereas mode grain size is vfsL). The sandstone shows a faint grain size lamination, with a single mudstone / mud-prone, discontinuous laminae.



The mudstone horizon attached / interbedded with the sandstone layer show notable intermixing with the sandstone material, with the boundary clearly being distorted / deformed through biogenic modification. Sandy elongated burrow-fill structures occur throughout the mudstone horizon. Otherwise the mudstone contains little, if any silt / sand grains.

The sandstone horizon demonstrates a highly compacted fabric, with notable grain contact elongation. The intercalated mudstone laminae within the main body of the sandstone material shows pronounced plastic deformation (the clay matrix is highly compressed / compacted).

FRAMEWORK GRAINS (67.5%)

- Monocrystalline quartz (21.5%): most of the ductile rock fragments are micaceous schist, with
- Polycrystalline quartz (9.0%):
- Chert (6.5%):
- Feldspar (17.0%):
- Extrabasinal Rigid rock fragments (13.5%):
- Heavy minerals (0%):

DUCTILE COMPONENTS (24.5%)

- **Ductile rock fragments** (15.5%): most of the ductile rock fragments are micaceous schist (intrabasinal mudclasts are minor). However, compaction is pronounced, and even the micaceous schist fragments show notable plastic deformation.
- Mica (0.5%):
- **Detrital clay** (8.0%):

Tunalik 5557.60 TSD Brief.docx Sample Descriptions



page 2 of 2

Well: Tunalik Depth: 5557.60ft DD

• Organic matter (0.5%):

AUTHIGENIC COMPONENTS (8.0%)

This sample has been cemented / overprinted by minor volumes of quartz (4.0%), kaolinite (2.0%) and anatase (2.0%), with relatively scarce dolomite (trace):

- The quartz forms variably developed syntaxial overgrowths, which are inhibited by elongated grain contacts, and therefore are generally not continuous around their host monocrystalline quartz grains. The overgrowths, where formed, however, are relatively thick, and have in fact ballooned outwards to occlude all remnant primary macropores. Where overgrowths are lacking (more lithic realms), grain contacts are even more highly elongated. This suggests that quartz precipitated during burial, after some significant compaction, but maximum compaction / burial occurred after quartz cementation.
- The kaolinite patchily occlude primary macropores, and is finely crystalline, forming small verms or large books that are very loosely packed. The kaolinite inhibits and is engulfed by quartz overgrowths.
- The anatase forms microcrystalline, slightly elongated euhedral prisms and more blocky euhedra, which sit scattered at pore margins (most pores contain some crystals of anatase). The crystals are typically ~10-30µm in diameter, and are engulfed by quartz overgrowths.
- The dolomite forms microcrystalline, euhedral rhombs sitting in primary pores, as well as small, discontinuous overgrowths on host detrital dolomite grains. The lack of staining means that it is not possible to tell whether the dolomite is non-ferroan or ferroan. The dolomite engulfs anatase.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 0\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0\%$ $\varnothing_{MICRO} = na$

The sandstone layer is devoid of macroporosity, due to pronounced compaction, which has destroyed most of the primary interparticle pore volume. The remnant primary macropores (those not destroyed by compaction) have been completely occluded by authigenic cements (mainly quartz and kaolinite). This sample, therefore, has negligible reservoir quality.

Tunalik 5557.60 TSD Brief.docx Sample Descriptions

page 1 of 2



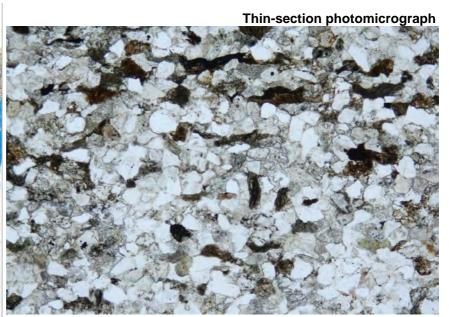
Grain Size: Classification: Well: Tunalik 0.125mm (vfsU) LS 5559.50ft DD Depth: Sorting: 0.361Ø (ws)



Field of view= 22mm



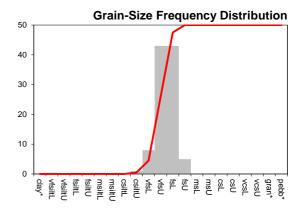
White Grains: Quartz / Feldspar Beige / Grey cement: Authigenic Carbonate



Field of View = 2.76mm Grey / Brown Grains: Ductile Grains + Lithic Grains

The thin-section is a legacy thin-section (provided by OSA / Santos). It does not appear to have been stained for Kfeldspar or carbonate. However, overall the thin-section is of good quality.

This sample is a well sorted, lithic, very fine-grained (Upper) sandstone, which demonstrates a laminated fabric. lamination is characterised by the localised preferential concentration of ductile rock fragments, within thin, discrete, darker coloured lamina. Compaction is overall moderate, although varies widely from realm to realm, with some patchy realms being notably open / weakly compacted, and others significantly more compacted. The remnant primary pore network has been pervasively occluded by carbonate.



FRAMEWORK GRAINS (59.5%)

- Monocrystalline quartz (22.5%): grain shapes vary widely from angular to rounded, but most grains are subrounded in shape.
- Polycrystalline quartz (7.0%): principally very finely crystalline and equigranular, grading into chert.
- Chert (7.0%): clean to very dirty-looking grains.
- Feldspar (10.5%): the majority of the feldspar grains appear to comprise plagioclase, which often, but not always, shows slight sericitisation. No twinned K-feldspar grains have been observed, but this does not mean that K-feldspar is not present (some of the untwinned, non-sericitised feldspar grains could comprise K-feldspar).
- Extrabasinal rigid rock fragments (12.5%): principally comprise metamorphic grains of quartz / mica schist and rarer welded meta-sedimentary material. Minor plutonic grains and highly altered / undifferentiated lithic grains complete the rigid extrabasinal rock fragment assemblage. The plutonic grains comprise finely crystalline composites of quartz, plagioclase and chlorite.
- Heavy minerals (0%):

DUCTILE COMPONENTS (16.0%)

- Ductile rock fragments (14.0%): extrabasinal ductile grains (mainly mica schist) dominate over intrabasinal mudclasts. The mudclasts have been highly plastically deformed, but the mica schist fragments also appear to facilitate compaction by plastically deforming, just not to the same degree as the mudclasts.
- Mica (1.5%): mostly comprises relatively large flakes of biotite.
- Detrital clay (0%):
- Organic matter (0.5%): small, scattered, irregular shaped particles, which show notable plastic deformation.



page 2 of 2

Well: Tunalik Depth: 5559.50ft DD

AUTHIGENIC COMPONENTS (24.5%)

This sandstone sample has been highly overprinted by abundant, pore-filling authigenic carbonate (24.0%), which pervasively occludes the primary pore network. In some realms, the carbonate appears to inhibit compaction, and maintains a relatively open grain framework. However, in other realms, the carbonate appears to post-date elongated grain contacts, suggesting that it precipitated after moderate burial compaction. It is possible, therefore, that there is more than one phase of carbonate, or that the carbonate formed over a prolonged period. Within a few (very minor volume) primary pores, the carbonate has not completely occluded the available pore space.

In the adjacent samples (e.g. 5560.0ft), where pore-filling carbonate cement occurs in much lower volumes, quartz overgrowths are more abundant. This suggests that the carbonate here mainly precipitated before quartz cementation, inhibiting quartz cementation (quartz overgrowths are scarce in this sample). However, in sample 5560.0ft, the carbonate present, mainly post-dates quartz overgrowths. The carbonate is not as abundant in sample 5560.0ft as it is in this sample, and it is possible that there is an earlier generation of carbonate cement (which predates and inhibits quartz) in this sample, which is lacking / scarce in the adjacent samples.

The carbonate forms a coarsely crystalline, poikilotopic, pore-filling cement, with no readily discernible rhombic shape. This habit / morphology is more consistent with calcite seen in previously studied wells. Calcite is also the main carbonate phase in the adjacent sample (5560.0ft), where it has been stained. Unfortunately, the lack of carbonate staining in this sample makes it impossible to definitely determine whether the carbonate species here is calcite or dolomite, although the former is thought more likely. Traces of thin dolomite overgrowths and small dolomite outgrowths have locally been observed precipitated on the surface of host detrital dolomite grains. These are engulfed/ overlain by the pore-filling carbonate.

The quartz overgrowths are very minor / scarce (0.5%), and where formed nucleate from only small areas of the host grain surface, although balloon-outwards to occlude remnant primary macropores. Traces of microcrystalline siderite replacing intrabasinal mudclasts have also been observed.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 0\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0\%$ $\varnothing_{MICRO} = na$

The primary pore network of this sample has been completely destroyed by pervasive carbonate cementation, and moderate compaction (approximately 45% of the original primary pore network has been destroyed by compaction, and 55% by carbonate cementation). No remnant macroporosity is visible. Reservoir quality, therefore, is likely to be negligible.

Tunalik 5559.50 TSD Full.docx Sample Descriptions

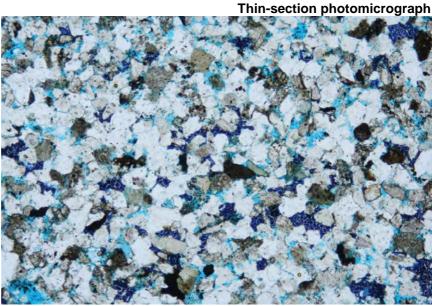
page 1 of 2



Well:TunalikGrain Size:0.117mm (vfsU)Classification:LSDepth:5560.00ft DDSorting:0.302Ø (vws)



Field of view= 22mm

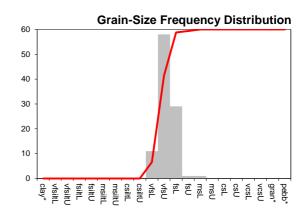


Key:White Grains: Quartz / Feldspar
Black: Organic Matter
Turquoise Blue = Porosity

Field of View = 2.76mm
Grey / Brown Grains: Ductile Grains + Lithic Grains
Dark Blue: Carbonate

The thin-section is a legacy thin-section (provided by OSA / Santos). It has been stained for carbonate. However, it is possible that that the thin-section has not been stained for K-feldspar (a few grains of feldspar have twinning that is more consistent with K-feldspar than plagioclase, and these lack K-feldspar staining).

This sample is a very well to well sorted, clean, highly lithic, very fine-grained (Upper) sandstone, which displays an essentially massive, homogeneous fabric. The circular, darker area of the thin-section is due to poor cover-slipping (bubble in the immersion oil). The sandstone has been highly overprinted by authigenic cements, and shows overall moderate compaction of the grain framework (this sample has lost approximately ~45% of its original primary intergranular volume via compaction).



FRAMEWORK GRAINS (73.0%)

- Monocrystalline quartz (24.5%): predominantly sub-rounded in shape.
- Polycrystalline quartz (9.5%): principally very finely crystalline and equigranular, grading into chert
- Chert (3.5%): typically clean, and more rarely dirty, and rarely show signs of corrosion.
- **Feldspar** (12.5%): dominated by twinned and untwinned grains of plagioclasem which locally show partial dissolution. Twinned K-feldspar grains have rarely been observed.
- Extrabasinal rigid rock fragments (22.0%): dominanted by foliated, quartz-rich schist grains (metamorphic grains), with minor dolomite / dolostone grains (monocrystalline and polycrystalline), finely crystalline composites of feldspar, quartz and chlorite (plutonic grains) and reworked sandstone clasts (very fine-grained, welded and most likely of extrabasinal, rather than intrabasinal, origin). The rigid rock fragment assemblage is completed by minor, highly altered / undifferentiated grains (indeterminate composition and origin). The dolostone grains often show oxidation (suggesting that they may have been ferroan).
- **Heavy minerals** (1.0%): zircon, undifferentiated opaques and possible rutile.

DUCTILE COMPONENTS (9.0%)

- **Ductile rock fragments** (7.5%): minor brown, intrabasinal mudclasts and extrabasinal, shighly micaceous metamorphic clasts (mainly schist).
- Mica (1.0%): rare flakes of biotite and highly altered / undifferentiated mica (possibly originally biotite).
 Muscovite is conspicuous by its absence (muscovite tends to be the dominant mica type in most of the other study wells).
- **Detrital clay** (0.5%): rare, brown, exceptionally thin, discontinuous clay coats.

Tunalik 5560.00 TSD Full.docx Sample Descriptions



page 2 of 2

Well: Tunalik Depth: 5560.00ft DD

• Organic matter (0%):

AUTHIGENIC COMPONENTS (18.0%)

This sample has been highly overprinted by authigenic cements, principally by prominent ferroan calcite (8.0%), with minor guartz (5.5%), undifferentiated authigenic clay (1.5%), anatase (1.5%) and kaolinite (1.5%).

- The **carbonate** forms a patchy, coarsely crystalline, pore-filling to locally poikilotopic cement, which also notably corrodes lithic grains. The intense dark blue colour, and the rather unusual cracked appearance of the carbonate stain, are more typically associated with calcite than with dolomite. The ferroan calcite overlies well developed / thick quartz overgrowths, engulfs anatase, post-dates grain contact elongation and precipitated within (and thus post-dates) secondary intraparticle macropores within corroded plagioclase grains.
- The quartz typically forms variably developed syntaxial outgrowths, which often cover only a small volume of their host grain surfaces, but which balloon outwards, significantly reducing the size of, and also locally completely occluding, primary macropores. More continuous overgrowths are more rarely observed. The quartz cement engulfs anatase and kaolinite, and appears to be inhibited by moderately elongated grain contacts.
- The **undifferentiated authigenic clay** locally occludes primary pores, and more rarely replaces lithic grains. It is extremely finely crystalline and loosely packed, and appears spongy in thin-section.
- The anatase forms microcrystalline, slightly elongated euhedral prisms and more blocky euhedra, which sit
 scattered at pore margins (most pores contain some crystals of anatase). The crystals are typically ~10-30µm in
 diameter, and are engulfed by quartz overgrowths, and also possibly kaolinite.
- The kaolinite patchily occlude primary macropores, and is finely crystalline, forming small verms or large books
 that are very loosely packed. The kaolinite inhibits and is engulfed by quartz overgrowths

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 4.8\%$ $\varnothing_{SIM} = 0.5\%$ $\varnothing_{SOM} = 0.9\%$ $\varnothing_{MICRO} = na$

This sample has been moderately compacted and relatively highly cemented (mainly by ferroan calcite and quartz), and therefore retains only minor volumes of primary macroporosity. The remnant primary macropores are relatively small (having been reduced in size by compaction and partial occlusion by quartz overgrowths), and are patchily distributed (in and around the patches of calcite cement). Overall they are poorly interconnected. Only a very minor volume of secondary macroporosity has been produced by the localised partial, to more rarely almost complete, corrosion of plagioclase grains.

Reservoir quality is therefore expected to be relatively poor.

Tunalik_5560.00 TSD_Full.docx

Sample Descriptions

page 1 of 1



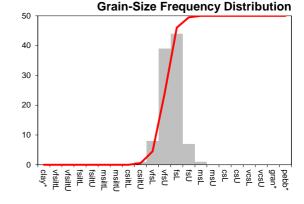
Well: Tunalik Grain Size: 0.126mm (fsL) Classification: LS Depth: 5561.00ft DD Sorting: 0.374Ø (ws)



The thin-section is a legacy thin-section (provided by OSA / Santos). It does not appear to have been stained for K-feldspar or carbonate. However, overall the thin-section is of good quality.

This sample is extremely similar to the adjacent sample (5560.0ft), which has been described in full. This sample therefore also comprises a well sorted, clean, highly lithic, very fine-grained (Upper) sandstone, which has been moderately compacted and highly cemented (mainly by carbonate and quartz). However, this sample locally displays a weakly laminated fabric (although the rest of the sample is relatively massive / homogeneous in nature).

The prominent carbonate present has not been stained, but demonstrates the same properties as the carbonate in



sample 5560.0ft (patchy, coarsely crystalline to locally poikilotopic, pore-filling cement, which overlies quartz overgrowths), and therefore is also likely to be ferroan calcite.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 4.8\%$ $\varnothing_{SIM} = trace$ $\varnothing_{SOM} = 0\%$ $\varnothing_{MICRO} = na$

This sample has been moderately compacted and relatively highly cemented (mainly by carbonate and quartz), and therefore retains only minor volumes of primary macroporosity. The remnant primary macropores are relatively small and are patchily distributed (in and around the patches of calcite and quartz cement). Overall they are poorly interconnected.

Reservoir quality is therefore expected to be relatively poor.

Tunalik_5561.00 TSD_Review.docx

Sample Descriptions



Grain Size: Classification: Well: Tunalik 0.107mm (vfsU) LS 6507.00ft DD Depth: Sorting: 0.507Ø (mws)

Thin-section scan

Thin-section photomicrograph Key:

Field of view= 22mm

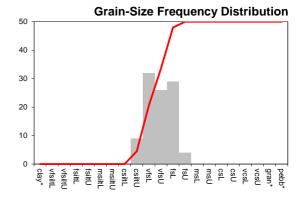
Black: Organic Matter

Field of View = 2.76mm Grey / Brown Grains: Ductile Grains + Lithic Grains

The thin-section is a legacy thin-section (provided by OSA / Santos). It does not appear to have been stained for carbonate or K-feldspar, but otherwise is of overall good quality.

This sample is a highly lithic, overall very fine-grained (Upper) sandstone, which mainly displays a very faint / weak grain size lamination, although the lower third of the thin-section is markedly finer grained (and consequently more ductile-rich) than the upper third of the thin-section, resulting in the moderately well sorted, as opposed to well sorted, texture (all the other samples from this well are very well to well sorted).

This sample is slightly finer grained compared to all the preceding Tunalik samples, and consequently more ductile-



rich (this sample has more mudclasts / ductile rock fragments, and detrital clay compared to the preceding samples). However, this sample is otherwise similar to most of the preceding samples, being moderately compacted (and losing approximately 40-45% of its original intergranular volume, as with most of the preceding samples), as well as being quite highly cemented (by quartz and carbonate).

FRAMEWORK GRAINS (58.5%)

- Monocrystalline quartz (17.5%):
- Polycrystalline quartz (8.5%):
- Chert (4.0%):
- Feldspar (11.0%):
- Extrabasinal Rigid rock fragments (17.5%):
- Heavy minerals (%):

DUCTILE COMPONENTS (25.5%)

- Ductile rock fragments (18.5%): intrabasinal mudclasts and highly micaceous extrabasinal schist clasts. The mudclasts demonstrate pronounced plastic deformation, locally forming small patches of pseudo-matrix. The mica schist fragments show less plastic deformation, but are none the less quite highly deformed.
- Mica (2.0%):
- Detrital clay (5.0%): predominantly represented by undifferentiated, brown, pore-filling matrix clay (difficult to determine whether these small patches of pore-filling clay represent detrital clay [i.e. real matrix] or deformed mudclasts [i.e. pseudo-matrix]).
- Organic matter (0%):



page 2 of 2

Well: Tunalik Depth: 6507.00ft DD

AUTHIGENIC COMPONENTS (16.0%)

This sample has been significantly overprinted by authigenic cement, mainly by syntaxial quartz overgrowths (10.0%), with rarer pore-filling, to more rarely grain-replacive, carbonate (6.0%), with trace anatase. The quartz overgrowths have a rather patchy distribution, based upon the distribution of their host monocrystalline quartz grains. In more lithic-rich realms (i.e. with less monocrystalline quartz grains), the overgrowths are poorly developed. However, in less lithic realms (i.e. with more monocrystalline quartz grains), the overgrowths are well developed, and occlude all available primary macropore volume. However, they are rarely, if ever, continuous, as they are inhibited by elongated grain contacts, and clearly post-date notable compaction. The quartz overgrowths engulf anatase.

The prominent carbonate present has not been stained, but demonstrates the same properties as the carbonate in sample 5560.0ft (patchy, coarsely crystalline to locally poikilotopic, pore-filling cement, which overlies quartz overgrowths), and therefore is also likely to be ferroan calcite.

RESERVOIR POTENTIAL

Porosity Data: \varnothing_{He} = naPermeability Data: K_h = naMacroporosity Data: \varnothing_{PRIM} = 0% \varnothing_{SOM} = 0% \varnothing_{MICRO} = na

This sample is devoid of macroporosity. The primary pore network has been completely destroyed by compaction and cementation (quartz > carbonate). Reservoir quality, therefore, is likely to be negligible.

Tunalik 6507.0 TSD Brief.docx Sample Descriptions



Well: **Grain Size:** 0.040mm (csiltL) Classification: Tunalik Depth: 6510.00ft DD Sorting: 0.463Ø (ws)

Thin-section scan





Thin-section photomicrograph

Key: White Grains: Quartz / Feldspar Black: Organic Matter

Field of View = 2.76mm Grey / Brown Grains: Ductile Grains + Lithic Grains Brown Matrix: Detrital Clay +/- Deformed Ductile Grains

Grain-Size Frequency Distribution

The thin-section is a legacy thin-section (provided by OSA / Santos). It does not appear to have been stained for carbonate or K-feldspar, but otherwise is of overall good quality.

This sample is a mud-prone siltstone, with an average coarse silt Lower grain size (although mode grain size is medium silt Upper). It displays a very finely laminated fabric, characterised by sub-mm scale changes in mud versus silt content. In the centre of the thin-section, the laminae appear folded / slumped and contorted. This deformation is probably related to syn-depositional slumping, with some possibly dewatering.

The sample does not appear to have been overprinted by authigenic phases (no room / primary volume in which to precipitate).

msitt msitt fsitU The silt grains principally comprise quartz. Lithic grains are relatively minor, due to the silt grain size, whilst feldspar grains (unstained / undifferentiated, although probably mainly plagioclase) are relatively abundant. Therefore, this sample classifies as a feldspathic wacke, and is the only sample of the entire 14 well sample set, to classify not a lithic wacke / sandstone.

50

40

30

20

10

RESERVOIR POTENTIAL

Permeability Data: Porosity Data: $K_h = na$ **Macroporosity Data:** \emptyset SIM = 0% \emptyset MICRO = na \emptyset PRIM = 0% \emptyset som = 0%

This sample has no reservoir potential, as it represents a mud-prone siltstone.

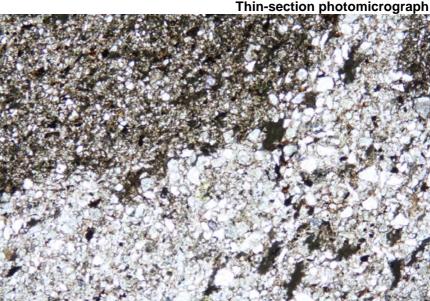
page 1 of 1



Well: Tungak Creek Grain Size: 0.104mm (vfsU) Classification: LW Depth: 3067.00ft DD Sorting: 0.694Ø (mws)



Field of view= 23.5mm



Field of View = 2.76mm Grey / Brown Grains: Ductile Grains + Lithic Grains Brown Matrix: Detrital Clay +/- Deformed Ductile Grains

The thin-section is a legacy thin-section (provided by OSA / Santos). It does not appear to have been stained for K-feldspar (or there is little or no K-feldspar present), and the surface finish is extremely uneven (making it difficult to focus evenly over larger areas).

The sample comprises only a small, single fragment / rock chip. Approximately 55% of the sample is represented by a ductile-rich, highly compacted, very fine-grained sandstone, bounded against mud-prone siltstone (which represents ~35-40% of the total volume of material), followed by silty mudstone (which represents ~5-10% of the total volume of material). The contacts / bedding planes between these lithologies are highly irregular and deformed. Deformation / churning is also significant within each lithology. The nature

of the churning is more consistent with biogenic modification than dewatering.

The matrix clay in the muddier lithologies has been patchily overprinted by microcrystalline siderite. The siderite also replaces some mudclasts within the sandier realms.

RESERVOIR POTENTIAL

Porosity Data: $\emptyset_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\emptyset_{PRIM} = 0\%$ $\emptyset_{SIM} = 0\%$ $\emptyset_{SOM} = 0\%$ $\emptyset_{MICRO} = na$

Key: White Grains: Quartz / Feldspar

This sample lacks macroporosity, even within the sandy(ier) realms, where abundant ductile material (mudclasts and matrix clay) has facilitated pronounced compaction. Therefore, due to its mud-prone and compaction nature, reservoir quality is likely to be negligible.

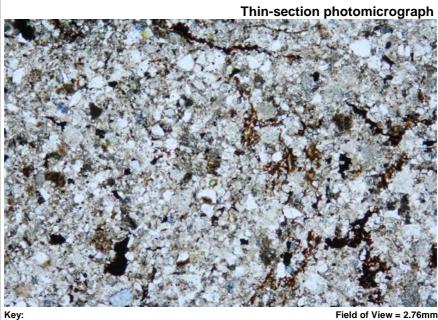
page 1 of 2



Well: Tungak Creek Grain Size: 0.063mm (vfsL) Classification: LW Depth: 3074.00ft DD Sorting: 0.651Ø (mws)

Thin-section scan

Field of view= 22.5mm

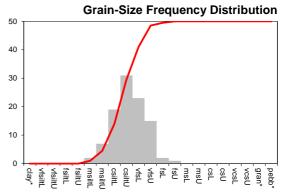


Key:White Grains: Quartz / Feldspar Black: Organic Matter

Grey / Brown Grains: Ductile Grains + Lithic Grains
Brown Matrix: Detrital Clay +/- Deformed Ductile Grains

The thin-section is a legacy thin-section (provided by OSA / Santos). The thin-section has been stained for carbonate, but it is unclear whether it has been stained for K-feldspar (a lack of yellow K-feldspar staining could simply be due to the paucity of K-feldspar grains).

This sample is a moderately well sorted, mud-prone siltstone to very fine grained (Lower) sandstone (mean grain size sits on the coarse silt Upper to very fine sand Lower boundary, with both median and mode grain size being coarse silt). The fabric is highly churned, with irregular, patchy distribution of prominent organic material. There has clearly been significant inter-mixing of finer grained, possibly more mud-prone silt with very fine-grained, possibly cleaner (albeit still ductile-rich) sand, resulting in the moderately well to almost moderately sorted texture.



The abundant clayey ductile material present appears to have facilitated notable compaction of the grain framework.

FRAMEWORK GRAINS (64.0%)

- Monocrystalline quartz (30.0%):
- Polycrystalline quartz (2.5%):
- Chert (1.5%):
- Feldspar (9.5%):
- Extrabasinal Rigid rock fragments (20.0%): dominated by metamorphic clasts (mainly schist) and carbonate grains. The carbonate grains mainly comprise monocrystalline and polycrystalline dolomite, which is non-ferroan. The dolomite grains have locally been replaced by finely crystalline rhombs of ferroan dolomite.
- Heavy minerals (0.5%):

DUCTILE COMPONENTS (34.0%)

- Ductile rock fragments (5.5%): minor, small, highly plastically deformed, brown (?illitic) mudclasts, and minor, highly micaceous extrabasinal rock fragments (mica schist), which are not as highly plastically deformed as the mudclasts.
- Mica (4.0%):
- Detrital clay (19.5%): abundant, pervasive, pore-filling, brown matrix clay.
- Organic matter (5.0%):

AUTHIGENIC COMPONENTS (2.0%)



page 2 of 2

Well: Tungak Creek Depth: 3074.00ft DD

This sample, probably due to its mud-prone nature, has been poorly overprinted by authigenic cements. Minor carbonate (1.5%) is present, along with relatively scarce kaolinite (0.5%). As this sample has been stained for carbonate (most of the legacy thin-sections for this project have not been stained for carbonate), it has been possible to identify at least 2 phases of carbonate. The dominant phase is microcrystalline, to more typically very finely crystalline, subhedral to euhedral rhombs of ferroan dolomite (the rhombs range in size from ~30-70m in diameter), which principally replace detrital dolomite grains, as well as chert grains and matrix clay, and more rarely precipitate in primary pores (probably because their was little space to precipitate in the first place, due to the mud-prone nature of this sample). Markedly rarer, more coarsely crystalline ferroan calcite is locally seen occluding primary pores and replacing lithic grains.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 0\%$ $\varnothing_{SIM} = 0\%$ $\varnothing_{SOM} = 0\%$ $\varnothing_{MICRO} = na$

This sample is a tightly compacted, mud-prone, siltstone bordering on very fine-grained sandstone, which is devoid of macroporosity. This sample, therefore, has no reservoir potential.

Tungak Creek 3074.00 TSD Brief.docx
Sample Descriptions

page 1 of 2



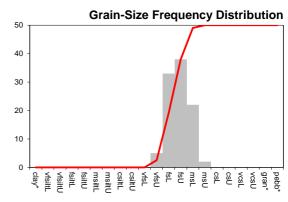
Well: Tungak Creek Grain Size: 0.201mm (fsU) Classification: LS

Depth: 4602.00ft DD Sorting: 0.394Ø (ws)



The thin-section is a legacy thin-section (provided by OSA / Santos). It does not appear to have been stained for carbonate or K-feldspar. Also, grinding / polishing medium commonly occurs within the resin, and along with surface imperfections (very small bubbles, etc.), often makes it difficult to observe and different anatase and authigenic clays.

Two small chips of material are mounted in thin-section. They appear to comprise the same highly lithic, well sorted, clean, fine-grained (Upper) sand. However, the larger chip shows a broad grain size lamination (a couple of very thin, finer grained laminae are present, which contain prominent heavy minerals), whilst the smaller chip appears massive fabric (this smaller chip is probably too small for any localised grain size lamination to be apparent).



Compaction appears overall moderate to pronounced, with most grains demonstrating elongated grain contacts, and significant plastic deformation of ductile grains being apparent. Overall this sample appears to have lost approximately 50% of its original primary intergranular volume through compaction.

FRAMEWORK GRAINS (76.5%)

- Monocrystalline quartz (34.0%): sub-angular to sub-rounded in shape, with typically uniform extinction.
- **Polycrystalline quartz** (8.5%): whilst some grains are equigranular, finely crystalline, with occasionally foliated fabrics (and grade into quartz-schist), others are inequigranular and more coarsely crystalline.
- Chert (3.0%): chert grains are often quite well rounded. They are relatively clean, and many show partial corrosion (spongy in nature), although a few are highly to almost completely corroded.
- **Feldspar** (14.0%): dominated by plagioclase, which often shows minor to pronounced corrosion. A few twinned feldspar grains possibly comprise K-feldspar, but otherwise most of the feldspar grains appear to be plagioclase.
- Extrabasinal rigid rock fragments (16.0%): dominated by metamorphic / meta-sedimentary clasts (quartz-mica schist, hornfels-like grains and metamorphosed siltstone). Minor plutonic / crystalline composite grains of quartz + feldspar +/- chlorite have also been observed, along with very minor reworked sedimentary clasts (sandstone and dolostone). Rare, green, highly altered lithic grains have also been observed (?chloritic).
- **Heavy minerals** (1.0%): angular grains of garnet, rutile and zircon. The rutile grains tend to show pronounced corrosion, with the skeletal remnants being replaced by authigenic anatase).

Tungak Creek 4602.00 TSD Full.docx
Sample Descriptions



page 2 of 2

Well: Tungak Creek Depth: 4602.00ft DD

DUCTILE COMPONENTS (14.0%)

- **Ductile rock fragments** (11.5%): small intrabasinal mudclasts and mud-prone siltclasts and extrabasinal, highly micaceous (mainly mica schist) clasts, which demonstrate moderate to locally pronounced plastic deformation.
- Mica (0.5%): scarce, small plates of undifferentiated (altered / degraded) mica.
- **Detrital clay** (2.0%): exceptionally thin, discontinuous coats developed on some grain surfaces. Whilst clayey material is locally observed, most of these grain rims appear granular in form, with clayey material probably being replaced by oxides (?anatase).
- Organic matter (0%):

AUTHIGENIC COMPONENTS (9.5%)

This sample has been overprinted by various different authigenic phases, which although individually are relatively minor in abundance, collectively result in moderate / prominent diagenetic modification, which is significantly more pronounced than in most of the other Nanushuk samples / wells included in this study. The authigenic assemblage comprises minor quartz (3.0%), anatase (3.0%), undifferentiated authigenic clay (2.0%) and kaolinite (1.5%), with trace, exceptionally thin, highly discontinuous plagioclase overgrowths developed on a few host plagioclase grains.

- The authigenic quartz forms variably developed syntaxial overgrowths around many, but not by no means all, monocrystalline quartz grains (some are highly discontinuous, others are relatively continuous). The overgrowths range from incipient, through to moderately continuous, and are typically relatively thick. Some form pore-filling outgrowths, and some form euhedral pyramidal outgrowths which project into primary pores. The overgrowths engulf microcrystalline anatase.
- The **anatase** occurs as microcrystalline, irregular shaped (anhedral) crystals and slightly prismatic (more euhedral) crystals, which occur scattered at pore margins, although are also locally seen replacing corroded rutile grains and lithic grains.
- The **undifferentiated authigenic clay** is relatively coarsely crystalline (compared to other wells in this study where undifferentiated authigenic clay is observed), and shows a platy to somewhat fibrous morphology, and low to moderate birefringence. Unfortunately, it is not possible to tell whether this phase comprises illite, chlorite or a different clay species. The authigenic clay locally plugs primary pores, and is also observed replacing partially corroded lithic grains.
- The **kaolinite** forms finely crystalline, moderately formed verms, through to more rarely coarsely crystalline, short verms, which are loosely packed, and principally occlude scattered, single primary pores, and are more rarely seen replacing feldspar grains. The pore-filling kaolinite inhibits and is engulfed by quartz overgrowths.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 7.0\%$ $\varnothing_{SIM} = 1.4\%$ $\varnothing_{SOM} = 2.3\%$ $\varnothing_{MICRO} = na$

This sample contains prominent, but not abundant, remnant primary macropores. However, notable corrosion of framework grains is apparent, generating prominent, albeit overall minor, secondary macroporosity (3.6%). The secondary macropores are principally oversized in nature (near-complete to complete dissolution of host grain), and enhance / connect to the remnant primary pore network. Slightly rarer secondary intraparticle macropores are also present, and occur within partially corroded grains (these are trapped within the non-corroded grain remnants, and do not connect to the primary pore network). Most of the secondary pores are generated by the dissolution of feldspar grains, although chert grains, rutile grains and the feldspathic component(s) of some lithic grains also demonstrate corrosion.

Grain dissolution / corrosion appears to be more significant in this sample, and the Tungak samples overall, compared to the other wells included in this study. Primary interparticle macropores have been significantly reduced in volume (both size and number) by compaction, and to a lesser extent cementation. The remnant primary macropores are typically <100µm in diameter, although a few are larger, and are overall moderately, to more rarely well, interconnected. The larger secondary oversized pores are up to ~280µm in diameter.

Overall this sample is likely to have moderate to good reservoir quality.

Tungak Creek 4602.00 TSD Full.docx
Sample Descriptions



Grain Size: Classification: Well: Tungak Creek 0.161mm (fsL) 4613.00ft DD Depth: Sorting: 0.347Ø (vws)



Field of view= 23mm

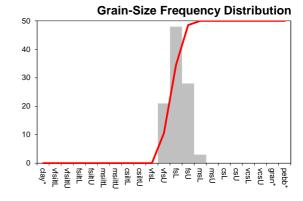
Thin-section photomicrograph

White Grains: Quartz / Feldspar Black: Organic Matter

Field of View = 2.76mm Grey / Brown Grains: Ductile Grains + Lithic Grains Turquoise Blue = Porosity

The thin-section is a legacy thin-section (provided by OSA / Santos). It does not appear to have been stained for carbonate or K-feldspar. Also, grinding / polishing medium commonly occurs within the resin, and along with surface imperfections (very small bubbles, etc.), often makes it difficult to observe and different anatase and authigenic clays.

This sample comprises only 2 small chips / pieces mounted into resin. Both chips are represented by well sorted, highly lithic, fine-grained (Lower) sandstone, which is relatively clean (clay-poor). However, ductile rock fragments are locally abundant in the lowermost portion of one of the chips (where they highlight a somewhat distorted fabric [patchy distribution]), with organic matter being locally abundant in



the other chip (concentrated within a thin, discrete, organic-rich laminae). Because the chips are so small, it is not possible to determine the nature / origin of the churning.

Compaction appears overall relatively pronounced, and grain contacts are principally elongated, to locally concavoconvex. The ductile rock fragments show significant plastic deformation. Overall this sample appears to have lost approximately two thirds of its original primary intergranular volume through compaction.

FRAMEWORK GRAINS (72.0%)

- Monocrystalline quartz (32.5%):
- Polycrystalline quartz (9.5%):
- **Chert** (5.0%): locally spongy and demonstrating corrosion.
- Feldspar (10.0%): rare twinned K-feldspar grains have been observed. Plagioclase dominates, and often show pronounced corrosion, resulting in prominent, albeit overall minor, secondary oversized macropores.
- Extrabasinal Rigid rock fragments (15.0%): dominated by metamorphic clasts (schist and welded, argillaceous metasedimentary grains). A few of the minor plutonic rock fragments present demonstrate quartz / feldspar intergrowths, more typically associated with igneous fabrics, rather than metamorphic fabrics.
- Heavy minerals (0%):

DUCTILE COMPONENTS (18.5%)

- **Ductile rock fragments (14.5%):**
- Mica (0.5%):
- Detrital clay (1.5%):
- Organic matter (2.0%):



page 2 of 2

Well: Tungak Creek Depth: 4613.00ft DD

AUTHIGENIC COMPONENTS (9.5%)

The authigenic assemblage comprises minor syntaxial, variably developed quartz overgrowths (4.5%), kaolinite (2.0%), undifferentiated authigenic clay (1.5%) and anatase (1.5%), which are similar in form / habit to the adjacent sample (4602.0ft), where they have been described in full.

The undifferentiated authigenic clay locally replaces detrital grains (original / host grain composition is impossible to determine, as replacement is pervasive), and demonstrates moderate birefringence, suggesting an illitic composition.

RESERVOIR POTENTIAL

Porosity Data: $\emptyset_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\emptyset_{PRIM} = 5.4\%$ $\emptyset_{SIM} = 1.3\%$ $\emptyset_{SOM} = 4.0\%$ $\emptyset_{MICRO} = na$

This sample contains relatively abundant macropores (total 10.7%), which vary significantly in size / form. Approximately half of the macropores represent small, poorly to moderately interconnected, remnant primary interparticle macropores, which have been severely reduced in volume (size and number) by compaction, and to a much lesser extent cementation. The remaining 50% of the macropores are secondary in origin, resulting from the localised pronounced corrosion of mainly feldspar grains, enhancing porosity. Corrosion is mainly complete, resulting in relatively large, oversized secondary macropores, which connect to adjacent primary macropores, and therefore also enhance permeability. Partial corrosion is less pronounced, and results in smaller secondary macropores that are trapped within their host partially corroded feldspar grains.

Overall this sample is likely to have a moderate to possibly good reservoir quality.

Sample Descriptions

page 1 of 1

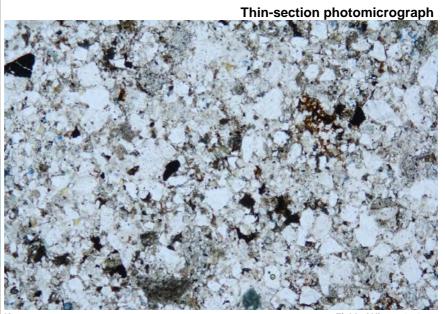


Well: Tungak Creek Grain Size: 0.103mm (vfsU) Classification: LS

Depth: 4627.00ft DD Sorting: 0.703Ø (mws)

Thin-section scan

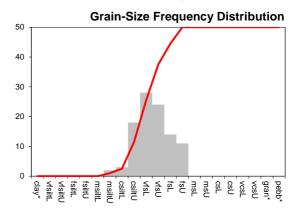




Key:White Grains: Quartz / Feldspar
Black: Organic Matter

Field of View = 2.76mm
Grey / Brown Grains: Ductile Grains + Lithic Grains
Brown Matrix: Detrital Clay +/- Deformed Ductile Grains

The thin-section is a legacy thin-section (provided by OSA / Santos). Staining appears to have been applied, but is very poor (and therefore it has not been possible to differentiate plagioclase and K-feldspar during modal analysis). Also the overall quality of the thin-section is poor. Grinding / surface finish is variable (the thickness of the slide varies), resulting in difficulty focussing evenly within a field of view. Large areas have also been over-ground, with no resin impregnation, making it difficult / impossible to identify mineral phases in some places, or identify pores (these areas have been skipped over during modal analysis) – one such area is highlighted by the red arrow in the thin-section above (large, irregular, light coloured patch in the centre of the rock chip).



This sample appears to be a ductile-rich, moderately sorted, overall very fine-grained (Upper), lithic sandstone. Whilst mean grain size is vfsU, median grain size is vfsL and mode grain size is csiltU (see grain size frequency distribution above). The fabric of this sample is difficult to determine, in part because comprises only 2 small rock chips, but also because of the significant issues in quality of the thin-section preparation. The fabric is possibly churned / deformed. The presence of abundant ductile material (ductile rock fragments [mainly mudlcasts] > detrital matrix clay) has facilitated pronounced compaction. Cementation is light. The very minor dolomite recorded occurs as replacive, finely crystalline, euhedral, ferroan rependence.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 0.5\%$ $\varnothing_{SIM} = 0.5\%$ $\varnothing_{SOM} = 0\%$

This sample contains only minor, extremely small remnant primary macropores within just a few, small cleaner (albeit still relatively ductile-rich) patches. Most of the sample appears devoid of macropores, with the primary pore network destroyed by abundant ductile material and compaction. Reservoir quality is expected to be very poor.

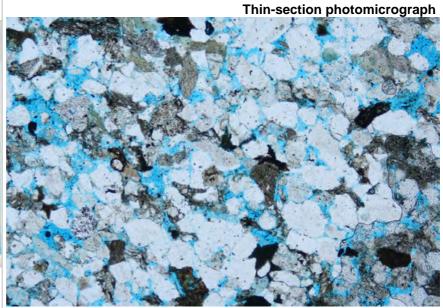
page 1 of 2



Well: Tungak Creek Grain Size: 0.172mm (fsL) Classification: LS Depth: 4633.00ft DD Sorting: 0.501Ø (mws)

Thin-section scan

Field of view= 23.5mm



Field of View = 2.76mm
Grey / Brown Grains: Ductile Grains + Lithic Grains
Turquoise Blue = Porosity

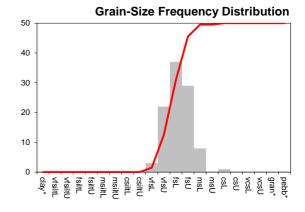
The thin-section is a legacy thin-section (provided by OSA / Santos). It does not appear to have been stained for carbonate or K-feldspar. Surface quality is not ideal, and the cover-slipping is poor, making it difficult to observe very fine detail, particularly authigenic clays and microcrystalline anatase.

Key:

White Grains: Quartz / Feldspar

Black: Organic Matter

This sample comprises small rock chips / fragments, ranging in size from only ~1.5mm in diameter, up to ~12mm in diameter. They all comprise relatively clean, highly lithic, poorly cemented, moderately well sorted, fine-grained (Lower) sandstone. The fabrics of the rock chips appear relatively massive, although as these chips are very small, larger scale depositional features / fabrics could easily have been missed. The smaller fragments of sandstone also demonstrate notable fracturing, probably as a result of



sample acquisition / drilling (it is possible that the chips of sandstone represent cuttings material).

The grain framework demonstrates notable compaction, with most grain contacts being highly elongated in nature, and the more highly micaceous extrabasinal rock fragments showing significant plastic deformation (and hence have been point-counted as extrabasinal ductile rock fragments, rather than extrabasinal rigid rock fragments). Overall the sandstone material appears to have lost approximately ~65-70% of its original / depositional intergranular volume through compaction.

FRAMEWORK GRAINS (80.5%)

- Monocrystalline quartz (39.0%): sub-rounded to sub-angular in shape. There is no relationship between grain shape / roundness and grain size (i.e. the larger grains are not anymore rounded in shape compared to the smaller grains).
- **Polycrystalline quartz** (6.0%): show a wide range in crystallite size, mainly between individual grains, and more rarely within individual grains (most grains show equigranular textures, although some are inequigranular in nature)
- Chert (1.5%): clean to highly dirty / dark brown grains. Rarely shows signs of corrosion.
- **Feldspar** (12.5%): although unstained, most of the twinning grains demonstrate plagioclase twinning, with only rare orthoclase twinning noted. The untwinned grains show partial sericitisation more commonly associated with plagioclase than with K-feldspar.
- Extrabasinal rigid rock fragments (21.5%): dominated by fragments of metamorphic material, mainly quartz-rich schist, and rarer more clayey / welded meta-sedimentary clasts. Minor plutonic clasts (quartz / feldspar composites, with rare, if any chlorite), highly altered / undifferentiated grains and reworked (at least 2nd cycle) sandstone fragments, have also been observed.

Tungak Creek 4633.00 TSD Full.docx
Sample Descriptions



page 2 of 2

Well: Tungak Creek Depth: 4633.00ft DD

• **Heavy minerals** (trace): dominated by rutile, with rarer zircon and garnet. The rutile grains often show significant corrosion.

DUCTILE COMPONENTS (14.5%)

- **Ductile rock fragments** (13.5%): dominated by extrabasinal, highly micaceous lithic grains (mica schist), which contain little, if any, crystalline quartz. Minor, brown intrabasinal mudclasts are also observed, which demonstrate notably greater plastic deformation relative to the mica schist clasts.
- **Mica** (0.5%): although mica is commonly evident within lithic / extrabasinal rock fragments, individual plates of mica are extremely scarce. Most appear altered / degraded, and thus of undifferentiated composition.
- Detrital clay (0.5%): most grain surfaces appear clean, but locally some contain exceptionally thin, discontinuous clay coatings. The clay is brown, with moderate birefringence, suggestive of an illitic composition, at least in part.
- Organic matter (trace): rare, small particle of organic material.

AUTHIGENIC COMPONENTS (5.0%)

The sample has been lightly overprinted by authigenic cements. Minor quartz overgrowths (3.5%) and undifferentiated authigenic clay (1.5%) have been observed, along with traces of kaolinite, siderite and anatase.

- The authigenic quartz typically forms incipient to small, discontinuous syntaxial overgrowths, although locally
 the overgrowths are thicker, albeit still discontinuous, and precipitate outwards and occlude small primary
 macropores. The overgrowths engulf microcrystalline anatase, undifferentiated authigenic clay and kaolinite,
 and appear to be inhibited by at least moderately elongated grain contacts.
- The undifferentiated authigenic clay is relatively coarsely crystalline (compared to other wells in this study where undifferentiated authigenic clay is observed), and shows a platy to somewhat fibrous morphology, and low to moderate birefringence. Unfortunately, it is not possible to tell whether this phase comprises illite, chlorite or a different clay species. The authigenic clay locally plugs primary pores, and is also observed replacing partially corroded lithic grains.
- The **kaolinite** forms extremely scarce, coarsely crystalline, small, pore-filling verms.
- The siderite forms a rare microcrystalline replacement of plastically deformed mudclasts (it is likely that the
 deformation occurred post replacement of the siderite, as significant volumes of host clay material are still
 preserved).
- The anatase occurs as microcrystalline, irregular shaped (anhedral) crystals, slightly prismatic (more euhedral) crystals, and thin needle-like crystals, which principally occur scattered at pore margins.

RESERVOIR POTENTIAL

Porosity Data: \varnothing_{He} = naPermeability Data: K_h = naMacroporosity Data: \varnothing_{PRIM} = 6.5% \varnothing_{SIM} = 1.8% \varnothing_{SOM} = 3.6% \varnothing_{MICRO} = na

This sample contains only minor, small, poorly to moderately interconnected remnant primary interparticle macropores (4.5%). Primary interparticle macropores were likely to have been abundant upon deposition, but have been severely reduced in volume (size and number) by pronounced compaction (the largest remnant primary macropores are still less than 100 microns long, and most are typically only ~20-40 microns in diameter). However, the primary pore network has been enhanced somewhat by the generation of prominent, albeit still volumetrically minor, secondary oversized macropores (3.6%), produced by the complete dissolution of framework grains, probably feldspar. Feldspar grains more rarely show partial corrosion (i.e. most corrosion results in the complete removal of the host grain), resulting in the presence of minor, small intraparticle macropores trapped within the non-corroded feldspar grain remnants (these do not connect / enhance the primary pore network).

Reservoir potential is likely to be moderate, at best.

Tungak Creek 4633.00 TSD Full.docx
Sample Descriptions

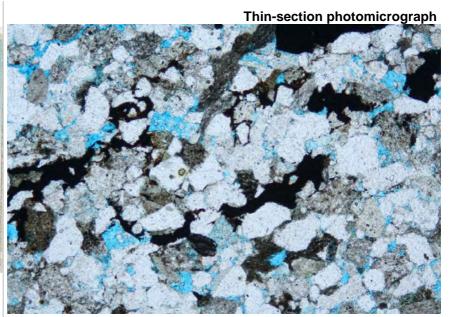
page 1 of 1



Well: Tungak Creek Grain Size: 0.191mm (fsU) Classification: LS Depth: 4636.00ft DD Sorting: 0.493Ø (ws)

Thin-section scan



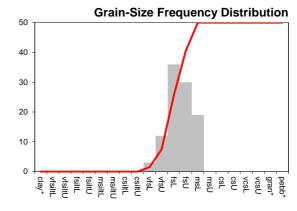


Key:White Grains: Quartz / Feldspar Black: Organic Matter

Field of View = 2.76mm
Grey / Brown Grains: Ductile Grains + Lithic Grains
Turquoise Blue = Porosity

The thin-section is a legacy thin-section (provided by OSA / Santos). It does not appear to have been stained for carbonate or K-feldspar. Surface quality is not ideal, but acceptable, and overall the quality of the thin-section is adequate.

This sample comprises a single, small rock chip, represented by a well sorted, fine-grained (Upper), lithic sandstone. Organic material, comprising relatively large, irregular shaped particles, some up to 1.3mm in diameter, along with rarer thin strands, are locally concentrated within a thin, organic-rich laminae. The sample contains only minor clayey ductile material, although micaceous extrabasinal rock fragments (schist) are common, and show notable plastic deformation.



Cementation is relatively light, with only minor quartz overgrowths and authigenic clays observed. Compaction, however, is pronounced, and has severely degraded the primary pore network (this sample has lost approximately ~70% of its original primary intergranular volume via compaction).

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 2.4\%$ $\varnothing_{SIM} = 1.0\%$ $\varnothing_{SOM} = 0.5\%$ $\varnothing_{MICRO} = na$

This clean, but highly lithic and intensely compacted sandstone, contains only minor, small, remnant primary interparticle macropores, which are overall poorly interconnected with one another. Minor secondary macropores are principally intraparticle in nature (not connected to the primary pore network). This sandstone, therefore, is likely to have poor reservoir quality.

page 1 of 2



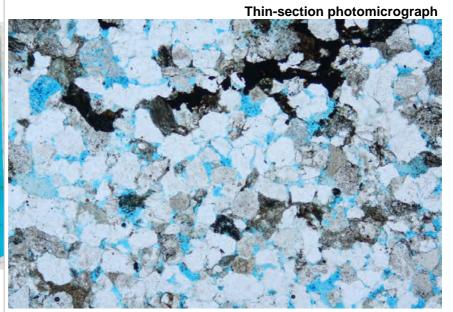
Well: Tungak Creek Grain Size: 0.188mm (fsU) Classification: LS

Depth: 4645.00ft DD Sorting: 0.414Ø (ws)

Thin-section scan



Field of view= 23mm

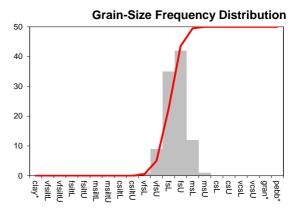


Key:White Grains: Quartz / Feldspar
Black: Organic Matter

Field of View = 2.76mm
Grey / Brown Grains: Ductile Grains + Lithic Grains
Turquoise Blue = Porosity

The thin-section is a legacy thin-section (provided by OSA / Santos). It does not appear to have been stained for carbonate or K-feldspar. Surface quality is not ideal, but acceptable, and overall the quality of the thin-section is adequate.

This sample comprises small chips / particles of material, and is probably derived from a cuttings sample. It is similar to that previously described at 4636.0ft from this well, and also comprises a well sorted, fine-grained (Upper), lithic sandstone. Again, organic material, comprising relatively large, irregular shaped particles, are locally concentrated within organic-rich laminae, although this time, along with prominent ductile rock fragments (mainly mudclasts in these laminae).



Cementation is relatively light. Compaction, however, is pronounced, and has severely degraded the primary pore network (this sample has lost approximately ~65-70% of its original primary intergranular volume via compaction). Grain contacts, therefore, are mainly elongated, although some of the very finely crystalline, metamorphic clasts demonstrate concavo-convex grain contacts.

FRAMEWORK GRAINS (80.5%)

- Monocrystalline quartz (36.0%):
- Polycrystalline quartz (10.0%):
- Chert (6.0%):
- Feldspar (11.0%): twinned K-feldspar grains are locally observed. Most of the twinned feldspar grains, however, comprise plagioclase. Significant corrosion of feldspar grains is observed.
- Extrabasinal Rigid rock fragments (17.5%): carbonate (dolostone) grains are rarely observed (trace volumes).
- Heavy minerals (trace): zircon, garnet and rutile.

DUCTILE COMPONENTS (14.5%)

- **Ductile rock fragments** (12.5%): sub-equal mixture of extrabasinal rock fragments (mainly mica-schist, although some unusual, highly altered grains are also observed) and brown, intrabasinal mudclasts. The mudclasts demonstrate pronounced plastic deformation, whereas the mica schist fragments show moderate to more rarely pronounced plastic deformation.
- Mica (0%):
- **Detrital clay** (0.5%):
- Organic matter (1.5%):



page 2 of 2

Well: Tungak Creek Depth: 4645.00ft DD

AUTHIGENIC COMPONENTS (5.0%)

The sample has been lightly overprinted by authigenic cements. The authigenic assemblage mainly comprises minor quartz overgrowths (5.0%), although traces of undifferentiated authigenic clay, kaolinite and anatase have also been observed. These phases are similar to those described in full in sample 4633.0ft, although the kaolinite is more finely crystalline in this sample.

The following paragenetic relationships have been observed:

- · Quartz overgrowths engulf kaolinite.
- Anatase is entrapped within quartz overgrowths.
- Quartz overgrowths post-date (are inhibited by) moderately elongated grain contacts.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 7.4\%$ $\varnothing_{SIM} = 2.2\%$ $\varnothing_{SOM} = 3.9\%$ $\varnothing_{MICRO} = na$

This sample contains relatively abundant macropores (13.4%), which comprise a sub-equal mixture of primary interparticle macropores and secondary macropores. The primary macropores are typically relatively small, having been significantly reduced in size and number by pronounced compaction, and are overall moderately interconnected (inter-connection ranges from poor to good). The secondary macropores have been produced by the typically advanced corrosion of framework grains, principally feldspar grains, although chert grains, and very rarely rutile grains, also show corrosion. The dissolution is more typically complete, resulting in prominent secondary oversized macropores, which are notably larger compared to the remnant primary macropores, and appear to enhance both porosity and permeability. Smaller, intraparticle macropores are rarer, and tend to be trapped within or restricted by the non-corroded remnants of their host feldspar grains.

The secondary oversized pores do not show signs of volume / size reduction by compaction, and very fragile, skeletal, highly corroded grain remnants remain intact (i.e. have not collapsed / compacted), suggesting that feldspar corrosion mainly occurred post-compaction.

Overall this sample is likely to have moderate to good reservoir potential.

Sample Descriptions

page 1 of 2

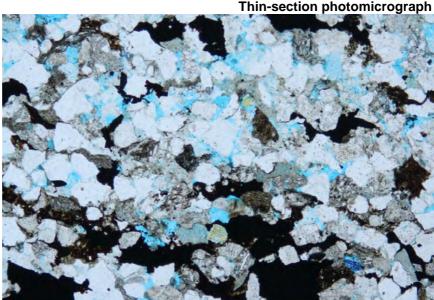


Well: Tungak Creek Grain Size: 0.179mm (fsU) Classification: LS Depth: 4653.00ft DD Sorting: 0.434Ø (ws)

Thin-section scan



Field of view= 23mm

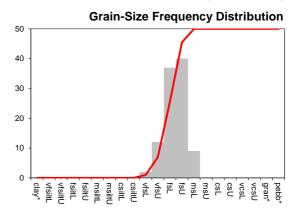


Key:White Grains: Quartz / Feldspar
Black: Organic Matter

Field of View = 2.76mm
Grey / Brown Grains: Ductile Grains + Lithic Grains
Turquoise Blue = Porosity

The thin-section is a legacy thin-section (provided by OSA / Santos). It does not appear to have been stained for carbonate or K-feldspar. Surface quality is not ideal, but acceptable, and overall the quality of the thin-section is adequate.

This sample comprises a single, small chip / particle of well sorted, highly lithic, fine-grained (Upper) sandstone. Matrix / detrital clay and mica are scarce. However, this sandstone contains abundant organic matter and ductile rock fragments, which have facilitated pronounced compaction of the grain framework. In fact, this sandstone sample is one of the most highly compacted of the Tungak sample set, and has lost approximately ~80% of its original / depositional intergranular volume via compaction, probably due to its more ductile-rich nature compared to the other fine-grained sandstone samples from this well.



FRAMEWORK GRAINS (58.5%)

- Monocrystalline quartz (21.0%):
- Polycrystalline quartz (6.5%):
- Chert (7.0%):
- Feldspar (8.5%):
- Extrabasinal Rigid rock fragments (15.5%):
- Heavy minerals (0%):

DUCTILE COMPONENTS (38.0%)

- **Ductile rock fragments** (20.5%): prominent, small intrabasinal mudclasts, which have been highly plastically deformed, such that they have been squeezed into, and hence occlude, adjacent primary macropores. Extrabasinal ductile rock fragments (mainly highly micaceous schist clasts) are more abundant than the intrabasinal mudclasts, but show less (more moderate degrees of) plastic deformation.
- Mica (trace):
- **Detrital clay** (0.5%):
- Organic matter (17.0%): organic material is extremely abundant in this sample, and mainly occurs within
 extremely large, irregular shaped grains / particles, and more rarely thick, elongated strands, some of which are
 up to 2.5mm in diameter. The organic particles show pronounced plastic deformation, and have significantly
 facilitated compaction.



page 2 of 2

Well: Tungak Creek Depth: 4653.00ft DD

AUTHIGENIC COMPONENTS (3.5%)

The primary pore network of this sample has only been modified by minor quartz overgrowths (2.5%), with scarce pore-filling kaolinite (0.5%), rhombic, finely crystalline dolomite (0.5%) and undifferentiated authigenic clay (trace ?illite). The quartz overgrowths engulf kaolinite verms, and the kaolinite verms appear to post-date the undifferentiated clay plates / sheets.

RESERVOIR POTENTIAL

Porosity Data: $\varnothing_{He} = na$ Permeability Data: $K_h = na$ Macroporosity Data: $\varnothing_{PRIM} = 1.4\%$ $\varnothing_{SIM} = 1.4\%$ $\varnothing_{SOM} = 0.5\%$ $\varnothing_{MICRO} = na$

This sample is ductile-rich (abundant ductile rock fragments and organic matter) and shows extremely pronounced compaction. Remnant primary macropores are very minor, small and poorly interconnected. Minor secondary macropores are also observed, although these are often intraparticle in nature, and even where they are oversized (i.e. complete dissolution of host grains), the oversized pores are relatively isolated, and do not always connect to the small, minor, remnant primary macropores.

Overall this sample is likely to have poor reservoir quality.

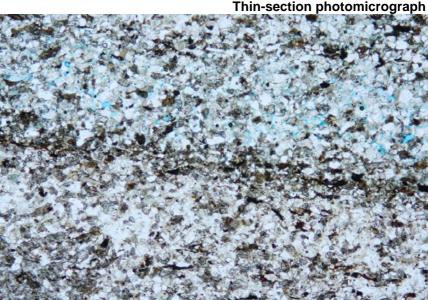
Sample Descriptions



Well: Tungak Creek **Grain Size:** Classification: 0.053mm (csiltU) 4661.00ft DD 0.590Ø (mws) Depth: Sorting:



Field of view= 23mm



Field of View = 2.76mm Grey / Brown Grains: Ductile Grains + Lithic Grains
Turquoise Blue = Porosity

The thin-section is a legacy thin-section (provided by OSA / Santos). It does not appear to have been stained for carbonate or K-feldspar. Surface quality is not ideal, but acceptable, and overall the quality of the thin-section is adequate.

Key:

White Grains: Quartz / Feldspar Black: Organic Matter / Pyrite / Heavy Minerals

This sample comprises a single, small rock chip. Despite the small size, it is readily apparent that the sample has a very finely laminated fabric, with lamination characterised by sub-mm to mm-scale changes in grain size and ductile abundance. Overall the material in the rock chip comprises ductile-rich, coarse siltstone, with ductile material

represented by a sub-equal mixture of small ductile rock fragments (intrabasinal mudclasts > extrabasinal micaceous schist) and pore-filling detrital matrix clay. The abundant matrix clay and ductile rock fragments have facilitated pronounced compaction.

Grain-Size Frequency Distribution 40 10 pebb*
gran*
yrcsU
vcsU
vcsU
csU
csI
fsU
fsU
fsiitU

The laminae in the centre portion of the rock chip are significantly cleaner than all the other laminae, and although compaction is still relatively pronounced, minor macroporosity is preserved.

RESERVOIR POTENTIAL

Porosity Data: Permeability Data: $K_h = na$ \emptyset _{He} = na **Macroporosity Data:** $\varnothing_{PRIM} = 0.5\%$ \varnothing SIM = 0% \emptyset som = 0% \emptyset MICRO = na

The majority of the laminae in this sample are extremely ductile-rich, highly compacted and lack macroporosity. However, as alluded to above, two laminae in the central portion of the rock chip are somewhat cleaner. Although ductile material is prominent in these two laminae, and has facilitated notable compaction, minor, remnant primary macropores are evident. However, these primary pores are extremely small, and poorly interconnected. Reservoir quality, therefore, is expected to be very poor / poor.



APPENDIX TWO – PETROGRAPHICAL TECHNIQUES

OPTICAL MICROSCOPY

Conventional transmitted, plane-polarised light microscopy was carried out using a Zeiss Axioskop40 microscope. Digital images were captured using a Canon PowerShot G5 digital camera.

MODAL ANALYSIS

Modal analysis has been undertaken by counting 200 points for mineral identification, with macroporosity recorded over the same interval using isolator channels (if possible to collect). Point-counting was carried out using a stage interval of 0.3mm and track-spacing of at least 2mm to ensure a minimum of three traverses of the thin-section. Traverses were made perpendicular to lamination (where lamination was evident).

The mineral counts were directly computed to percentages. If modal macropore abundances were determined on isolated channels, then percentages of macroporosity were calculated using the formula:

x 100 = modal porosity (%)

Where n = the number of macroporosity points recorded during the modal analysis and <math>p = the total number of mineral points recorded.

Macroporosity was counted based on the following definitions:

- Primary interparticle macroporosity: interparticle macropores which existed on deposition of the rock.
- Secondary macroporosity: macroporosity generated by the dissolution of detrital grains. This is divided according to the effectiveness of this porosity in enhancing the primary macropore network, into:
 - Secondary oversized macroporosity: macroporosity which enhances the primary macropore network and acts as a conduit to fluid flow.
 - Secondary intraparticle macroporosity: macroporosity assumed to be largely isolated within grains and not contributing to the permeability of the adjacent pore network.

Microporosity was calculated as helium porosity minus total modal macroporosity.

TEXTURAL ANALYSIS

The long axes of 100 grains, excluding ductile grains (e.g. micas, mudclasts), bioclasts, heavy minerals and any deformed grains were measured from a series of photomicrographs taken of each sample to capture the variability in grain size. Mean grain size was calculated as the arithmetic mean of the long axes (measured in millimetres), and categorised on the Udden-Wentworth grain size scale with \emptyset upper and lower divisions. Sorting was calculated as the standard deviation from the mean length (expressed as \emptyset), and are categorised according to the scheme of Folk and Ward (1957).