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GEOLOGICAL SURVEY OF CANADA OPEN FILE 7647

Petrographic Study of the Nanaimo Group from OW-11-01-Nanaimo Obs Well 390

L. Zhai and S.E. Grasby

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EXECUTIVE SUMMARY

Thin section petrography was conducted on forty-four (44, see Table 1) samples from the OW-11-01-Nanaimo OBS well 390, to determine their mineralogical, textural, diagenetic and reservoir characteristics. Work was focused on pore systems and processes affecting the porosity evolution.

The 44 Nanaimo Group samples include 43 sandstones and 1 silty mudstone. Most samples are massive; some finer-grained samples show clay and organic material-rich lamination, shale/siltstone cross lamination, burrows and bioturbated structures. All Nanaimo Group samples show low mature features in texture and composition with significant amounts of matrix clay (most samples are between 10 to 30% clay). Grain composition was characterized by abundant feldspar, chert and volcanic rock fragments. Quartz, feldspar and rock fragments are the three major components; although their proportions vary between samples. Coarser grained sandstone samples have a wide grain size range, varying from coarse silt to very coarse sand. The framework grains are angular, subangular to subrounded and poorly sorted or poorly to moderately sorted, showing a grain supported, moderately compacted fabric. Whereas finer (very fine to fine, or silt to very fine) grained sandstone samples demonstrated a grain-supported, well sorted fabric. Grains are subangular to subrounded or rounded, with most grain size ranging from very fine to fine.

Common diagenetic phases include authigenic chlorite coating, quartz overgrowth, feldspar overgrowth, dissolution, emplacement of pyrite, calcite and organic matter or bitumen. Evolution of the pore system is apparently controlled by depositional environment and later diagenesis. Various diagenetic features have affected the reservoir quality to varying degrees, both creating and destroying porosity. The original intergranular pores are blocked by matrix clay and further reduced by early chlorite lining, quartz overgrowth, feldspar overgrowth and compaction, therefore no original

intergranular pores were observed in any sample. Later stage dissolution produced secondary intergranular pores and improved the reservoir quality of Nanaimo Group sandstones to some degree. The formation of pyrite, calcite cement and organic matter emplacement locally occludes secondary pore spaces, all sandstone samples show very low to low visible porosity (trace to 2-3%).

The porosity types of the Nanaimo Group sandstones can be generalized as: secondary porosity (sp), microporosity (mp) and microfractures.

Secondary porosity (as a result of feldspar dissolution) is the major pore type in the Nanaimo sandstones. Microporosity is abundant and is extensive within the clay matrix, leached feldspars, chert, and rock fragments (volcanic, plutonic and metomorphic rock fragments) and has little contribution to reservoir quality due to the very smaller pore size. Microfractures appeared in two directions to cut through the rocks and locally enhanced the reservoir permeability.

INTRODUCTION

A Groundwater Assessment in the Nanaimo Lowlands project was initiated by the British Columbia Department of Environment, related local municipalities, and the Geological Survey of Canada in 2010 to evaluate groundwater resources in the Nanaimo Basin of eastern Vancouver Island. This included studies of both surficial and bedrock aquifers, including the Upper Cretaceous Nanaimo Group (Nanaimo Group stratigraphy is summarized in Hamblin 2012). During drilling of a bedrock monitoring well, a core of the Nanaimo Group was collected. Detailed descriptions of lithology, porosity and permeability are provided in Hamblin and McCartney (2014). In addition to this work, thin section petrography was conducted on forty-four (44, see Table 1) samples from the OW-11-01-Nanaimo OBS well 390, to determine their mineralogical, textural, diagenetic and reservoir characteristics. The results are presented here.

The prepared thin sections were examined petrographically. Major mineralogical compositions, grain constituents and porosity are semi-quantified using visual estimate method. Petrographic data is summarized in table format (Table 1), including framework mineralogy, diagenetic minerals, rock type, texture and porosity.

Representative photomicrographs with descriptions of the thin sections are provided in an appendix (Plates 1 to 44) at the end of report. Plates are sorted by depths and sample IDs. When examples are used in text report, they are referred to certain plates by their sample numbers.

Table 1A: Petrographic Summary

Sample ID	Spot Depth (m)	Structure	Grain Size (цm)	Sorting	Lithology	Porosity (Helium) Fraction
1	384.75	Massive	Fine - Medium	Poor - Moderate	Litharenite	0.096
2	367.00	Massive	Medium - Coarse	Poor	Fd Litharenite	0.077
4	361.75	Massive - Fracture	Fine - Medium	Moderate	Fd Litharenite	0.052
7	340.00	Massive	Fine - Medium	Moderate	Lithic Arkose	0.033
9	332.08	Laminated - Burrowed	Silt - Very Fine	Moderate - Well	Litharenite	0.073
10	328.50	Massive	Fine - Medium	Poor - Moderate	Fd Litharenite	0.048
12	318.75	Massive	Fine - Medium	Poor - Moderate	Lithic Arkose	0.048
14	305.75	Massive	Fine	Poor	Litharenite	0.056
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17	286.50	Massive	Fine	Well - Very Well	Fd Litharenite	0.098
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34	180.00	Massive	Fine - Medium	Poor - Moderate	Lithic Arkose	0.092
35	171.75	Massive - Burrowed	Very Fine - Fine	Well	Lithic Arkose	0.085
36	163.75	Massive	Very Fine - Fine	Well - Very Well	Fd Litharenite	0.091
37	161.25	Massive	Fine - Medium	Medium - Well	Fd Litharenite	0.108

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42	144.92	Massive - Laminated	Silt - Very Fine	Well - Very Well	Sublitharenite	0.076
43	139.00	Massive - Burrowed	Very Fine - Fine	Moderate - Well	Fd Litharenite	0.083
44	135.58	Massive - Burrowed			Silty mudstone	0.058
45	127.50	Massive	Very Fine - Coarse	Poor	Fd Litharenite	0.068
46	122.50	Massive	Fine - Coarse	Poor - Moderate	Fd Litharenite	0.036
48	106.67	Massive	Fine - Coarse	Poor	Lithic Arkose	0.026
50	100.67	Massive	Fine - Coarse	Poor	Lithic Arkose	0.087
51	96.00	Massive - Bioturbated	Very Fine - Fine	Well	Lithic Arkose	0.092
52	89.50	Massive	Medium - Coarse	Poor - Moderate	Fd Litharenite	0.067
53	78.50	Massive	Fine - Medium	Moderate	Fd Litharenite	0.091
55	73.33	Massive - Bioturbated	Fine - Coarse	Poor	Fd Litharenite	0.073
56	68.50	Massive - Laminated	Very Fine - Fine	Moderate	Lithic Arkose	0.063
57	62.00	Massive	Fine - Medium	Moderate - Well	Lithic Arkose	0.102
60	47.75	Massive	Fine - Medium	Poor - Moderate	Fd Litharenite	0.097
62	33.00	Massive - Bioturbated	Very Fine - Fine	Poor - Moderate	Subarkose	0.083
63	30.50	Massive	Medium - Coarse	Moderate	Fd Litharenite	0.080
64	26.25	Massive - Laminated	Very Fine - Fine	Well	Lithic Arkose	0.090
66	19.42	Massive	Medium - Coarse	Moderate - Well	Fd Litharenite	0.077

Table 1B: Petrographic Summary Continued

*Note: Fd Litharenite-----Feldspathic Litharenite

PETROGRAPHIC SUMMARY & DISCUSSION

The 44 Nanaimo samples from the OW-11-01-Nanaimo OBS well 390, include 43 sandstones and 1 silty mudstone (Table 1), all 43 sandstone samples can be further classified as feldspathic litharenites (25), lithic arkoses (14), litharenites (2), sublitharenite (1) and subarkose (1) according to Folks classification, 1968. Summary of the petrographic data is given in Table-1. The details of rock constituents, texture and diagentic features are elaborated in 44 Plates. Key petrographic features are summarized and discussed together in the following text.

Structure: Most Nanaimo sandstones are massive. Some very fine to fine grained sandstones show well developed ellipse shaped burrows (samples 19, 30, 35, 43, 44) and other bioturbation structures (samples 9, 14, 51, 55, 56). Samples 9, 35 and 42 show laminated structure which are defined by organic matter-rich and clay-rich lamina, dark brown to black organic matter and clay compressed into thin strips or lamina paralleling to bedding plane. Also elongated grains and mica are preferentially oriented and aligned along bedding planes.

Texture/fabrics: The petrographic analysis indicates that most Nanaimo Group samples are low mature in texture and composition, especially in medium to coarse grained sandstone samples. Sand grains and matrix clay were deposited together, clays blocked the intergranular pore spaces and therefore the primary pores are not well preserved before compaction. Coarser grained sandstone samples have a wide range in grain size, varying from coarse silt to very coarse sand. The framework grains are angular, subangular to subrounded and poorly sorted or poorly to moderately sorted, showing a grain supported, moderately compacted fabric. Grains are commonly pointplanar contacted to slightly concave-convex-contacted (as indicated by deformation of ductile grains; eg. mica, shale clasts, volcanic and metamorphic rock fragments). Whereas finer (very fine to fine or silt to fine) grained sandstone samples demonstrated a

grain-supported, well sorted or moderately to well sorted fabric. Grains are subangular to subrounded or rounded, with most grain size ranging from very fine to fine.

Compositions: The Nanaimo Group sandstone framework grains are composed of three major components: quartz, feldspars and rock fragments (chert, shale clasts, volcanic, plutonic and metamorphic rock fragments etc.). Minor mica, glauconite and trace heavy minerals and glauconite are also present.

Quartz (qtz) grains include monocrystalline and polycrystalline quartz, they are mainly monocrystalline, inclusion free or with rare mica and heavy mineral (e.g. zircon) inclusions. Quartz tends to increase its quantity in finer (very fine to fine) grained sandstones. Quartz grains are moderately to well sorted and subangular to subrounded. Trace to minor authigenic quartz overgrowths are mainly found in coarser grained sandstone samples (samples 4, 16, 21, 29, 30, 32, 38, 41, 46, 48, 52, 46, 48, 52, 63, 66). Feldspar (fd) occurs mainly as plagioclase with minor potassium feldspar, all Nanaimo Group sandstones are characterized by considerable feldspar. Feldspar grains are identified by elongated shape, weathered surfaces (sericited), cleavages, Carlsbad twining, albite twining, polysynthetic twining (microcline) and Carlsbad-albite twining (plagioclase). Dissolution or leaching of feldspar grains generated minor secondary porosity within feldspar grains or volcanic rock fragments and improved reservoir quality in some degree. Chert (cht) often inclusion-rich (clays, dolomite and pyrite), is the main constituent of the framework, characterized by crypto- to microcrystalline and rare fibrous chalcedony textures. Also chert grains can be leached to various extents, generating microporosity and secondary porosity in kerogen mature stage. Volcanic rock fragments (VRF) are characterized by their unique fabric, with feldspar laths floating in cryptocrystalline groundmass. Both feldspar laths and groundmass are commonly leached to various extents (like chert grains), forming secondary intragranular porosity and microporosity. Chloritization and pyritization are the most common alteration products in volcanic rock fragments. Metamorphic rock fragments (MRF) consist of micaceous

schist and phyllite clasts, and are often compressed between harder grains. Metamorphic rock fragments are also frequently altered by chlorite and pyrite. However, no secondary pore spaces are found within metamorphic rock fragments. Sedimentary rock fragments are mainly <u>shale clasts (sh)</u> with trace to minor <u>bioclasts</u>. Shale clasts occur in all sandstone samples regardless of grain size variation. They are ductile grains, sub-preferentially oriented, often squeezed between other grains, even forming pseudo matrix and lowered reservoir quality.

Diagenesis: Reservoir quality in the Nanaimo Group sandstone is a function of a complex interrelationship of both depositional and diagenetic processes. Common diagenetic phases encountered in the Nanaimo sandstones include authigenic chlorite, quartz overgrowth, feldspar overgrowth, chlorite filling, feldspar filling, emplacement of pyrite, calcite and organic matter or bitumen.

Chlorite (chl) exists extensively in all Nanaimo Group samples, it has two different kinds of forms: ① chlorite as products of alteration of volcanic/ metamorphic rock fragments, replacement of chert/feldspar; ② it occurs as tiny needle-like crystals coating grains and lining pores. Chlorite is characterized by its bluish green interference color. It is a few microns to tens of microns in size. In some coarse sand grained samples, pore lining chlorite crystals appear larger in size and form thin films surround grains (samples 28, 32, 34 39, 46, 50, 51, 57, 62, 63, 66). Some unstable grains such as feldspars and volcanic rock fragments were leached to various extent, even completely, leaving relict chlorite rims. This indicates that chlorite coating had formed before the grain dissolution, and is the first stage of intergranular pore-filling followed by quartz and feldspar overgrowths. Minor medium to coarse crystalline, pore-filling chlorite was also observed in several samples 32, 36, 50, 51, 57.

<u>**Quartz overgrowths (qtz)**</u> appear as trace or minor quantities surrounding monocrystalline quartz grains, they are not commonly developed due to abundant matrix clay and chlorite coating, locally occluded intergranular pores and have the adverse effect on reservoir quality

in most sandstone samples. <u>Feldspar cement (fd)</u> was found as overgrowths around feldspar grains in most samples and as prismatic crystals filling intergranular pores (sample 39) in several samples. Apparently, feldspar cement also lowered the reservoir quality.

<u>Calcite cement (cal)</u> is a major porosity reducing diagenetic phase in the Nanaimo Group sandstones. We detected variable amounts of calcite cement, varying from trace to 17-20% (sample 17), it occurs as fine to coarse crystals filling intergranular pores and secondary pores within feldspar and volcanic/plutonic rock fragments, severely decreasing reservoir porosity and permeability. It is recommended that thin sections should be stained for the future work using Alizarin Red-S and potassium ferricyanide to assist identifying calcite versus dolomite, and ferroan versus non-ferroan carbonate.

<u>Pyrite (pyr)</u> was found in minor to moderate volume existing in all Nanaimo Group samples. It occurs as both pore-filling and replacement of chert and rock fragments, especially volcanic, plutonic, metamorphic rock clasts. Thin section analysis shows that pore-filling pyrite usually combined or intergrowthed with organic matter or bitumen. Samples 50, 64 show pyrite first filled secondary dissolution pores from pore wall and followed by black organic matter or bitumen at the pore center, and formed a pyrite ring around organic matter or bitumen. Precipitation of pore-filling pyrite is associated with organic matter that was in the oil window, kerogen became mature and released organic acid and H_2S , H_2S encountered Fe²⁺ and had produced pyrite. In general, the quantities of the pyrite are supposed to be high enough to affect their resistivity log responses. Neither pyrite nor siderite has caused considerable reduction of pore spaces.

Organic matter (org) or bitumen (bitm) was detected in most Nanaimo samples, its content varies from minor to 16-18% in sample 42. This dark brown to black, amorphous material occurred as patches or spots occluding intergranular pores or locally lining or filling secondary dissolution pores (samples 57, 63 and 66). In samples 35 and 42, considerable organic matter (bitumen?) mixed with pyrite appeared as thin strips paralleling to bedding planes. Some burrows and bioturbated structures are porous and also filled with black

bituminous material and sands (sample 44). Emplacement of organic matter or bitumen occludes and lowers secondary enhanced porosity and permeability, it is the final diagenetic phase in the Nanaimo Group intervals. Fluorescence microscopy should be conducted to confirm the occurrence of bitumen in the Nanaimo sandstones, and its impact on diagenesis and pore evolution should be further investigated.

Degrees of mechanical compaction are reflected by various grain contact patterns, ranging from point-contact, planar-contact, and locally concave-convex-contact, deformation of ductile grains (mica, shale and VRF, MRF fragments, etc.) and pseudo matrix. No sutured contact is observed between grains. Framework compositions apparently control the mechanical compaction process. Higher degrees of compaction took place where sandstones are finer grained, containing considerable amount of soft grain constituents.

Pore system: Depositional factors that affect porosity and reservoir quality include sediment grain size, sorting, framework composition, volumes of matrix and pseudo matrix and primary fabric. In general, coarser grained sandstone should be more permeable than similar, finer grained sandstone. Well sorted sand should have higher porosity than more poorly sorted sand. The framework composition plays a key role in the evolution of reservoir quality, as more lithic (chert, feldspar, volcanic and plutonic, metamorphic rock fragments) rich sand tends to be highly susceptible to grain leaching, while highly quartzose sediment is susceptible to severe quartz cementation. Development of intergranular porosity in both coarser and finer grained sandstones depends largely on whether interstitial spaces are filled with matrix clay, therefore the primary depositional environment (e.g. energy level of water body) has a direct control on initial intergranular pore spaces. All Nanaimo Group samples are immature in texture and composition, especially coarser grained sandstones are usually poorly or poorly to moderately sorted, rich in feldspar, chert and unstable rock fragments (volcanic, plutonic, metomorphic rock fragments), considerable detrital matrix clay deposited with sand

grains together, the original intergranular pores are not preserved and plugged by matrix clay, therefore the original intergranular pores are not developed in the Nanaimo Group sandstone samples. But various diagenetic features have affected the reservoir quality to varying degrees of creating and destroying porosity, thin section observation reveals that the later stage dissolution produced secondary intergranular and intragranular pores and improved the reservoir quality of Nanaimo Group sandstones to some degree. Also groups of microfractures cut through the rocks and enhanced the reservoir permeability.

The porosity types of the Nanaimo Group sandstones can be generalized as: secondary porosity (sp), microporosity (mp) and microfractures.

Secondary porosity (sp) include secondary intergranular porosity and secondary intragranular porosity, they were detected in coarser grained samples (57, 63 and 66) with very low visible porosity from trace to 2-3%. Secondary porosity generally has smaller pore sizes within grains, it is a dissolution product of feldspar grains (along cleavages), chert and unstable rock fragments (volcanic, plutonic, metomorphic rock fragments, selectively leaching of feldspar laths), as well as in organic matter and kerogen. With continuously stronger leaching, some feldspar or volcanic ash grains are completely dissolved with a relict of chlorite rims left behind (samples 63 and 66) or formed an enlarged intergranular pore without chlorite clay films. These type of secondary pores are prone to be filled by calcite cement, pyrite and bituminous material (samples 63 and 66) spaces. Burial history of the Nanaimo and source rock should be examined to better understand the late stage diagenesis and secondary porosity development.

<u>Microporosity (mp)</u> is smaller than a few microns in size; however, it accounts a greater percentage than secondary porosity. Microporosity is commonly found within leached feldspars, chert and unstable rock fragments (volcanic, plutonic and metomorphic rock fragments), and within detrital clay matrix, within micritic limemud. All the Nanaimo sandstone samples contain significant amounts of matrix clay, varying from less than

10% to more than 30%, abundant microporosity exists between these matrix clays. Impregnations of blue epoxy often turn the microporous grains bluish color (artifact). SEM study is suggested to further document this type of porosity.

<u>Natural fractures</u> (frac): two groups of microfractures had developed in some sample intervals, they can be classified as vertical microfractures and oblique microfractures according to the fracture direction. Vertical microfractures are more common than oblique microfractures, they are perpendicular to bedding plane and cut through the rocks, usually 1-10um in width and can extend longer distance (samples 4,); in contrast, oblique microfractures extends a short distance. All these fractures are the passages for the pore fluid system and improved the reservoir quality, they are sealed by calcite cement in the later diagenetic stage.

Diagenetic features recognized from each individual sample are shown in the petrographic descriptions (Appendix). Based on various authigenic minerals, diagenetic phases and their crosscutting relationships, a general paragenetic sequence is summarized as: Deposition - Compaction - Chloritization - Chlorite filling - Quartz and feldspar overgrowth - Feldspar filling - Grain dissolution - Pyritization- Calcite Cementation - Organic matter or bitumen emplacement.

The relevant diagenesis and their effects on porosity are summarized semi-quantitatively in following table:

Major Diagonatia Events	Fault: > Lata	Porosity %
Major Diagenetic Events	Early> Late	5 10 15 20 25
Deposition		
Compaction		
Chloritication	-	
Chlorite Filling		
Quartz & Feldspar Overgrowth	—	
Feldspar Filling		
Grain Dissolution		
Pyritization		
Calcite Cementation		
Organic Matter or Bitumen		

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43	139.00	Massive - Burrowed	Very Fine - Fine	Moderate - Well	Fd Litharenite	0.083
44	135.58	Massive - Burrowed			Silty mudstone	0.058
45	127.50	Massive	Very Fine - Coarse	Poor	Fd Litharenite	0.068
46	122.50	Massive	Fine - Coarse	Poor - Moderate	Fd Litharenite	0.036
48	106.67	Massive	Fine - Coarse	Poor	Lithic Arkose	0.026
50	100.67	Massive	Fine - Coarse	Poor	Lithic Arkose	0.087
51	96.00	Massive - Bioturbated	Very Fine - Fine	Well	Lithic Arkose	0.092
52	89.50	Massive	Medium - Coarse	Poor - Moderate	Fd Litharenite	0.067
53	78.50	Massive	Fine - Medium	Moderate	Fd Litharenite	0.091
55	73.33	Massive - Bioturbated	Fine - Coarse	Poor	Fd Litharenite	0.073
56	68.50	Massive - Laminated	Very Fine - Fine	Moderate	Lithic Arkose	0.063
57	62.00	Massive	Fine - Medium	Moderate - Well	Lithic Arkose	0.102
60	47.75	Massive	Fine - Medium	Poor - Moderate	Fd Litharenite	0.097
62	33.00	Massive - Bioturbated	Very Fine - Fine	Poor - Moderate	Subarkose	0.083
63	30.50	Massive	Medium - Coarse	Moderate	Fd Litharenite	0.080
64	26.25	Massive - Laminated	Very Fine - Fine	Well	Lithic Arkose	0.090
66	19.42	Massive	Medium - Coarse	Moderate - Well	Fd Litharenite	0.077

Table 1B: Petrographic Summary Continued

*Note: Fd Litharenite-----Feldspathic Litharenite

PETROGRAPHIC SUMMARY & DISCUSSION

The 44 Nanaimo samples from the OW-11-01-Nanaimo OBS well 390, include 43 sandstones and 1 silty mudstone (Table 1), all 43 sandstone samples can be further classified as feldspathic litharenites (25), lithic arkoses (14), litharenites (2), sublitharenite (1) and subarkose (1) according to Folks classification, 1968. Summary of the petrographic data is given in Table-1. The details of rock constituents, texture and diagentic features are elaborated in 44 Plates. Key petrographic features are summarized and discussed together in the following text.

Structure: Most Nanaimo sandstones are massive. Some very fine to fine grained sandstones show well developed ellipse shaped burrows (samples 19, 30, 35, 43, 44) and other bioturbation structures (samples 9, 14, 51, 55, 56). Samples 9, 35 and 42 show laminated structure which are defined by organic matter-rich and clay-rich lamina, dark brown to black organic matter and clay compressed into thin strips or lamina paralleling to bedding plane. Also elongated grains and mica are preferentially oriented and aligned along bedding planes.

Texture/fabrics: The petrographic analysis indicates that most Nanaimo Group samples are low mature in texture and composition, especially in medium to coarse grained sandstone samples. Sand grains and matrix clay were deposited together, clays blocked the intergranular pore spaces and therefore the primary pores are not well preserved before compaction. Coarser grained sandstone samples have a wide range in grain size, varying from coarse silt to very coarse sand. The framework grains are angular, subangular to subrounded and poorly sorted or poorly to moderately sorted, showing a grain supported, moderately compacted fabric. Grains are commonly pointplanar contacted to slightly concave-convex-contacted (as indicated by deformation of ductile grains; eg. mica, shale clasts, volcanic and metamorphic rock fragments). Whereas finer (very fine to fine or silt to fine) grained sandstone samples demonstrated a

grain-supported, well sorted or moderately to well sorted fabric. Grains are subangular to subrounded or rounded, with most grain size ranging from very fine to fine.

Compositions: The Nanaimo Group sandstone framework grains are composed of three major components: quartz, feldspars and rock fragments (chert, shale clasts, volcanic, plutonic and metamorphic rock fragments etc.). Minor mica, glauconite and trace heavy minerals and glauconite are also present.

Quartz (qtz) grains include monocrystalline and polycrystalline quartz, they are mainly monocrystalline, inclusion free or with rare mica and heavy mineral (e.g. zircon) inclusions. Quartz tends to increase its quantity in finer (very fine to fine) grained sandstones. Quartz grains are moderately to well sorted and subangular to subrounded. Trace to minor authigenic quartz overgrowths are mainly found in coarser grained sandstone samples (samples 4, 16, 21, 29, 30, 32, 38, 41, 46, 48, 52, 46, 48, 52, 63, 66). Feldspar (fd) occurs mainly as plagioclase with minor potassium feldspar, all Nanaimo Group sandstones are characterized by considerable feldspar. Feldspar grains are identified by elongated shape, weathered surfaces (sericited), cleavages, Carlsbad twining, albite twining, polysynthetic twining (microcline) and Carlsbad-albite twining (plagioclase). Dissolution or leaching of feldspar grains generated minor secondary porosity within feldspar grains or volcanic rock fragments and improved reservoir quality in some degree. Chert (cht) often inclusion-rich (clays, dolomite and pyrite), is the main constituent of the framework, characterized by crypto- to microcrystalline and rare fibrous chalcedony textures. Also chert grains can be leached to various extents, generating microporosity and secondary porosity in kerogen mature stage. Volcanic rock fragments (VRF) are characterized by their unique fabric, with feldspar laths floating in cryptocrystalline groundmass. Both feldspar laths and groundmass are commonly leached to various extents (like chert grains), forming secondary intragranular porosity and microporosity. Chloritization and pyritization are the most common alteration products in volcanic rock fragments. Metamorphic rock fragments (MRF) consist of micaceous

schist and phyllite clasts, and are often compressed between harder grains. Metamorphic rock fragments are also frequently altered by chlorite and pyrite. However, no secondary pore spaces are found within metamorphic rock fragments. Sedimentary rock fragments are mainly <u>shale clasts (sh)</u> with trace to minor <u>bioclasts</u>. Shale clasts occur in all sandstone samples regardless of grain size variation. They are ductile grains, sub-preferentially oriented, often squeezed between other grains, even forming pseudo matrix and lowered reservoir quality.

Diagenesis: Reservoir quality in the Nanaimo Group sandstone is a function of a complex interrelationship of both depositional and diagenetic processes. Common diagenetic phases encountered in the Nanaimo sandstones include authigenic chlorite, quartz overgrowth, feldspar overgrowth, chlorite filling, feldspar filling, emplacement of pyrite, calcite and organic matter or bitumen.

Chlorite (chl) exists extensively in all Nanaimo Group samples, it has two different kinds of forms: ① chlorite as products of alteration of volcanic/ metamorphic rock fragments, replacement of chert/feldspar; ② it occurs as tiny needle-like crystals coating grains and lining pores. Chlorite is characterized by its bluish green interference color. It is a few microns to tens of microns in size. In some coarse sand grained samples, pore lining chlorite crystals appear larger in size and form thin films surround grains (samples 28, 32, 34 39, 46, 50, 51, 57, 62, 63, 66). Some unstable grains such as feldspars and volcanic rock fragments were leached to various extent, even completely, leaving relict chlorite rims. This indicates that chlorite coating had formed before the grain dissolution, and is the first stage of intergranular pore-filling followed by quartz and feldspar overgrowths. Minor medium to coarse crystalline, pore-filling chlorite was also observed in several samples 32, 36, 50, 51, 57.

<u>**Quartz overgrowths (qtz)**</u> appear as trace or minor quantities surrounding monocrystalline quartz grains, they are not commonly developed due to abundant matrix clay and chlorite coating, locally occluded intergranular pores and have the adverse effect on reservoir quality

in most sandstone samples. <u>Feldspar cement (fd)</u> was found as overgrowths around feldspar grains in most samples and as prismatic crystals filling intergranular pores (sample 39) in several samples. Apparently, feldspar cement also lowered the reservoir quality.

<u>Calcite cement (cal)</u> is a major porosity reducing diagenetic phase in the Nanaimo Group sandstones. We detected variable amounts of calcite cement, varying from trace to 17-20% (sample 17), it occurs as fine to coarse crystals filling intergranular pores and secondary pores within feldspar and volcanic/plutonic rock fragments, severely decreasing reservoir porosity and permeability. It is recommended that thin sections should be stained for the future work using Alizarin Red-S and potassium ferricyanide to assist identifying calcite versus dolomite, and ferroan versus non-ferroan carbonate.

<u>Pyrite (pyr)</u> was found in minor to moderate volume existing in all Nanaimo Group samples. It occurs as both pore-filling and replacement of chert and rock fragments, especially volcanic, plutonic, metamorphic rock clasts. Thin section analysis shows that pore-filling pyrite usually combined or intergrowthed with organic matter or bitumen. Samples 50, 64 show pyrite first filled secondary dissolution pores from pore wall and followed by black organic matter or bitumen at the pore center, and formed a pyrite ring around organic matter or bitumen. Precipitation of pore-filling pyrite is associated with organic matter that was in the oil window, kerogen became mature and released organic acid and H_2S , H_2S encountered Fe²⁺ and had produced pyrite. In general, the quantities of the pyrite are supposed to be high enough to affect their resistivity log responses. Neither pyrite nor siderite has caused considerable reduction of pore spaces.

Organic matter (org) or bitumen (bitm) was detected in most Nanaimo samples, its content varies from minor to 16-18% in sample 42. This dark brown to black, amorphous material occurred as patches or spots occluding intergranular pores or locally lining or filling secondary dissolution pores (samples 57, 63 and 66). In samples 35 and 42, considerable organic matter (bitumen?) mixed with pyrite appeared as thin strips paralleling to bedding planes. Some burrows and bioturbated structures are porous and also filled with black

bituminous material and sands (sample 44). Emplacement of organic matter or bitumen occludes and lowers secondary enhanced porosity and permeability, it is the final diagenetic phase in the Nanaimo Group intervals. Fluorescence microscopy should be conducted to confirm the occurrence of bitumen in the Nanaimo sandstones, and its impact on diagenesis and pore evolution should be further investigated.

Degrees of mechanical compaction are reflected by various grain contact patterns, ranging from point-contact, planar-contact, and locally concave-convex-contact, deformation of ductile grains (mica, shale and VRF, MRF fragments, etc.) and pseudo matrix. No sutured contact is observed between grains. Framework compositions apparently control the mechanical compaction process. Higher degrees of compaction took place where sandstones are finer grained, containing considerable amount of soft grain constituents.

Pore system: Depositional factors that affect porosity and reservoir quality include sediment grain size, sorting, framework composition, volumes of matrix and pseudo matrix and primary fabric. In general, coarser grained sandstone should be more permeable than similar, finer grained sandstone. Well sorted sand should have higher porosity than more poorly sorted sand. The framework composition plays a key role in the evolution of reservoir quality, as more lithic (chert, feldspar, volcanic and plutonic, metamorphic rock fragments) rich sand tends to be highly susceptible to grain leaching, while highly quartzose sediment is susceptible to severe quartz cementation. Development of intergranular porosity in both coarser and finer grained sandstones depends largely on whether interstitial spaces are filled with matrix clay, therefore the primary depositional environment (e.g. energy level of water body) has a direct control on initial intergranular pore spaces. All Nanaimo Group samples are immature in texture and composition, especially coarser grained sandstones are usually poorly or poorly to moderately sorted, rich in feldspar, chert and unstable rock fragments (volcanic, plutonic, metomorphic rock fragments), considerable detrital matrix clay deposited with sand

grains together, the original intergranular pores are not preserved and plugged by matrix clay, therefore the original intergranular pores are not developed in the Nanaimo Group sandstone samples. But various diagenetic features have affected the reservoir quality to varying degrees of creating and destroying porosity, thin section observation reveals that the later stage dissolution produced secondary intergranular and intragranular pores and improved the reservoir quality of Nanaimo Group sandstones to some degree. Also groups of microfractures cut through the rocks and enhanced the reservoir permeability.

The porosity types of the Nanaimo Group sandstones can be generalized as: secondary porosity (sp), microporosity (mp) and microfractures.

Secondary porosity (sp) include secondary intergranular porosity and secondary intragranular porosity, they were detected in coarser grained samples (57, 63 and 66) with very low visible porosity from trace to 2-3%. Secondary porosity generally has smaller pore sizes within grains, it is a dissolution product of feldspar grains (along cleavages), chert and unstable rock fragments (volcanic, plutonic, metomorphic rock fragments, selectively leaching of feldspar laths), as well as in organic matter and kerogen. With continuously stronger leaching, some feldspar or volcanic ash grains are completely dissolved with a relict of chlorite rims left behind (samples 63 and 66) or formed an enlarged intergranular pore without chlorite clay films. These type of secondary pores are prone to be filled by calcite cement, pyrite and bituminous material (samples 63 and 66) spaces. Burial history of the Nanaimo and source rock should be examined to better understand the late stage diagenesis and secondary porosity development.

<u>Microporosity (mp)</u> is smaller than a few microns in size; however, it accounts a greater percentage than secondary porosity. Microporosity is commonly found within leached feldspars, chert and unstable rock fragments (volcanic, plutonic and metomorphic rock fragments), and within detrital clay matrix, within micritic limemud. All the Nanaimo sandstone samples contain significant amounts of matrix clay, varying from less than

10% to more than 30%, abundant microporosity exists between these matrix clays. Impregnations of blue epoxy often turn the microporous grains bluish color (artifact). SEM study is suggested to further document this type of porosity.

<u>Natural fractures</u> (frac): two groups of microfractures had developed in some sample intervals, they can be classified as vertical microfractures and oblique microfractures according to the fracture direction. Vertical microfractures are more common than oblique microfractures, they are perpendicular to bedding plane and cut through the rocks, usually 1-10um in width and can extend longer distance (samples 4,); in contrast, oblique microfractures extends a short distance. All these fractures are the passages for the pore fluid system and improved the reservoir quality, they are sealed by calcite cement in the later diagenetic stage.

Diagenetic features recognized from each individual sample are shown in the petrographic descriptions (Appendix). Based on various authigenic minerals, diagenetic phases and their crosscutting relationships, a general paragenetic sequence is summarized as: Deposition - Compaction - Chloritization - Chlorite filling - Quartz and feldspar overgrowth - Feldspar filling - Grain dissolution - Pyritization- Calcite Cementation - Organic matter or bitumen emplacement.

The relevant diagenesis and their effects on porosity are summarized semi-quantitatively in following table:

Major Diagonatia Events	Fault: > Lata	Porosity %
Major Diagenetic Events	Early> Late	5 10 15 20 25
Deposition		
Compaction		
Chloritication	-	
Chlorite Filling		
Quartz & Feldspar Overgrowth	—	
Feldspar Filling		
Grain Dissolution		
Pyritization		
Calcite Cementation		
Organic Matter or Bitumen		

Geological Survey of Canada	Well ID:	OW-11-01-N	JANAIMO OBS V	VELL 390
Sample ID: 1	Depth:	384.75		
Image A:			Composit	ion: (vision estimate)
	and the second		Grains:	
	mh l	A P	Q%	27-30
	and all	S. Cart	F%	25-27
cht	A MARKE		R%	35-40
- Colored and the second and the sec	117	and the second	Others: 1.5-2.0)% mica, trace: glau.
	shale	Contraction of the	Matrix:	15-17
			Rock Type:	
		chî	F	eldspathic Litharenite
fd	diam fd	md:	Texture	
		1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	Grain size	fine to medium
	the second second		Sorting:	poor- moderately
States and the	A States	MA Y	Roundness:	subang.
		X	Fabric:	grain supported
250um	Contraction of the second	N		
		A. W.S.C.	Structure	
	All all	Cores		Massive
			Authigenic Co	mponents

Image B		
	Cements (Pore I	illings):
	Chlorite	common
	Qtz ovgh	tr
AL STATE OF ALL ALL ALL ALL ALL ALL ALL ALL ALL AL	Feldspar ovgh	tr
and the second and the second s	Calcite	1
erectory	Organic matter	1.5-2.0
	Pyrite	0.5
and the second and and and and and and and and and a		
cal	Replacement	
	Chlorite	tr
	Calcite	tr
	Pyrite	0.5
a state of the second state of the second se	Porosity (Visual	Estimate):
a for the second		
100um	Intergranular:	
and a fight	Secondary:	
	Fracture:	
	Microporosity:	common

A massive, fine to medium grained feldspathic litharenite shows a grain-supported, non-porous fabric. Poorly moderately sorted grains are subangular, consisting mainly of quartz, feldspar (fd) and chert (cht) with lesser amounts of volcanic rock fragments (VRF), shale clasts (sh) and metamorphic rock fragments (MRF). Elongated grains are preferentially aligned along bedding plane. Contacts between grains vary from point to planar (image A). Intergranular pores are predominantly reduced by clay matrix (15-17%) and moderate compaction. Image B shows black organic matter (bitumen?) mixed with pyrite (org+pyr) are found between grains. Minor calcite cement (cal) filled intergranular pore and feldspar moldic pore (image B). Microporosity is abundant and exists within matrix clays.

Others:

Description of T	hin Section P	hotomicrograp	bh	
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS W	/ELL 390
Sample ID: 2	Depth:	367.00m		
Image A:	17		Compositi Grains:	on: (visual estimate)
	in as	C.A.	Q%	25-27
VRF	F Ph	A Draft	F%	23-25
fd		1 2 - C	R%	43-45
fd	fd	Contraction of the	Others:	2-3% mica ,0.5% glau.
	J.		Matrix:	10-12
	The last	at a gar	Rock Type:	
A CONTRACTOR AND	Star 1	ALLY L	Fe	ldspathic Litharenite
fd org-pyr	org+py	5 5 6	Texture	
A A A A A A A A A A A A A A A A A A A		22	Grain size	Medium to coarse
VRF VRF	The second		Sorting:	poorly
shil	to seal	A A A A A A A A A A A A A A A A A A A	Roundness:	ang subang.
AND A DOWN	A DOT	a la	Fabric:	grain supported
	CAR	org+pyr	Structure	
500um				Massive
	the same	A A	Authigenic Cor	nponents
Image B				
A STATES CONSTRUCT	Att Bank I was	and the set	Cements (Pore	Fillings):
cal	fdlovah		Chlorite	common
	S day april	A State of the	Qtz ovgh	tr
		10 01	Feldspar ovgh	tr
	1.0000	all and	Calcite	3-5
fd ovgh	A ab t	N Start	Organic matter	0.5-1.0
	Nie e	- Ander	Pyrite	0.5
ca	1		Replacement	
fdlovgh cal			Chlorite	Minor
		124	Calcite	tr
1 1 1 2 4 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	and and	and a	Pyrite	0.5
			, Porosity (Visua	Il Estimate):
cal			Intergranular:	
A CARLES MAN			Secondary:	
	Call Sight	A STATE	Fracture	
100um	30- 27	N. Contraction	Microporocity	common
	Astrony .		Others:	common

Image A shows a non-porous, massive, medium to coarse grained feldspathic litharenite. Framwork grains are dominated by sub-equal quartz, feldspar (fd) and chert (cht), with lesser amounts of volcanic rock fragments (VRF), shale clasts (sh) and metamorphic rock fragments (MRF). Minor mica, glauconite and bivalves are also present. Grains are angular to subrangular and poorly sorted (image A). Intergranular pores are reduced by clay matrix (10-12%), trace to minor authigenic minerals (calcite, org+pyrite, quartz and feldspar overgrowth) and compaction. Image B shows the rough and dirty feldspar grains with clear overgrowth thin rim. Note the minor calcite cement (cal) filling intergranular pores.

Description of Thi	n Section P	hotomicrograp	h	
Geological Survey of Canada	Well ID:	OW-11-01-NA	NAIMO OBS WE	ELL 390
Sample ID: 4	Depth:	361.75m		
Image A:			Compositio	n: (visual estimate)
CarDonateClast	1 3-20		Grains:	
	Ling	<u> </u>	Q%	30-33
Chu Chu	Child .		=%	20-22
			R%	40-43
	Z.	AI	Others:	2% mica , trace glau.,
VRF			Matrix:	13-15
Shi		21	Rock Type:	
	于物	CX !!	Feld	dspathic Litharenite
	1.10	Part 1	Texture	
	de.		Grain size: fine u	pper to medium lower
fd	t f f	· · · · ·	Sorting:	Moderately
A A A A A A A A A A A A A A A A A A A	17		Roundness:	subangsubrou.
And the second is	Varya.		Fabric:	grain supported
matrix		ke ke	Structure	
250um				Massive
A A A A A A A A A A A A A A A A A A A			Authigenic Com	ponents
Image B				
	AL .		Cements (Pore F	illings):
	111		Chlorite	common
	1, 1		Qtz ovgh	
Cal Cal			Feldspar ovgh	tr
			Calcite	1
A A A A A A A A A A A A A A A A A A A			Organic matter	0.5
		- 1/1	Pyrite	0.5
		a 1 1	Replacement	
			Chlorite	Minor
		1 4	Calcite	tr
cal			Pyrite	0.5
	L'alle ar	1	Porosity (Visual	Estimate):
The second s		M.S.		
		152.20	ntergranular:	
Cal	Trans.		Secondary:	
100um		and all the	Fracture:	common
			Microporosity:	common
	1711	1. 1.	Others:	

A massive, fine to medium grained feldspathic litharenite is characterized by abundant rock fragments (chert, volcanic rock fragments (VRF), shale clasts (sh), metamorphic rock fragments (MRF) and lesser feldspar grains. Platy and elongated grains are compacted parallel to bedding planes (image A). Considerable detrital matrix clays (13-15%) blocked Intergranular pores and produced a tight, non-porous fabric. Note a group of vertical thin fractures (10-20um width) cut through the rock and improved the reservoir quality to some degree (image A). Image B shows some oblique microfractures broke through framework grains and were sealed by calcite (cal).

Description of Thi	n Section P	hotomicrogra	ph	
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WE	ELL 390
Sample ID: 7	Depth:	340.00m		
Image A:	R		Composition	n: (visual estimate)
	CALL R	A. A	0%	38-40
I. W. X. I Proved	Page 1		E %	30-32
Carlos and a second			R%	22-23
VRF	fi	9	Others:	2% mica , 2% glau.,
org shi		A.	Matrix:	5-7
	AR.	A REAL	Rock Type:	
the second of th			Lith	iic Arkose
1	9 1 1		Texture	
	N TEL	A State	Grain size: fine u	pper to medium lower
MARKER RECEIPTION	a second	alle bo	Sorting:	Moderately
		South a get	Roundness:	subangsubrou.
		glau	Fabric:	grain supported
A State of the second second	an.		Structure	
250um	A Carlos			Massive
	13	a state	Authigenic Com	ponents
A THERE I AN A THE	-	and the second		
			Cements (Pore F	illings):
			Chlorite	common
		1 2 3	Qtz ovgh	tr
cal			Feldspar ovgh	tr
qtz ovgh	- Carl		Calcite	17-20
		20 1	Organic matter	tr
She was the system		4	Pyrite	tr
cal	Section.		Replacement	
1995	stans.		Chlorite	Minor
ALL ALL ALL	12 . 1	e al date	Calcite	tr
			Pvrite	0.5
			Porosity (Visual	Estimate):
qtzovgh	At-	A State		
cal	cal	cal	Intergranular:	
			Secondary:	
50um			Fracture:	
	Varia a	1 1 1 A	Microporosity:	
			Others:	

Image A displays a moderately sorted, fine to medium grained lithic arkose with a massive, non-porous fabric. Framework grains are composed mainly of quartz, feldspar (fd) and lesser rock fragments (chert, volcanic rock fragments (VRF), shale clasts (sh), metamorphic rock fragments (MRF)). Minor mica and glauconite are also present (image A). Extensive calcite cement (17-20%) and minor matrix clay blocked intergranular pores, resulting in a tight rock. Image B shows that calcite cement (cal) occluded interstitial pore space and also replaced unstable grains (feldspar and VRF etc.). Trace quartz overgrowth was also found in the sample (Image B).

Description of Thin S	Section Pho	otomicrograp	h	
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WI	ELL 390
Sample ID: 9	Depth:	332.08m		
Image A:			Composition	v: (visual estimate)
A LOND AND A LOND			Composition	i. (visual estillate)
		a second	Grains:	
Print		1000	Q%	48-50
ar).	a state	a series	F%	13-15
			R%	15-20
	har P	A Second	Others: 3-5 %mi	ca , 0.5% glau,
	Ser.		Matrix:	27-30
		erg.	Rock Type:	
	- anto		Lith	arenite
ong,	OTG.		Texture	
		State States	Size Average:	silt to very fine
			Sorting:	moderately-well
Form			Roundness:	subang subroun.
	200		Fabric:	grain supported
250um	1 All	10 A T		
and the second s			Structure	
OLCP.			Laminated a	and burrowed
			Authigenic Com	ponents
Image B				
		AND STORES	Cements (Pore I	illings):
org			Chlorite	common
	Ser 1	A.A.	Qtz ovgh	
and the second second			Feldspar ovgh	
		A COMPANY AND A STREET		
chil	Contraction of the second s	ALC: NOT	Calcite	
			Calcite Organic matter	3.0-5.0
A CARLENCE			Calcite Organic matter Pyrite	3.0-5.0 2
fd), chi			Calcite Organic matter Pyrite	3.0-5.0 2
fč) chi			Calcite Organic matter Pyrite Replacement	3.0-5.0 2
fdj cht			Calcite Organic matter Pyrite Replacement Chlorite	3.0-5.0 2 tr
fč) chi	ある		Calcite Organic matter Pyrite Replacement Chlorite Calcite	3.0-5.0 2 tr
fi) chi	ent		Calcite Organic matter Pyrite Replacement Chlorite Calcite Pyrite	3.0-5.0 2 tr 0.5
fid) chi	chi		Calcite Organic matter Pyrite Replacement Chlorite Calcite Pyrite Porosity (Visual	3.0-5.0 2 tr 0.5 Estimate):
fi) chi	ehi t		Calcite Organic matter Pyrite Replacement Chlorite Calcite Pyrite Porosity (Visual	3.0-5.0 2 tr 0.5 Estimate):
fč) chi nit crg:	chi	EAA.	Calcite Organic matter Pyrite Replacement Chlorite Calcite Pyrite Porosity (Visual Intergranular:	3.0-5.0 2 tr 0.5 Estimate):
fč) chl chl clm	chi		Calcite Organic matter Pyrite Replacement Chlorite Calcite Pyrite Porosity (Visual Intergranular: Secondary:	3.0-5.0 2 tr 0.5 Estimate):
fil chi rati arg; 100um	ehl	J. J	Calcite Organic matter Pyrite Replacement Chlorite Calcite Pyrite Porosity (Visual Intergranular: Secondary: Fracture:	3.0-5.0 2 tr 0.5 Estimate):
fid) chi ant Crap 100um	chi	Line,	Calcite Organic matter Pyrite Replacement Chlorite Calcite Pyrite Porosity (Visual Intergranular: Secondary: Fracture: Microporosity:	3.0-5.0 2 tr 0.5 Estimate):
fil) chi chi chi chi chi	ahi	DAA	Calcite Organic matter Pyrite Replacement Chlorite Calcite Pyrite Porosity (Visual Intergranular: Secondary: Fracture: Microporosity: Others:	3.0-5.0 2 tr 0.5 Estimate):

A silt to very fine grained, moderately to well sorted litharenite shows a laminated structure locally disturbed by burrows. Laminations are defined by quartz-rich laminae and clay-rich laminae, dark brown to black organic matter concentrated in the clay-rich laminae and compressed into thin stripes paralleling to bedding plane. Considerable amount of clay matrix (27-30%) occurs within grain-supported fabric (image A). Image B shows the tight fabric, with Intergranular pore spaces plugged by abundant matrix and minor chlorite rims (chl). Greenish chlorite occurred as thin rims coating grains in the very early diagenetic stage. Framework grains are mainly quartz, chert and detrital feldspar. Abundant microporosity occurs within the clay minerals.

Description of Thin Section Photomicrograph				
Geological Survey of Canada	Well ID:	OW-11-01-N	1-01-NANAIMO OBS WELL 390	
Sample ID: 10	Depth:	328.50m		
Image A:	-		Composition: (visual estimate)	
	AL	TY W	Grains:	40.45
A she was the state	1P	A to the	Q%	40-45
CIII CIII	the fill		F%	20-23
and and a start	ETT .	CAR T	R%	25-30
	X.	Adam 10	Others: 2 % mica, 1% glau,	
	and C		Matrix:	8.0-12
MRE	N.C.E		Rock Type:	
A A A A A A A A A A A A A A A A A A A			Feldspahic Litharenite	
THE REAL PROPERTY OF THE PROPE	- The		Texture	
MRE	of the	ha the	Size Average:	fine to medium
	1 miles		Sorting:	poor-moderately
		2 mar	Roundness:	subang subroun.
COL	- Me	1700	Fabric:	grain supported
AND A LANDER	and the	VRE		
VRF	a start		Structure	
500um	N	A LAN	1	Massive
	Corres of	the state	Authigenic Com	ponents
Image B				
and the state of t			Cements (Pore Fillings):	
A State of the second sec	and the second	12.54	Chlorite	tr
fd overb		The shall	Qtz ovgh	tr
in the second		22.85	Feldspar ovgh	tr
fd ovah		At the second	Calcite	5.0-7.0
and the second s	fd ov	gh	Organic matter	0.5-1.0
	ca		Pyrite	tr
	All the second	(Colle	Replacement	
		Cal	Chlorite	tr
		the part of the second		
	1	C STO	Calcite	tr
			Calcite Pyrite	tr tr
	OIG"		Calcite Pyrite Porosity (Visual	tr tr Estimate):
cal w	erg,		Calcite Pyrite Porosity (Visual Intergranular:	tr tr Estimate):
cal a	CIQ.		Calcite Pyrite Porosity (Visual Intergranular: Secondary:	tr tr Estimate):
Ceal Colum	ciĝ		Calcite Pyrite Porosity (Visual Intergranular: Secondary: Fracture:	tr tr Estimate):
Ccal du 500um	erg.		Calcite Pyrite Porosity (Visual Intergranular: Secondary: Fracture: Microporosity:	tr tr Estimate):

A massive, fine to medium grained, poor to moderately sorted feldsparthic litharenite is composed mainly of quartz, feldspar (fd) and lesser rock fragments (chert, volcanic rock fragments (VRF), shale clasts (sh), metamorphic rock fragments (MRF). Elongated grains are compacted parallel to bedding planes and tightly packed. The interstitial pore spaces are mainly blocked by 8-12% matrix clay and 5-7% calcite cement. Image B shows calcite cement filled intergranular pore and also replaced feldspar grains. Note authigenic feldspar overgrowth on the feldspar grain surfaces.
Description of Thin	n Section Ph	notomicrograp	bh	
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WE	ELL 390
Sample ID: 12	Depth:	318.75m		
Image A:			Composition	: (visual estimate)
fd fd	Par a	171		22_25
A RULA CRAME		X TOR	Q70 E%	22-22
NO LA CONTRACTOR		HALL CON	F /0 D 0/	20-30
Ciana Antonio A	2 10	ALC: NO	N70	25-27
Org.			Motrix:	1, 0.5% gidu.
	XX		Rock Typo	10.0-15.0
	C. A. C.			rkana
	-			rkose
Start Broken	17 ACM	State March		fina ta madium
	bioc	last	Size Average:	
Org.	The second	Contraction of the second seco	Sorting:	poor
fd	A MA	AND SOM	Roundness:	subang subroun.
mica	THE T	The As	Fabric:	grain supported
TO REPORT ALA PAR	177	SAL-	Charles	
	AL		Structure	A
250um mitca fd	1 AL	A	ſ	viassive
mica		PA	Authigenic Com	ponents
Image B			Cements (Pore F	illings):
		april 1	Chlorite	common
A CALLER AND	No.		Qtz ovgh	tr
maîrîtxelay	17 10		Feldspar ovgh	tr
A CARLES CONTRACTOR	No the No.	12	Calcite	2.0-3.0
		a set of	Organic matter	1.0-1.5
call		cal	Pyrite	0.5
Glava		K D REAL	Replacement	
	THE REAL		Chlorite	tr
cal. ^{fd ovgh}		and a second	Calcite	0.5-1.0
		-	Pvrite	tr
QIZZOVEN		Service Space	, Porosity (Visual	Estimate):
				/
	7		Intergranular:	
		Ser. d	Secondary:	
1.00 um	2100		Fracture:	
	All and a state of the state of	A REAL PROPERTY AND A REAL		
	10		Microporosity:	common

A massive, fine to medium grained lithic arkose exhibits a grain-supported, non-porous fabric. Grains are subangular to subrounded, poorly sorted, consisting of sub-equal quartz, feldspar (fd) and rock fragments (chert, volcanic rock fragments (VRF), shale clasts (sh), metamorphic rock fragments (MRF) (image A). Intergranular pores are mainly reduced by compaction, clay matrix (10-15%) and minor calcite cement. Image B displays major interstitial components: matrix clay and calcite cement (cal). Note that feldspar grains contain irregular shaped calcite spots, indicating that calcite was replacing feldspar grains (image B). Trace to minor feldspar and quartz overgrowth developed on the grain surfaces.

Description of T	hin Section P	Photomicrograph
Geological Survey of Canada	Well ID:	OW-11-01-NANAIMO OBS WELL 390
Sample ID: 14	Depth:	305.75m
Image A:		Composition: (visual estimate)
		composition. (visual estimate)
	NO P	Grains:
	C. C. S.	Q% 28-30
		F% 10-15
fd f	hit	R% 40-50
Charles September 1		Others: 3-5 % mica , 0.5% glau,
	4	Matrix: 25-27
	CIIL	Rock Type:
Dy.		Litharenite
mica fd		Texture
	10	ALLA.
The former of the second	THE	Grain size fine
	Imica	Sorting: poor
		Roundness: subang subroun.
	mica	Fabric: grain supported
250um	AR	Structure
CALLY DELLE		Massive, burrowed
ANT IN ASSAULT		- and -
		Authigenic Components
Image B		
	1	Cements (Pore Fillings):
	C. MA	Chlorite minor
Lotan Barris A	The Case	Qtz ovgh
A CAR AND PARA - WAR COMPANY	A AN	Feldspar ovgh
X . Y . Y	And and	Calcite
matrix clay	(The second	Organic matter 1.0-2.0
PRF	A	Pyrite 0.5
	a start the	
	Assist	Replacement
a the second		Chlorite tr
· · · · · · · · · · · · · · · · · · ·		Calcite
MRF fd		Pyrite
The superior for the second se	15	Porosity (Visual Estimate):
	in the	
fd	for the	Intergranular:
	VIDE	Secondary:
100um	VICE	Fracture:
	The set	Microporosity: Abundant
	State of the second	Others:

A fine grained litharenite shows an overall massive structure slightly disturbed by burrows. Poorly sorted grains are subanguler to subrounded, size ranging from coarse silt (30um) to coarse sand (750um). This sample contains 25-27% clay matrix which blocked interstitial pore spaces (image A). Some ductile grains (mica and volcanic rock fragments) are deformed between harder grains due to compaction (image A). Image B shows the tight fabric, with Intergranular pore spaces reduced by abundant matrix and minor grain rimming chlorite(chl) in the early diagenetic stage, and remaining pore spaces occluded by late stage organic matter (bitumen?). Microporosity is abundant in the clay minerals.

Description of Thin	Section Pl	notomicrograp	bh	
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WELL 390	
Sample ID: 16	Depth:	294.75m		
Image A:			Composition: (visual estimate)	
	abath 1			
ORC		pr and	Q% 50-55	
cht			F% 15-20	
	1 1 1 1	MRF	R% 35-42	
cht cht		S CAR	Matrix 9 10	
cht	-	The second	Reak Type:	
	11	- Alland	ROCK Type:	
ORG.	A.B.	- Charles		
WRE A A A	110	A	Texture	
WEE		and the second	Grain size: fine to searce sand	
	CALL	Call X	Sorting:	
	E.S.		Boundhoss: subang subroup	
	AL AN	Contraction of	Esprice grain supported	
		MAR	Structure	
500um			Massiva	
ATTACK AND A	ALL R		IVIdSSIVE	
			Authigenic Components	
Image B				
AND AN AN AN AN AN			Cements (Pore Fillings):	
	15		Chlorite tr	
	in the	al Market	Qtz ovgh tr	
olig.		A A	Feldspar ovgh tr	
	6.43	and and a state of the second	Calcite 5.0-6.0	
cal		1000	Organic matter 0.5-1.0	
			Pyrite tr	
	10000	ali	Replacement	
	111. 2	Dest	Chlorite tr	
qtz ovgh			Calcite 1.0-2.0	
			Pyrite tr	
	1	A 4	Porosity (Visual Estimate):	
			Intergranular:	
fractures	al e		Secondary: tr	
250/um	0 0	- Andrew	Microfracture: minor	
		ALC: NOT	Microporosity: abundant	
	-		Others:	

Image A exhibits a massive, fine to coarse grained feldsparthic litharenite with a grain-supported, non-porous fabric. Poorly sorted grains are subanguler to subrounded, size ranging from coarse silt (30um) to very coarse sand (1500um). Grains are dominated by rock fragments (chert, VRF, PRF, MRF) and quartz with lesser feldspars. The primary intergranular pores were predominantly plugged by 8-10% matrix clay and 5-6% calcite cement (image A). Note some vertical microfractures cut through rocks and are sealed by calcite. Image B shows calcite occurs as both replacement of grains and pore filling phase. Some volcanic rock fragments developed secondary pores due to dissolution of unstable minerals.

Description of Thin	Section Pl	notomicrograp	h	
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WE	ELL 390
Sample ID: 17	Depth:	286.50m		
Image A:			Composition	n: (visual estimate)
	- Parts	y Contraction		
	a H	and a	Grains:	
		A The	Q%	45-50
Sh	IIIICa	4	F%	15-20
NET ALL PRIME		and sales	R%	25-27
mica	AND A	A	Others: 2-3 % m	ica , 0.5% glau,
	11 200 L	a a particular	Matrix:	23-25
was some and the	A second	ALL ALL A	Rock Type:	
	A. 1. 1. 5-5	shi	Felfspat	thic Litharenite
mica org.	2-2-1	Car ba	Texture	
	Can the second	att y	Size Average:	fine
A NOT A CONSTRAINT	THE T	L.C.	Sorting:	well-very well
org	P D	and the second	Roundness:	subround-rounded.
Silicification			Fabric:	grain supported
EP a Part In		14. 3CA		
		Silicification	Structure	
250um	ACT	and the	ו	Massive
MEN Y END SIG	to a la	H. VE		
	19-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-1-	J. E. A	Authigenic Com	ponents
Image B				
	1.1	AN AN	Cements (Pore I	Fillings):
	2000		Chlorite	common
		- All	Qtz ovgh	tr
qtzovgh	and the second	1 Star	Feldspar ovgh	tr
	A DO N		Calcite	tr
	and the first	the same the state	Organic matter	1.0-2.0
	9	123 OVG11	Pyrite	tr
The second s			Replacement	
	- q1	- A. 140 A.	Chlorite	tr
	100		Calcite	tr
	E.	7449 - 1994 - 19	Pyrite	tr
	in the			
ftl exch		and a second	Porosity (Visual	Estimate):
		a state of	Intergranular:	
fd ovah	Ser.		Secondary:	
50um	19 4 A A		Fracture:	
		And the second	Microporosity:	abudant
and the second se			Others:	
			· · · · · ·	

Image A is an overview of a massive, fine grained, well-very well sorted feldsparthic litharenite. The subrounded framework grains consist mainly of quartz and rock fragments (chert, VRF, PRF, MRF) with lesser feldspars, minor mica and glauconitic are also present. Considerable amount of clay matrix (23-25%) occurred within grain-supported fabric and reduced intergranular pores (image A). Image B shows the primary Intergranular pore spaces plugged by abundant matrix and minor quartz and feldspar overgrowth (image B), no visible porosity was detected in the sample. Microporosity is abundant in the clay minerals.

Description of Thir	n Section Ph	notomicrograp	h	
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WE	LL 390
Sample ID: 19	Depth:	279.00m		
Image A: fd			Composition	: (visual estimate)
No the second	A STATE	Contra C	0%	35-40
		VRF	€%	30-32
States and the second states			R%	23-25
NO CONTRACTOR OF THE	Sel-4	VII BAT	Others: mica 2-3	% glau
	A		Matrix:	20-22
fd		the test	Rock Type:	20 22
	IU C	18 200	Lithic A	kose
A CARLEN DE CALVE	AN S		Texture	
fd VRF	No Para		Grain size	verv fine to coarse
	1- Ale		Sorting:	poor
fd			Roundness:	angsubrounded
A loss and a support of the		and the	Fabric:	grain supported
				0 11
	See		Structure	
500um		0.	Massive, I	ocally laminated
A los and the second second	and a	and the second	Authigenic Com	ponents
Image B				
and the second second second	14		Cements (Pore F	illings):
	1 3 m		Chlorite	tr
	No.		Qtz ovgh	tr
and the second sec	1		Feldspar ovgh	tr
qtz ovgh			Calcite	
			Organic matter	0.5-1.0
		A 16 3	Pyrite	tr
	fd over	the state	Replacement	
	iuovyn	6	SIO2	
	a sere y	10	Chlorite	tr
			Calcite	
matrix clay	All and the	AT THE	Pyrite	tr-0.5
		14	Porosity (Visual	Estimate):
	2 dev		Intergrapulari	
		- California	Socondany	
100 mg			Fracture:	
Toum		1	Microporosity:	
A STATE AND A STAT		1. 8	Others	
		and the second	others.	

Image A is an overview of a locally laminated to massive, very fine to coarse grained lithic arkose. Poorly sorted grains are angular to subrounded, size ranging from very fine (50um) to very coarse sand (1100um). Grains are dominated by quartz, feldspars and rock fragments (chert, VRF, PRF, MRF). Minor dark brown to black organic matter (bitumen?) occluded intergranular pores. The primary intergranular pores were predominantly reduced by compaction and 20-22% matrix clay, and produced a tight, non-porous fabric (image A). Image B shows quartz and feldspar overgrowth was identified by clear rims around grains. Considerable matrix clay occurred between grains , and microporosity is abundant in the clay minerals.

Description of Thin	Section Ph	notomicrograp	h	
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS W	ELL 390
Sample ID: 21	Depth:	267.00m		
Image A:			Compositio	a: (visual ostimato)
	CAL H	AL X	composition	i. (visual estimate)
A A A A A A A A A A A A A A A A A A A	A DE LA	CAT D	Grains:	
And the second of the second	1	X YA	Q%	38-42
VRE	A 6	1	F%	22-25
Cit	And a	VAL 8	R%	25-30
	the late	AF BK	Others: 2% mica	a , trace glau,
	ant		Matrix:	25-30
fd	A BARREN	A COL	Rock Type:	
	and they		Feldspa	thic Litharenite
A A A A A A A A A A A A A A A A A A A	-	EA St.	Texture	
	TO ANY		grain size	very fine to coarse
fd	F	THE A	Sorting:	poorly
		Contractor	Roundness:	angsubrounded
The part shad	fd	A Langely	Fabric:	grain supported
Anos Lui Cart	Ca and			
			Structure	
250um	Carlon adding			Massive
	- And	260		
NO POPULATE		The state	Authigenic Com	ponents
Image B				
ALL AND THE		3.9	Cements (Pore	Fillings):
and the second second	A CAL		Chlorite	common
	5.1	a la in	Qtz ovgh	tr
fd	Berg	A A	Feldspar ovgh	tr
	C Bill		Calcite	0.5
org			Organic matter	0.5-1.0
" & house a second have	4	fd ovgh	Pyrite	tr-0.5
		Sec. 1	Replacement	
chi	cal a		SiO2	
fd ovgh		fd	Chlorite	tr
	5	the line &	Calcite	0.5-1.0
fd/		1 M	Pyrite	1.0
U PACINO	SEA.		Porosity (Visual	Estimate):
A THE REAL PROPERTY AND A REAL PROPERTY A REAL PROPERTY A REAL PROPERTY AND A REAL PROPERTY AND A REAL PRO	Len	The second		
matrix	XT3	the h	Intergranular:	
	A La	A PAR	Secondary:	
100 km	Ser A		, Fracture:	
		ALK C	Microporosity:	abundant
A A A A A A A A A A A A A A A A A A A		A CAR	, , Others:	

This massive, very fine to coarse grained feldspathic litharenite is mainly composed of quartz, rock fragments (chert, VRF, PRF, MRF) and feldspars. Poorly sorted grains are angular to subrounded, size ranging from very fine (60um) to very coarse sand (1250um). Moderate compaction and 25-30% matrix clay reduced and blocked intergranular pores, and produced a tight, non-porous fabric (image A). Image B shows dissolution of unstable grains (VRF, PRF, feldspar etc.) formed secondary porosity which in filled with organic matter or bitumen? and followed by calcite cement. The early diagenetic phases included chlorite rimming and feldspar overgrowth. Considerable matrix clay occurred between grains, and microporosity is abundant in the clay minerals.

Description of Thin Sec	ction Photomicrograph
Geological Survey of Canada We	ell ID: OW-11-01-NANAIMO OBS WELL 390
Sample ID: 22 De	pth: 253.00m
Image A:	Composition: (visual estimate)
	composition (visual commute)
A THE MARKER AND	Grains:
	Q% 30-35
International	F% 28-30
	R% 30-32
CONTRACTOR AND A REAL	Others: 1-2 % mica , 0.5% glau,
matňix/clay	Matrix: 15-17
	Rock Type:
	Feldspathic Litharenite
matrix(cl	Texture
Contraction of the second	grain size medium to coarse
	Sorting: moderately
	Roundness: subangsubroun.
	Fabric: grain supported
Confirm Date	
	Structure
1mm	Massive
A COMPANY AND A COMPANY	Authigenic Components
Image B	
CARLES AND AND	Cements (Pore Fillings):
	Chlorite common
	Qtz ovgh tr
and the second second second	Feldspar ovgh tr
	Calcite
A MARINE A	Organic matter 1.0
matrixel	ay Pyrite 0.5-1.0
and the second sec	Replacement
	SiO2
maîritz clay	Chlorite tr
fdjovgh	Calcite
	Pyrite tr
	Porosity (Visual Estimate):
Provide the second second	
a standard a standard a standard	Intergranular:
	Secondary: tr
100um	Microfracture tr
	Microporosity: common
19	Others:

Image A exhibits a massive, medium to coarse grained feldsparthic litharenite with a grain-supported, non-porous fabric. Moderately sorted grains are subanguler to subrounded, size ranging from coarse silt (60um) to very coarse sand (1500um). Grains consists of sub-equal quartz, rock fragments (chert, VRF, PRF, MRF) and quartz (image A). Note some vertical microfractures cut through rocks and are filled with bitumen? and pyrite (image A). Image B shows the primary intergranular pore spaces plugged by abundant matrix clay and minor feldspar overgrowth (image B), no visible porosity was detected in the sample. Microporosity is abundant and exists in the clay minerals.

Description of Thir	Section Pl	hotomicrograp	bh	
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WE	ELL 390
Sample ID: 24	Depth:	236.25m		
Image A:	CA		Compositior Grains:	ı: (visual estimate)
Y CARA	1.	Z.Z.	Q%	45-50
Imilea	L'istor	1	F%	25-30
	mic		R%	15-17
	A des	A The	Others: 2-3 % m	ica , 0.5% glau,
	V A	and and	Matrix: 20-22 (n	nicritic limemud)
limemud		1300	Rock Type:	· · · · · · · · · · · · · · · · · · ·
	-		Lithic A	rkose
mica	The second		Texture	
The second second	Sell.	X	grain size	fine to medium
and the second s	THE C		Sorting:	moderately well
limemud		MC L	Roundness:	, subangsubroun.
	grau	F.	Fabric:	grain supported
	A STATE	limemud		0 11
	Same -	A PL	Structure	
250um	- Martin	al.	1	Massive
	di ta di		Authigenic Com	ponents
Image B	<u></u>		Ŭ	
			Cements (Pore F	illings):
A CAR BOARD AND AND AND AND AND AND AND AND AND AN		-2	Chlorite	minor
A ANTAL SAF STATISTICS	19.63		Qtz ovgh	tr
			Feldspar ovgh	tr
m state	1		Calcite	
limemud () (cell	4 8 B	4000	Organic matter	tr
Call Call	lovgh	Care and the	Pyrite	tr
cal		1.	Replacement	
fa		A CARLER AND	SiO2	
Imenud		ASS P	Chlorite	
		NBY !!	Calcite	
	emuu		Pyrite	tr
			Porosity (Visual	Estimate):
	a start			-
	the way		Intergranular:	
			Secondary:	
100um	a la	ater	Fracture:	
	1		Microporosity:	common
a day the form of the			Others:	

Image A shows a massive, fine to medium grained lithic arkose. Grains are moderately well sorted, and composed mainly of quartz and feldspar with lesser rock fragments (chert, VRF, PRF, MRF). Grain supported fabric shows subtle preferential orientation of grains due to compaction. The sample has very low visible porosity, and pores are blocked by considerable micritic lime mud (image A). Image B is closer view of micritic lime mud between grains. Also note that grain boundaries often look corroded (image B) in contact with lime mud, suggesting a replacement modification of the grains by microcrystalline calcite (image B). Microporosity is abundant and exists in the micritic lime mud.

Description of Thir	Section Ph	notomicrograp	h	
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WE	ELL 390
Sample ID: 26	Depth:	227.50m		
Image A:			Composition	: (visual estimate)
	art			. ,
HIM ALL ALL ALL	glau		Grains:	
	1330	A STORE	Q%	48-50
	51.12		F%	25-26
	AND.	1.3 0	R%	20-22
shi			Others: 2% mica	a, trace glau,
	- Contra		Matrix:	25-26
That he wanted the		FLAN	Rock Type:	
	LAN	AN -	Lithic A	rkose
	AN AL	Mane d	Texture	
	A CHES		Grain size	fine
A MALE AND A	mic	a	Sorting:	very well
The set is a set of the ball	and the second second	10	Roundness:	subrounded
An Alexander	A Carl	Carlos Car	Fabric:	grain supported
The state of the s		mica		
		THE LE	Structure	
<u>500um</u>			Massive, I	ocally laminated
	3000		Authigenic Com	ponents
Image B				
	10	ALC NO.	Cements (Pore F	illings):
	6247 20		Chlorite	minor
	Conta N		Qtz ovgh	tr
		0.12	Feldspar ovgh	tr
fd.ovgh			Calcite	0.5-1
		cal	Organic matter	0.5
			Pyrite	tr
The second s	All and	and the second	Replacement	
STALL AND STALL		cal	SiO2	
		- OF A STREET	Chlorite	tr
Later Plant Plant	1 and		Calcite	
fd cal	and the second	Million Charles	Pyrite	tr
	1 and	1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	Porosity (Visual	Estimate):
TO A A A A A A A A A A A A A A A A A A A	1.6	a start on		
Call	140	and the	Intergranular:	
		FL	Secondary:	
100um	1	1	Fracture:	
		112	Microporosity:	common
	and the	and the second	Others:	

A fine grained, very well sorted lithic arkose shows an overall massive texture with minor shale laminae. The subrounded framework grains consist mainly of quartz, feldspars and rock fragments (chert, VRF, shale clasts, PRF, MRF), minor mica and glauconitic are also present. Considerable amount of clay matrix (25-26%) occurred within grain-supported fabric and reduced intergranular pores (image A). Image B shows the primary Intergranular pore spaces plugged by abundant matrix and minor calcite cement. Feldspar overgrowth (image B) was recognized by clear rims, no visible porosity was detected in the sample. Microporosity is abundant and exists in the clay minerals.

Description of Thin	Section Ph	notomicrograp	bh	
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS W	ELL 390
Sample ID: 28	Depth:	216.75m		
Image A:	PI	RF	Composition Grains:	n: (visual estimate)
10	The Real	TAKE	Q%	40-42
A CONTRACTOR	ALLA P		F%	20-23
PRE	AND THE R		R%	30-32
	50	20.0	Others: 2% mica	a, trace glau,
VIE		and Sta	Matrix:	17-18
	Real Providence		Rock Type:	
	1 Arton	the start	Feldspa	thic Litharenite
		1 - A	Texture	
	Risting .	a state of the	Grain size	fine to medium
fd still	and a	F1 -	Sorting:	moderately
UNDERST NO SERVICE	shi	VRF	Roundness:	subangsubroun.
fd	GIL	VRF	Fabric:	grain supported
ALL DE LE REAL DE LE R				
500um			Structure	
Alter Callers	ALL.	PH 3		Massive
			Authigenic Com	ponents
Image B				
chi	A. C.	A STATE	Cements (Pore	Fillings):
fd.ovgh	1.6.1.5	Constant of	Chlorite	common
THE SAME TO PARTY		North Contraction	Qtz ovgh	tr
chi	1		Feldspar ovgh	tr
	Sig mat	chi	Calcite	
	1 4 3	No.	Organic matter	0.5-1
J Contract of the second	R. may	to the	Pyrite	0.5
qtz/ovgh		14.	Replacement	
rd oyah chi	12 Test		SiO2	
	1 115		Chlorite	tr
			Calcite	
The second for the second second	AL ANT	1.30	Pyrite	tr
Stranger C. J. Harris R. S.	.7. 4	CAL AND	Porosity (Visual	Estimate):
	1 - 10 - 10 - 10 - 10 - 10 - 10 - 10 -			
ehil			Intergranular:	
chi			Intergranular: Secondary:	
etil 50um			Intergranular: Secondary: Fracture:	
etil 50um	A		Intergranular: Secondary: Fracture: Microporosity:	common

Image A is an overview of a massive, fine to medium grained feldsparthic litharenite. The moderately sorted, subangular to subrounded framework grains consist mainly of quartz and rock fragments (chert, shale clasts, VRF, PRF, MRF etc.) with lesser feldspars, minor mica and glauconitic are also present. The original primary pores are reduced by moderate compaction and further blocked by 17-18% clay matrix, indicating by tight, non-porous fabric. Image B shows the early diagenetic phases: chlorite lining pores and followed by feldspar and quartz overgrowth (image B). Microporosity is abundant and exists in the clay minerals.

Description of Thin S	ection Pł	notomicrograp	h	
Geological Survey of Canada		WELL ID: OW	-11-01-NANAIM	O OBS WELL 390
Sample ID: 29 E	epth:	214.50m		
Image A:			Composition	: (visual estimate)
A STATE AND A STATE AND A STATE				
A PART AND A PART AND A PART	A CON	A BAR	Grains:	
Cht shi	3	1 Delle	Q%	35-37
and the second s	6.20	Start A	F%	27-28
A COMPLEX STOR	HA TH	ser i	R%	30-32
cht	in the second	Cal Cont	Others: mica: 2-	3%, glau: tr.
	A and		Matrix:	18-20
		P	Rock Type:	
		A a to a	Feldspa	thic Litharenite
and the second second	nest	glau	Texture	
CH C		Contraction of the	Grain size	medium to coarse
A A MARTINE AND AND AND AND A REAL	Y a	12.2 C	Sorting:	moderatly
THE A LOCAL CONTRACT OF THE	States 19		Roundness:	subangsubroun.
	ES.	1 Part	Fabric:	grain supported
sh		653 Te		
A STATE AND A LAND	an and		Structure	
500um	1-1		1	Massive
the state of the state of		Cart		
		and the second	Authigenic Com	ponents
Image B				
The second second	No. Co	4.3	Cements (Pore F	illings):
	and 1	194 10	Chlorite	common
		A Start	Qtz ovgh	tr
		- Carling	Feldspar ovgh	0.5-1
	1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	Ter	Calcite	tr
	1 - 1		Organic matter	0.5
		1-3	Pyrite	0.5
L' NE AUTOM	49	1 A	Replacement	
	VAL Y		SiO2	
V. A MARINA	And the second s	- these	Chlorite	tr
	A.L.	Ser in 1	Calcite	
	SE S	And De	Pyrite	0.5
		19 1 - 2 C	Porosity (Visual	Estimate):
org pyr:	Progent .	1 2.		
	A Se		Intergranular:	tr
	- All		Secondary:	tr
100um	Ser Fe		Fracture:	
	L R	and a	Microporosity:	common
	4 Dray	1. 5 MA.	Others:	

A massive, medium to coarse grained feldsparthic litharenite shows a framework consisting mainly of quartz and rock fragments (chert, shale clasts, VRF, PRF, MRF etc.) with lesser feldspars, minor mica and glauconitic are also present (image A). Platy and elongated grains are compacted parallel to bedding planes (image A). The moderately sorted, subangular to subrounded fabric is tight, non-porous because the primary pores are reduced by moderate compaction and further blocked by 18-20 % clay matrix. Image B shows the early chlorite grain coating. Note some feldspar grains were dissolved and produced secondary pores which filled by calcite and black org.+pyr. or bitumen? (image B).

Geological Survey of Canada	WELL ID:	OW-11-01-N	ANAIMO OBS WE	11 390
Sample ID: 30	Depth:	207 50m		
Image A:		207.000		
	(Thinks	A	Compositio	n: (visual estimate)
The second second	- Char	Org	Grains:	
WREA		H. A.	Q%	37-40
	149	and the second	F%	24-25
	ALL!	- St	R%	27-30
A A A A A A A A A A A A A A A A A A A		- Frank	Others: mica: 1-	2%, glau: tr.
VRF MRF			Matrix:	15-16
A A A A A A A A A A A A A A A A A A A		org	Rock Type:	
A EL OF STATE	Co. Series		Feldspa	thic Litharenite
PRF. Cht.	Shi	to a second	Texture	
		The s	Size Average:	medium to coarse
	Romain	- 42 110	Sorting:	Poorly - moderatly
	Cer.L	2105:	Roundness:	angsubroun.
		The start	Fabric:	grain supported
	CI	n shi		
add of the second second		The Star	Structure	
500um	Jan 3		Massi	ve, borrowed
	and the second			
A Contract of the second	This	SA S	Authigenic Com	ponents
Image B	1 And	SA S	Authigenic Com	ponents
Image B			Authigenic Com Cements (Pore F	ponents ;illings):
Image B			Authigenic Com Cements (Pore F Chlorite	ponents Fillings): common
Image B			Authigenic Com Cements (Pore F Chlorite Qtz ovgh	ponents Fillings): common
Image B			Authigenic Com Cements (Pore F Chlorite Qtz ovgh Feldspar ovgh	ponents ;illings): common
Image B			Authigenic Com Cements (Pore F Chlorite Qtz ovgh Feldspar ovgh Calcite	ponents ;illings): common
Image B			Authigenic Com Cements (Pore F Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter	ponents Fillings): common 1-1.5
Image B			Authigenic Com Cements (Pore F Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite	ponents Fillings): common 1-1.5 0.5-1
Image B		pore ?	Authigenic Com Cements (Pore F Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement	ponents Fillings): common 1-1.5 0.5-1
Image B		pore ?	Authigenic Com Cements (Pore F Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2	ponents iillings): common 1-1.5 0.5-1
Image B		pore ?	Authigenic Com Cements (Pore F Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite	ponents Fillings): common 1-1.5 0.5-1 tr
Image B		pore ?	Authigenic Com Cements (Pore F Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite	ponents fillings): common 1-1.5 0.5-1 tr
Image B		pore ?	Authigenic Com Cements (Pore F Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite Pyrite	ponents Fillings): common 1-1.5 0.5-1 tr 0.5
Image B		pore ?	Authigenic Com Cements (Pore F Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite Pyrite Porosity (Visual	ponents iillings): common 1-1.5 0.5-1 tr 0.5 Estimate):
Image B		pore ?	Authigenic Com Cements (Pore F Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite Pyrite Porosity (Visual	ponents iillings): common 1-1.5 0.5-1 tr 0.5 Estimate):
Image B		pore ?	Authigenic Com Cements (Pore F Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite Pyrite Porosity (Visual Intergranular:	ponents iillings): common 1-1.5 0.5-1 tr 0.5 Estimate): tr
Image B		pore ?	Authigenic Com Cements (Pore F Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite Pyrite Porosity (Visual Intergranular: Secondary:	ponents iillings): common 1-1.5 0.5-1 tr 0.5 Estimate): tr tr tr
Image B		pore ?	Authigenic Com Cements (Pore F Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite Pyrite Porosity (Visual Intergranular: Secondary: Fracture:	ponents Fillings): common 1-1.5 0.5-1 tr 0.5 Estimate): tr tr tr tr
Image B		pore ?	Authigenic Com Cements (Pore F Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite Pyrite Porosity (Visual Intergranular: Secondary: Fracture: Microporosity:	ponents iillings): common 1-1.5 0.5-1 tr 0.5 Estimate): tr tr tr common

Description of Thin Section Dhotomicrograph

A massive, medium to coarse grained feldspathic litharenite shows a grain-supported, poorly to moderately sorted, angular to subrounded framework. Grains are dominated by quartz, rock fragments (chert, shale clasts, VRF, PRF, MRF etc.) and feldspars (image A). The original primary pores are reduced by moderate compaction and further blocked by 15-16 % clay matrix, therefore the sample has a very low visible porosity. Image B shows minor black organic matter (bitumen?) mixed with pyrite filled remaining pore spaces (image B) between grains after pore-blocking matrix clay. Note the red arrow shows the pore could be a remaining intergranular pore or grain secondary dissolution pore?

Description of Thin Section Photomicrograph					
Geological Survey of Canada	WELL ID:	OW-11-01-N	ANAIMO OBS WELL 390		
Sample ID: 32	Depth:	194.50m			
Image A:			Composition	n: (visual estimate)	
VIRE	J. March	Set a	0%	35-40	
	(The second		E%	23-25	
giau	Lack.		R%	30-33	
MRE			Others: mica: 1-	2% glau:tr	
			Matrix:	25-27	
AND A AND AND A		SAF DE	Rock Type	25 27	
		and the	Feldsna	thic Litharenite	
Shi and a shi and a shi	The second		Texture		
A BALLAND BALL	shi		Grain size	very fine to coarse	
cht		ATO AT 2	Sorting.	Poorly	
	and the	* JAN	Boundness:	ang -subroun	
the tot the set of	A-1-61	- Jack	Fabric:	grain supported	
	and the		rabrie.	grain supported	
olit has	- AT		Structure		
500um	A-231	Stoppe		Massive	
	1821				
	A March	P NO	Authigenic Com	ponents	
Image B					
	Sec.		Cements (Pore F	illings):	
Car in the second second	A PLAN		Chlorite	common	
	1. 1. 1.		Qtz ovgh	tr-0.5	
	17.0	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Feldspar ovgh	tr-0.5	
and the second	~	to a set	Calcite		
States of the second second	AAA	The second second	Organic matter	0.5-1	
		A set	Pyrite	0.5	
	State Care	Contract of	Replacement		
org.	and the second	1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1. 1	SiO2		
chi		autice 1	Chlorite	tr	
matrix day org.		a the second	Calcite		
ch			Pyrite	0.5-1	
Corg.	- Filie		Porosity (Visual	Estimate):	
A CONTRACT AND A CONTRACT OF A	1800		Intergranular:	tr	
	E Most	Real States	Secondary:		
100um	ALC: NO	N RW	Fracture:		
		2	Microporosity:	common	
	A. 1. 14	C. Sandard	Others:		

Image A shows a massive, very fine to coarse grained feldspathic litharenite with a grain-supported, tight and non-porous fabric. Poorly sorted grains are angular to subrounded, size ranging from coarse silt (30um) to very coarse sand (1200um). Grains are dominated by quartz, rock fragments (chert, shale clasts, VRF, PRF, MRF etc.) and feldspars. The primary intergranular pores were predominantly reduced by compaction and 25-27% matrix clay (image A), therefore the sample has a very low visible porosity. Image B shows minor green-coloured authigenic chlorite and black organic matter (bitumen?) filled intergranular pores (image B). Considerable matrix clay occurred between grains and blocked pores.

Description of Thir	n Section Ph	notomicrograp	bh
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WELL 390
Sample ID: 34	Depth:	180.00m	
Image A:			Composition: (visual estimate)
ALTAN TO AND A			Grains:
	RANK		0% 35-40
	× 172	12 X ZAN	F% 30-32
ic) ic)			R% 23-25
silty	shale		Others: mica 2-3 % glau
fd	S.X		Matrix: 16-18
	1 mar		Rock Type:
		Andrea	Lithic Arkose
	a a cu		Texture
folan	Cht		Grain size fine to medium
	NV	rade	Sorting: poorly-moderately
	- The second	(Barrow	Roundness: subangsubrounded
	shi	1	Fabric: grain supported
Sector Se	hl	inica	
inica de la companya			Structure
500um		1 Ser	Massive
A STATE AND A STATE AND A STATE	CT X		
	2 mark	- Ar	Authigenic Components
Image B			
	17 35	100	Cements (Pore Fillings):
	ar th	mar and	Chlorite common
ansie of the last	14.5	-10	Qtz ovgh tr
A MARKEN MARK	A		Feldspar ovgh tr
		ant	Calcite
Set 19 And And	50	AC	Organic matter 0.5-1.0
	The Mich	STEP &	Pyrite tr-0.5
	- And	100 COS 4	Replacement
A THE SECTION IN THE	LET IST	The second	SiO2
Call Call		N	Chlorite tr
ACTION AND AND AND AND AND AND AND AND AND AN	org!+pyr	- Aller	Calcite tr
Ebil.	1 . S. C.		Pyrite 0.5-1
chi		gtz oydb	Porosity (Visual Estimate):
	KAT.		
Strand and the second second second	Ex 2	and the	Intergranular:
	ALL A	and the	Secondary:
10000	L. I.	the .	Fracture:
			Microporosity: common
	18	1-1-14-17	Others:

A massive, fine to medium grained lithic arkose shows a framework consisting mainly of quartz, feldspars and rock fragments (chert, shale clasts, VRF, PRF, MRF etc.), minor mica and glauconitic are also present (image A). Platy and elongated grains are compacted parallel to bedding planes (image A). The poorly to moderately sorted, subangular to subrounded fabric is tight, non-porous because the primary pores are reduced by moderate compaction and further blocked by 16-18% clay matrix. Image B shows the early chlorite grain coating and later chlorite filling in the feldspar dissolved moldic pore?. Minor black org.+pyr. or bitumen? locally pugged the intergranular pores (image B).

Description of Thin Section Photomicrograph					
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS W	ELL 390	
Sample ID: 35	Depth:	171.75m			
Image A:			Compositio	n: (visual estimate)	
org.	A STATE		Grains:		
Org.		S. A.C.	Q%	45-47	
		20 mm	F%	26-28	
		Org	R%	15-20	
	a statest	Con Con	Others: mica 3-	5 %, glau,	
	Kan de	4-0	Matrix:	27-30	
OIG.			Rock Type:		
	1000- 0	ALL COM	Lithic A	Arkose	
			Texture		
and the second	3		Grain size	very fine to fine	
the second of the	1		Sorting:	moderately-well	
	ă 😽	ALC: A	Roundness:	subrounrounded	
burrow	7		Fabric:	grain supported	
	CA POR	SCIE-CA			
	Constant -	2. 3 P &	Structure		
<u>500um</u>			Massi	ive, burrowed	
			Authigenic Com	nponents	
Image B					
	C BAG		Cements (Pore	Fillings):	
a substant of a state of the second state of t		bes dented	Chlorite	common	
ora 2 bitumen		AND AND	Qtz ovgh	tr	
	1.		Feldspar ovgh	tr	
		10-	Calcite	tr	
org.? bitumen	10	34. ···	Organic matter	10-12	
chi	a State		Pyrite	3-5	
			Replacement		
	-		SiO2		
eren 19 la marca	C States	burn and mark	Chlorite	tr	
	(Red		Calcite	tr	
The Albert			Pyrite	1	
chi-			Porosity (Visua	l Estimate):	
fd oveh	and the second				
		and the second	Intergranular:		
Tchi	and the P	and the	Secondary:		
1000		~ ** · · ·	Fracture:		
	se p	2. Set	Microporosity:	common	
	A CALLER	12 martin	Others:		

A very fine to fine grained lithic arkose shows an overall laminated to massive structure slightly disturbed by burrows, which are identified by cleaner, coarser and rotated grains (imageA). Moderately-well sorted grains are subrounded to rounded, and consist mainly of quartz, feldspars and lesser chert, shale clasts and volcanic rock fragments. This sample contains 27-30% clay matrix and 10-12% organic matter (bitumen) which blocked interstitial pore spaces (image A), indicated by tight, non-porous fabric. Image B displays black organic matter (bitumen?) mixed with pyrite occurred as thin strips paralleling to bedding planes (image B). Note the extensive early chlorite grain coating and trace feldspar overgrowth (image B) had developed.

Seelogical Survey of Canada Well ID: OW-11-01-MANAIMO OBS WELL 390 Sample ID: 36 Depti: 163.75m Image A: Composition: (visual estimate) Grains: Q% 38-40 Q% 38-40 R% P% 18-20 R% R% 35-37 Others: mica 2 %, glau. 0.5-1% Matrix: 20-22 Rock Type: Feldspathic Litharenite Texture Texture Grain size very fine to fine Sorting: wery fine to fine Controst Massive Hourdness: subrounded Fabric: grain supported Fabric: Common Qz cowigh	Description of Thin Section Photomicrograph					
Sample ID: 36 Depth: 163.75m Image A: Composition: (visual estimate) Grains: Composition: (visua	Geological Survey of Canada We	ell ID:	OW-11-01-N	ANAIMO OBS WE	ELL 390	
Image A: Composition: (visual estimate) Grains: 0% 38-40 0% 35-37 0% 0% 35-37 0% 0% 35-37 0% 0% 0% 0% 0% 0% 0% 0% 0% 0% 0% 0% 0% 0% 35-37 0% 0% 0%	Sample ID: 36 De	epth:	163.75m			
Image B Centres (Pore Fillings): Chorite Chorite Canon Construction Construction Construction Construction Conset Conset Con	Image A:			Composition	· (visual estimate)	
Image B Grains: Q% 38-40 P% 38-37 P% 38-37 Others: mica 2 %, glau. 0.5-1% P% 38-37 Matrix: 20-22 Rock Type: Feldopathic Litharenite Fedure Grain size very fine to fine Sorting: well-very well Roundness: subrounded Pabric: grain supported PM Massive Massive PM Image B Chorite Common Qz very fine to fine Grain size very fine to fine Sorting: Chorite Chorite Image B Chorite Common Qz very fine to fine Sorting: Grain size	A CARLER AND A CONTRACTOR	Mar 9		composition	. (visual estimate)	
Image B Components Components Components Components Components Control Components Control Components Control Control Control Control <th></th> <th>A-1.13</th> <th></th> <th>Grains:</th> <th></th>		A-1.13		Grains:		
Image B Cements (Pore Fillings): Chorite tr Chorite tr Colored Common Ct organic matter 1-2 Pyrite tr Redspacement SiO2 Chorite tr Redspacement SiO2 Chorite tr Redspacement SiO2 Chorite tr	cht	A Brie		Q%	38-40	
Image B Cements (Pore Fillings): Chiers: mica 2 %, glau. 0.5-1% Matrix: 20-22 Rock Type: Feldspathic Litharenite Texture Grain size Sorting: well-very well Roundness: subrounded Fabric: grain supported Structure Massive Chiers: Massive Structure Cathingenic Components Chiers: components <t< th=""><th></th><th></th><th>cht</th><th>F%</th><th>18-20</th></t<>			cht	F%	18-20	
Image B Centers (Pore Fillings): Chlorite Common Clay of the common Clay of the clay of	fd	10 P	STR.	R%	35-37	
Image B Cements (Pore Fillings): Chlorite cnl Cements (Pore Fillings): Chlorite tr Calcite Organic matter 1-2 Pyrite tr		· 1/4	- ALT	Others: mica 2 %	5, glau. 0.5-1%	
Image B Cements (Pore Fillings): Chlorite Common Qz orgh tr Feldspart orgh tr <td< th=""><th>glau.</th><th></th><th>Carlo D</th><th>Matrix:</th><th>20-22</th></td<>	glau.		Carlo D	Matrix:	20-22	
Feldspathic Litharenite Texture Grain size very fine to fine Sorting: well-very well Roundness: subrounded Fabric: grain supported Structure Massive Image B Cements (Pore Fillings): Chlorite common Qtz ovgh tr Feldspat very response Orgain catter 1-2 Pyrite tr Catter Orgain catter Chlorite tr Corgain catter 1-2 Pyrite tr SiO2 Chlorite tr Chlorite tr SiO2 Chlorite tr Chlorite tr SiO2 Chlorite tr Chlorite tr SiO2 Chlorite tr	A TON WAS TO BE AND	sh	and the	Rock Type:		
Image B Cements (Pore Fillings): Chlorite tr Calicite Organic matter 1-2 Pyrite tr Texture	SN SN	~24	A no Dai	Feldspat	hic Litharenite	
Grain size very fine to fine Sorting: well-very well Roundness: subrounded Fabric: grain supported Structure Massive Authigenic Components Cements (Pore Fillings): Chlorite common Qtz ovgh tr Feldspar ovgh tr Gaite Organic matter 1-2 Pyrite tr Replacement SiO2 Chlorite tr		e ka	-	Texture		
Sorting: well-very well Roundness: subrounded Fabric: grain supported Structure Massive Massive Authigenic Components Authigenic Components Cements (Pore Fillings): Chlorite common Qtz ovgh tr Feldspar ovgh tr Calcite Organic matter 1-2 Pyrite tr Replacement SiO2 Chlorite tr	chit	AL AL		Grain size	very fine to fine	
Roundness: subrounded Fabric: grain supported Structure Massive Massive Massive Massive Cements (Pore Fillings): Chlorite common Qtz ovgh tr Feldspar ovgh tr Calcite Organic matter 1-2 Pyrite tr Replacement SiO2 Chlorite tr	Contraction of the second of	14.3		Sorting:	well-very well	
Shine Fabric: grain supported Structure Massive Image B Authigenic Components Chlorite common Qtz ovgh tr Feldspar ovgh tr Feldspar ovgh tr Organic matter 1-2 Pyrite tr Replacement SiO2 Chlorite tr		4 . 1		Roundness:	subrounded	
250um Structure Massive Image B Cements (Pore Fillings): Chlorite Chorite tr Feldspar ovgh tr Feldspar ovgh tr Feldspar ovgh tr Size Organic matter 1-2 Pyrite tr Replacement SiO2 Chlorite tr		a ra	and the second	Fabric:	grain supported	
250um Chi Massive Image B Authigenic Components Cements (Pore Fillings): Chlorite common Qtz ovgh tr Feldspar ovgh tr Calcite Organic matter Organic matter 1-2 Pyrite tr Replacement SiO2 Chlorite tr		CAR A	~ ?? ~?			
250um Massive Image B Authigenic Components Image Components Cements (Pore Fillings): Chlorite common Qtz ovgh tr Feldspar ovgh tr Organic matter 1-2 Pyrite tr Replacement SiO2 Chlorite tr	E State of the second	and the second	at any at	Structure		
Image B Cereants (Pore Fillings): Chlorite common Qtz ovgh tr Feldspar ovgh tr Calcite Organic matter 1-2 Pyrite tr Replacement SiO2 Chlorite tr	250um cht	de .	A A A	Ν	/lassive	
Image B Cements (Pore Fillings): Chlorite common Qtz ovgh tr Feldspar ovgh tr Calcite Organic matter Organic matter 1-2 Pyrite tr Replacement SiO2 Chlorite tr	the second s	and a				
Image B Cements (Pore Fillings): Chlorite common Qtz ovgh tr Feldspar ovgh tr Calcite Organic matter Organic matter 1-2 Pyrite tr Replacement SiO2 Chlorite tr		- 4×		Authigenic Com	ponents	
Cements (Pore Fillings): Chlorite common Qtz ovgh tr Feldspar ovgh tr Calcite Organic matter 1-2 Pyrite tr Replacement SiO2 Chlorite tr	Image B					
Chlorite Common Qtz ovgh tr Feldspar ovgh tr Calcite Organic matter 1-2 Pyrite tr Replacement SiO2 Chlorite tr	Real Provide States and		-	Cements (Pore F	illings):	
Chi C		test a		Chiorite Ota avala	common	
chi c	-Org.		Sector Sector	Qtz ovgn	tr	
Chi Chi Organic matter 1-2 Pyrite tr Replacement SiO2 Chlorite tr			er ander	Feldspar ovgn	tr	
Chi Chi Chi Chi Chi Chi Chi Chi		3 PER	1		1.0	
Chi Chi Chi Replacement SiO2 Chlorite tr		ch		Organic matter	1-2	
SiO2 Chlorite tr	chl	The st	- Bar	Pyrite	tr	
Chlorite tr	chl	AS AN	200	Replacement		
chionte tr			CAN LOCA	SIU2 Chlorite	1	
Coloita	- No - Contraction of the second s	223	72.200	Chlorite	u	
	gutz ovgh	10 21	12010	Calcile	0 5 1	
Pyrile 0.5-1		A	A Street	Pyrite Deresity (Misuel	U.5-1	
Porosity (Visual Estimate):		- A	State -	Porosity (visual	csumatej:	
Intergrapulari				Intergrapulari		
Intergranular.	Charles and the second second	Contra I		Socondanu		
South Ensteiner	Boum		and the second	Fracture:		
College Colleg	Chi	A 1.3	S.P.S.	Microporocity:	common	
chi Others:	chi			Others:	common	

Image A is an overview of a massive, very fine to fine grained feldsparthic litharenite with a tight, non-porous fabric (image A). Well to very well sorted framework grains are subrounded to rounded, and consist mainly of quartz, rock fragments (chert, shale clasts, VRF etc.) and lesser feldspars. The primary pores are first reduced by moderate compaction and further blocked by 20-22% matrix clay (mage A). Image B displays chlorite occurred as thin rims coating grain surfaces and also as cement filling intergranular pores (image B). Note the trace quartz overgrowth (image B) and minor pore-plugging black organic matter (bitumen?) are also present.

Description of Thin Section Photomicrograph				
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WELL 390	
Sample ID: 37	Depth:	161.25m		
Image A:			Composition: (visual estimate)	
	200			
	(The read	A. C. M.	Grains:	
		A AN	Q% 33-35	
	VRF		F% 23-25	
Cht	0		R% 35-37	
cht	200	18	Others: mica 1 %, glau. 0.5-1%	
Sh	glau. 🚕	Str 24	Matrix: 18-20	
fél	2	A CARLER	Rock Type:	
fd	Set The	ar tar	Feldspathic Litharenite	
	VRF	AR	Texture	
s Sh o o	and .	The	Grain size fine to medium	
Cht. VRF		to all	Sorting: moderately	
	cht		Roundness: subang.	
cht	a to	The the	Fabric: grain supported	
	X	A Der		
500um			Structure	
	02	Start Con	Massive	
	the las	H-M		
			Authigenic Components	
Image B	9424-76776-77677-007-0800			
			Cements (Pore Fillings):	
	Service 1		Chlorite common	
			Qtz ovgh tr	
	Carl A		Feldspar ovgh tr	
	and the state	- Jun	Calcite	
chi	fractur	es	Organic matter 1	
	1th	- Jon Martin	Pyrite 1	
fil out	- AL	1	Replacement	
	1		SiO2	
		2 in	Chlorite tr	
	and a		Calcite	
erg-Apyr	chl	and the second in	Pyrite 2-3	
and the second sec			Porosity (Visual Estimate):	
chl	2 mar . "	the second and		
A RANGE TO A RANGE	24. 19		Intergranular:	
		and the second s	Secondary:	
	E. South	P. Mark	Microfracture:	
	The second second		Microporosity: common	
	1. 4 1	-	Others:	

A massive, fine to medium grained feldspathic litharenite shows a grain-supported, non-porous fabric. Framework exhibits a low mature features in texture and composition. Grains are subangular, moderately sorted, and consisting mainly of quartz, rock fragments (chert, shale clasts, VRF etc.) and lesser feldspars. The primary pores are first reduced by moderate compaction and further blocked by 18-20% matrix clay (image A). Image B displays chlorite occurred as thin rims lining pores and also as cement filling intergranular pores (image B). Minor quartz overgrowth grew around grains. Later stage organic matter (bitumen?) and pyrite filled remaining pore spaces (image B). Note microfractures cut through the rock and sealed with authigenic chlorite (image B).

Description of Thin Section Photomicrograph				
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS W	'ELL 390
Sample ID: 38	Depth:	158.75m		
Image A:	X	ACT	Compositio	n: (visualestimate)
ent cht			0%	34-36
fractures	glau.		E%	27-28
sh ellysh	1 NA	1. marca	R%	27 20
mice	A	H AN	Others: mica 1	9994 % σlau 05%
	cht.	HEAT	Matrix:	23-25
fractures Sh		fd	Rock Type:	25 25
1	fd	Charles and	Feldsna	thic Litharenite
rta di la companya di	Shart P.	COL ZELE	Texture	
limemud	The second		Grain size	medium to coarse
	VRF	1-10-	Sorting:	moderately
	34	ALL!	Roundness:	subrouned
sh	r sh	limemud	Fabric:	grain supported
	A AN	A W A		
500um		A TANK	Structure	
THE REAL BUCK	EAS.	and a		Massive
	Same 1	1 LAND		
			Authigenic Con	nponents
Image B			Authigenic Con Cements (Pore Chlorite	nponents Fillings):
Image B	le filmemud		Authigenic Con Cements (Pore Chlorite Qtz ovgh	nponents Fillings): tr
Image B	le linemud		Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh	nponents Fillings): tr tr
Image B	ls Ilmemud		Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite	rponents Fillings): tr tr tr tr
Image B	le filmemud		Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter	rponents Fillings): tr tr tr 0.5
Image B	is fimemud		Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite	rponents Fillings): tr tr tr 0.5 tr
Image B	etimemud		Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement	rponents Fillings): tr tr tr 0.5 tr
Image B	le Ilmemud		Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2	rponents Fillings): tr tr tr 0.5 tr
Image B	lo limemud		Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite	rponents Fillings): tr tr tr 0.5 tr tr
Image B	le Ilmemud		Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite	rponents Fillings): tr tr tr 0.5 tr tr 1-2
Image B	le limemud		Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite Pyrite	rponents Fillings): tr tr tr 0.5 tr tr 1-2 1
	tettie Ilmemud		Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite Pyrite Porosity (Visua	Fillings): tr tr tr 0.5 tr tr 1-2 1 I Estimate):
	le limemud		Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite Pyrite Porosity (Visua Intergranular:	Fillings): tr tr tr 0.5 tr tr 1-2 1 I Estimate):
	is limemud		Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite Pyrite Porosity (Visua Intergranular: Secondary:	Fillings): tr tr tr 0.5 tr 1-2 1 I Estimate):
	ettis Ilmemud		Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite Pyrite Porosity (Visua Intergranular: Secondary: Microfracture:	rponents Fillings): tr tr tr 0.5 tr tr 1-2 1 I Estimate):
	rttis Ilmemud		Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite Pyrite Porosity (Visua Intergranular: Secondary: Microfracture: Microporosity:	rponents Fillings): tr tr tr 0.5 tr tr 1-2 1 I Estimate):

Image A shows a massive, medium to coarse grained feldspathic litharenite with a tight, non-porous fabric, moderately sorted framework grains are subrounded, and dominated by quartz, rock fragments (chert, shale clasts, VRF etc.) and feldspars. This sample was characterized by abundant micritic lime mud (23-25%), which totally pugged the original intergranular pores. Two groups of microfractures cut through the rock and improved reservoir quality in some degree. Image B is a closer view of the fractures and matrix lime mud. Interstitial lime mud appeared as very fine crystals blocked intergranual pores and also filled some microfractures. Note the corroded boundaries of some grains, suggesting lime mud locally replaced grains.

Description of Thin Section Photomicrograph					
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WELL 390		
Sample ID: 39	Depth:	153.00m			
Image A:	1	CTT.	Composition: (visual estimate) Grains:		
and the second second	- Cally		Q% 3-35		
	C De St	fd	F% 28-30		
cht cht	and and	Terrant	R% 30-33		
			Others: mica 2-3 %, glau. trace		
A AVANA A AND TO		and and	Matrix: 18-20		
Sh	the second	CAN	Rock Type: Lithic Arkose		
Cnt	124	and the second	Texture		
VRF fd		CLED	Grain size fine to medium		
to part of the second second second second		PT A	Sorting: poorly		
	Jos H Let	27 C.	Roundness: ang subang.		
	r dest		Fabric: grain supported		
CARA AND TALLEY	AN	19X			
	Star M	Star M	Structure		
500um	cht		Massive		
the second s	A		Authigenic Components		
Image B		A. 19	Cements (Pore Fillings):		
7 - De Martin Contraction of the			Chlorite common		
qt	z ovgh 🦾	R. E. K	Qtz ovgh tr		
Org-+pyr	1.4	Self and	Feldspar ovgh tr		
		3 to the	Calcite		
qtz ovgn	chl	× 100	Organic matter 0.5-1.0		
qtz ovgh	3. E.A.	12	Pyrite 1.5		
Notes and the second	in with	fd filling	Replacement		
CNI	and the		SiO2		
		he while it	Chlorite tr		
A Strate and a strate of the second		Ren and	Calcite		
Otgr#bi	St. Carl		Pyrite 1		
	d ovgh	10	Porosity (Visual Estimate):		
the parts	Carl 1		Intergranular:		
Cni	fd fillin		Secondary:		
A MARTINE AND	and a second		Microfracture: minor		
		m I	Microporosity: common		
	Martin St.	SAN SA	Others:		

A massive, fine to medium to grained lithic arkose shows a framework consisting mainly of quartz, feldspars and rock fragments (chert, shale clasts, VRF, PRF, MRF etc.), minor mica and glauconitic are also present (image A). Platy and elongated grains are compacted parallel to bedding planes (image A). The poorly to moderately sorted, subangular to subrounded fabric is tight and non-porous because the primary pores are reduced by moderate compaction and further blocked by 16-18% clay matrix. Image B shows the early chlorite grain coating and later chlorite filling in the feldspar dissolved moldic pore?. Minor black org.+pyr. or bitumen? locally pugged the intergranular pores (image B).

Coolering Summers of Comeda	Mallip	OW 11 01 N		-11 200
Geological Survey of Canada	Well ID:	000-11-01-IN	ANAINO OBS WI	ELL 390
Sample ID: 41	Deptn:	148.00m		
Image A:			Composition	n: (visual estimate)
	Jane L		Croince	
sh cht		7 500	Grains:	25 27
MRF	N.C.	A here	Q%	2527
the second second	mica	stal.	F%	28-30
Cht		the set of	R%	40-42
Cnt, VRF	Dan Bar	A start	Others: 1-2% mi	ca, 1% glau,
	2000-9	2 min	Matrix:	16-18
mica	AN AN	S. F.	Rock Type:	
eho eho	1 m		Feldspa	thic Litharenite
fd			Texture	_
sh	mica	ALK A	Grain size	very fine to coarse
	15 9	March -	Sorting:	poorly
ta t	at the	ch	Roundness:	subangsubroun.
CARDEN AND A LANCE	CANS DA	start and	Fabric:	grain supported
the second s	The first	a con		
	FR	L. MY	Structure	
500um cht	Mar and	(Alar	ı	Massive
fd_o_	and and a	hyper		
			Authigenic Com	ponents
Image B				
	chl	Contraction of the second	Cements (Pore I	illings):
the second se		A CONTRACTOR	Chlorite	common
The matrix to be a first of the	M in	fd overh	Qtz ovgh	tr
	Contraction of the second s	la ovgn	, ,	u
	A 18	ia ovgn	Feldspar ovgh	tr
	all the		Feldspar ovgh Calcite	tr
qtz ovgh			Feldspar ovgh Calcite Organic matter	tr 0.5
qtz ovgh-		I I I I I I I I I I I I I I I I I I I	Feldspar ovgh Calcite Organic matter Pyrite	tr 0.5 0.5
qtz ovgh-		ing ovgin	Feldspar ovgh Calcite Organic matter Pyrite Replacement	tr 0.5 0.5
qtz, ovgh		S	Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2	tr 0.5 0.5
qtz ovgh		ing over	Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite	tr 0.5 0.5 tr
qtz ovgh		In orgin	Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite	tr 0.5 0.5 tr
qtz ovgh qtz ovgh Org.+pyts		in orgin	Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite Pyrite	tr 0.5 0.5 tr 1.5
qtz ovgh qtz ovgh org.+pyp. fd:ovgh		Ing over	Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite Pyrite Porosity (Visual	tr 0.5 0.5 tr 1.5 Estimate):
qtz ovgh qtz ovgh org.+pyr. fd:ovgh		In order	Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite Pyrite Porosity (Visual	tr 0.5 0.5 tr <u>1.5</u> Estimate):
qtz ovgh qtz ovgh org.+pyx fd:ovgh		In organization of the second s	Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite Pyrite Porosity (Visual Intergranular:	tr 0.5 0.5 tr 1.5 Estimate):
qtz ovgh qtz ovgh dt ovgh fd ovgh		In organization of the second se	Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite Pyrite Porosity (Visual Intergranular: Secondary:	tr 0.5 0.5 tr 1.5 Estimate):
qtz ovgh qtz ovgh fdrovgh fdrovgh		I'u ovgr	Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite Pyrite Porosity (Visual Intergranular: Secondary: Fracture:	tr 0.5 0.5 tr <u>1.5</u> Estimate):
dts ovgh dts ovgh dts ovgh dto vgh			Feldspar ovgh Calcite Organic matter Pyrite Replacement SiO2 Chlorite Calcite Pyrite Porosity (Visual Intergranular: Secondary: Fracture: Microporosity:	tr 0.5 0.5 tr <u>1.5</u> Estimate):

Image A is an overview of a massive, very fine to coarse grained feldspathic litharenite with a grain-supported, nonporous fabric. The poorly sorted, subangular to subrounded framework grains, size ranging from very fine (50um) to coarse sand (1700um), consist mainly of rock fragments (chert, shale clasts, VRF, PRF, MRF etc.) with subequal amounts of quartz and feldspars. The original primary pores are reduced by moderate compaction and further blocked by 16-18% clay matrix. Image B shows the early diagenetic phases: chlorite lining pores and followed by feldspar and quartz overgrowth. Later stage organic matter (bitumen?) plugged remaining pore spaces (image B). Microporosity are abundant and exist in the clay minerals.

Description of Thin Section Photomicrograph				
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WE	ELL 390
Sample ID: 42	Depth:	144.92m		
Image A:			Composition	n: (visual estimate)
	- Port	A MAR		(,
			Grains:	
9.010 P		1. A	Q%	60-63
	THE NE		F%	10-12
		Chief and	R%	20-22
A REAL PROPERTY AND AND			Others: 2-3% mi	ca, trace glau,
and the second of the second of the	-	- AL	Matrix:	27-30
the second second parts of	100	1	Rock Type:	
	mica	No.	Sublitha	arenite
	- AND	the state	Texture	
org.?		2	Grain size	silt to very fine
	- Carter	and the way	Sorting:	well-very well
	A TAN	Contraction of the	Roundness:	subangsubroun.
(Jong)	A		Fabric:	grain supported
	-	200		
A REAL PROPERTY OF THE REAL PR	THE	Sec. and	Structure	
250um	mica		Massiv	ve, laminated
mica	A DO	See 1		
	1 Can	A - Salar	Authigenic Com	ponents
Image B				
		All Providence	Cements (Pore F	illings):
វៅថ្ងៃ ទោ ចរាច	m		Chlorite	common
	The second	Standard and all all all	Qtz ovgh	
		and P	Feldspar ovgh	
ero - Coro	or bitm	and and	Calcite	
	- Bart	nt	Organic matter	16-18
org or bitm	C. S. State	and the second second	Pyrite	2
chi		and a second	Replacement	
and the second		AN FO	SiO2	
A A A A A A A A A A A A A A A A A A A	2 Y	32 6	Chlorite	tr
	17		Calcite	
chl	the life	A Star	Pvrite	1
	and the second	6	Porosity (Visual	Estimate):
States and a second	AND LE	and the second		
	1	chi	Intergranular [.]	
	anos de	A LA SUMMER C	Secondary:	
50um			Fracture	
CARLES THE	a shall		Microporosity:	common
	Constant of the	TO BE	Others:	Common
	The second second	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	others:	

A silt to very fine grained sublitharenite shows an overall massive texture with clay-rich and organic matter-rich laminae. The framework grains are subangular to subrounded, well to very well sorted, consisting mainly of quartz with lesser amounts of rock fragments (chert, shale clasts, VRF, etc.) and feldspars. This sample contains 27-30% clay matrix and 16-18% organic matter (bitumen?) which blocked interstitial pore spaces (image A), indicated by tight, non-porous fabric. Image B shows the early authigenic chlorite coating grain surfaces (image B). Abundant black organic matter (bitumen?) mixed with pyrite occurred as thin strips parallel to bedding planes (image B). Microporosity is abundant and exist in the clay minerals.

Description of Thin Section Photomicrograph				
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WE	ELL 390
Sample ID: 43	Depth:	139.00m		
Image A:			Composition	v (visual estimate)
		TAYS	composition	(tibual cottinate)
	1 miles	- Andrew	Grains:	
	K	The sa	Q%	45-48
sh	ST	A State	F%	18-20
	12.1	cht	R%	25-28
		3	Others: 2-3% mi	ca, trace glau,
	CAL P	The start	Matrix:	19-22
		bitm?	Rock Type:	
Sh	Charles	2 23	Feldspa	thic Litharenite
fd	4		Texture	
A CALLER AND A CALLER OF	A	VYL MAG	Grain size	very fine -fine
VRE	The states		Sorting:	moderate to well
	Start Start	ALT	Roundness:	subangsubroun.
fd	1	SI	Fabric:	grain supported
cht		1000		
The second se		C. The	Structure	
250um	The -	1. 1.	Massiv	ve, burrowed
A REAL PROPERTY AND A REAL	N. S			
	and a start	the sames	Authigenic Com	ponents
Image B				
		Sale in	Cements (Pore F	illings):
met a strike	No. 14	SOK:	Chlorite	common
chl		A X	Qtz ovgh	tr
	-	1. 1 - ta	Feldspar ovgh	tr
CAR ELANA	- deni	17 - P	Feldspar filling	minor
	7 21		Calcite	tr
Y I I		it man	Organic matter	16-18
	Fa	filling	Pyrite	2
a contraction of the second seco		a and a second	Replacement	
fd augh org?-	大学院	my 1 4	Chlorite	tr
IU OVGII	Josh A	PALL -	Calcite	tr
		CAR!	Pyrite	1
org?	A BA	-	Porosity (Visual	Estimate):
		A. J. A. T.		
chi	. At	200	Intergranular:	
		22.20	Secondary:	
250um	#	Section .	Fracture:	
The second with the second	No.		Microporosity:	common
		STRAM.	Others:	

A very fine to fine grained feldspathic litharenite shows an overall massive texture slightly disturbed by burrows. Subangular to subrounded, moderate to well sorted framework consist mainly of quartz with lesser amounts of rock fragments (chert, shale clasts, VRF, etc.) and feldspars. This sample contains 19-22% clay matrix which blocked interstitial pore spaces (image A), resulting in a tight, non-porous fabric. Image B shows major diagenesis sequences: chlorite lining pores - feldspar overgrowth- feldspar filling - calcite filing - later stage organic matter (bitumen?) filling (image B).

Description of Thin	1 Section Ph	otomicrograp	bh
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WELL 390
Sample ID: 44	Depth:	135.58m	
Image A:	4 (0)2 × 0 × 0 ×		Composition: (visual estimate)
and the second	TEN AL		
руга	and with		Grains:
A Construction of the second	Sec. 1		Q%
The second s	and the states	A States Aug	F% 25-30
	A Low And And		
		Sector Sector	Others: 3-5% milda, 0.5-1% glau,
			ROCK Type: Silty Shalo
e			
		and the second second	
The second s		and the second	Sorting.
	Sale St		Soluting. Roundness:
	Contraction of the second	SUPPORT STATE	Fahric
burrow	5 AL	CARE C	
of the second	Arth		Structure
500um	burrow	A Designed	Massive. burrowed
and the second s	A State	Mar and	
		y de	Authigenic Components
Image B			
and the second		Contraction of the	Cements (Pore Fillings):
	AL CA		Chlorite
	aret to	and the second second	Qtz ovgh
	orgep	yu ana	Feldspar ovgh
	-	ALC: NO	Feldspar filling
	Market	10000	Calcite
	在 外型		Organic matter 5-6
OFFICIENT	Sec. 1	100	Pyrite 0.5-1
oliachan	C. R. Leije	Ser Car	Replacement
ottono	VP	100	Chlorite
	10		Calcite
			Pyrite 0.5
	A STOR	Mar Mar	Porosity (Visual Estimate):
	Star Print	San De	
	ig+pyr		Intergranular:
			Secondary:
	and the second		Fracture:
			Microporosity: common
	A BARRENT B		Others:

Image A is an overview of silty shale with a massive texture locally disturber by burrows . Cleaner, coarser and quartzrich sands are found in burrows (image A). Total about 25-30% silts are floating in the clay matrix, consist mainly of quartz, feldspars and lesser chert, shale clasts. Pyrite appeared as black spots scattered in the sample (image A). Image B shows dark brown to black organic matter (or bitumen?) mixed with pyrite filled borrows which are porous due to bioturbating (image B). Locally organic matter occurred as thin strips paralleling to bedding plane.

Description of Thin Section Photomicrograph					
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WE	ELL 390	
Sample ID: 45	Depth:	127.50m			
Image A:			Composition	v (visual estimate)	
A REAL PROPERTY	-	No.			
		A BOOT	Grains:		
SII CHI MRF	1. C. (2)	M here	Q%	27-28	
A MAN MARKER		AT.	F%	28-32	
cht	miča	A A A A	R%	35-37	
cht VDF		1.1.2	Others: 2-3% mi	ca, 1% glau,	
	Jar 4	2 Sent	Matrix:	10-12	
mica	A. A.		Rock Type:		
	240	St You	Feldspa	thic Litharenite	
sho		the de	Texture		
sh	1 431	A BA	Grain size	very fine to coarse	
	mica	March .	Sorting:	poorly	
fd	PA DA	A Ca	Roundness:	subang.	
A REAL AND A REAL	and C	sh	Fabric:	grain supported	
the second second second second	the for				
State of the cards	Row	CANY	Structure		
500um cht	the state	2 Alter	1	Massive	
fd_o_	and and a	hugens			
		the second	Authigenic Com	ponents	
Image B					
	abl	the second	Cements (Pore F	illings):	
And the second second second		A STA	Chlorite	common	
	A in	fd ovgh	Qtz ovgh	tr	
	e ca	C.C.A.	Feldspar ovgh	tr	
	Part of	Tax to A.	Calcite		
atz ovgh-	and the	Mar Arth	Organic matter	1-2	
2 A CAR AND A CA	A CALLER OF	a cho	Pyrite	0.5-1.0	
		416-	Replacement		
atz ovah		we have	Chlorite	tr	
		ALSIS	Calcite		
		The state	Pyrite	0.5	
org.+pyr		141			
fdtovgh			Porosity (Visual	Estimate):	
and the second of	C	Y with the		·	
	P Ast	L. Carles	Intergranular:		
C. ANDER C. S.	A SP		Secondary:		
160um chi	- John	1 minute	, Fracture:		
	All Mar	h Ship	Microporosity:	common	
The second second	Provent in	X	Others:	-	

A massive, very fine to coarse grained feldspathic litharenite with a grain-supported, non-porous fabric (image A). The poorly sorted, subangular framework grains, size ranging from very fine (50um) to coarse sand (1200um), consist mainly of rock fragments (chert, shale clasts, VRF, PRF, MRF etc.) with subequal amounts of quartz and feldspars (image A). The original primary pores are reduced by moderate compaction and further blocked by 10-12% clay matrix. Image B shows the early diagenetic phases: chlorite lining pores and followed by feldspar and quartz overgrowth. Later stage organic matter (bitumen?) plugged remaining pore spaces (image B). Microporosity are abundant and exist in the clay minerals.

Description of Thin Section Photomicrograph				
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WE	ELL 390
Sample ID: 46	Depth:	122.50m		
Image A:	R		Composition	n: (visual estimate)
(d)	2 miles			22.25
	AA	ALL T	Q%	22-22 20 20
Trans Mathing Tomos	A MA	Sich	F 70	29-30
BRF		and Dear	R70	30-32
	110		Others: 2-3% mi	ca, 0.5-1% giau,
MRP	C.A.	VRF		5-7
Achieven	T	AUN	Rock Type:	
Sin glau	of the second	1233	Feldspa	thic Litharenite
	M. Com	cht	Texture	a
A Province A	cht		Grain size	fine to coarse
Contraction of the second	1 Star	7 X	Sorting:	poorly-moderaterly
fd	Hand a	and the second	Roundness:	subang.
and the second s	N BRO	Car a Car ha	Fabric:	grain supported
	Chan -	7 5	Structure	
500um	ch	TTT (1	Massive
	1 the set	K N	Authigenic Com	ponents
Image B	S.		Cements (Pore I Chlorite	Fillings): common
ALL AND .	70.14		Qtz ovgh Feldspar ovgh	
cal			Calcite	10-12
chi	Sec.	and the second	Organic matter	1-2
You and a second second second	1.1	1. 2	Pyrite	0.5
Cliftoby.		And the second	Replacement	
A BROWN AND AND AND AND AND AND AND AND AND AN		cal	Chlorite	tr
	a si	they t	Calcite	-
chi and a set of the s	*	13.0	Pyrite	1
	Land	a specific	Porosity (Visual	Estimate):
A STO	1	and the second	Intergranular: Secondary:	
Tohn	S. S. Carlo		Fracture:	
	the second se	e	Microporosity:	common
Carl Carl	28.20	Constant 24	Others:	

This fine to coarse grained feldspathic litharenite exhibits a grain-supported, calcite-cemented, non-porous fabric, consisting of subequal amounts of quartz, feldspars and rock fragments (chert, shale clasts, VRF, PRF, MRF etc.) (image A). The subangular framework grains are poorly to moderately sorted, size ranging from fine (60um) to coarse sand (1500um). Minor matrix clay (5-7%) and 10-12% calcite cement occluded the original primary pores. Image B shows intergranular pore were first lined with chlorite rims and filled by calcite cement, remaining pore spaces were further plugged by later stage organic matter (bitumen?). The centre of the image B displays the organic matter also filled secondary dissolution pores within unstable feldspar or VRF grains (image B).

Description of Thin Section Photomicrograph				
Geological Survey of Canada	Well ID:	OW-11-01-N	NANAIMO OBS W	/ELL 390
Sample ID: 48	Depth:	106.67		
Image A:		A	Compositio	n: (visual estimate)
The Arters	Char ist ?	AL S	0%	48-50
VRF	TER	The first	F%	25-26
North Area States and States	Mary Con	Real C	R%	20-21
	fd	A Property of the second se	Others: 2-3% m	nica 0 5-1% glau
	A CONT	A starter	Matrix:	3-5
fd	2008	ZAL MAG	Rock Type	5.5
	sh		Lithic	Arkose
cal	the total	cal	Texture	
Y WARRANT	The second secon	JA A	Grain size	fine to coarse
	fd	K - it	Sorting	noorly
L'AND AND WILL	and the second	omi,	Boundness:	subang
A PART A PART	2 2	And Mark	Fabric:	grain sunnorted
cal and been	6-6-5			Sign supported
250um	SI	mate	Structure	
fd	STOP 5	AT CAR		Massive
And the second of the		DA ATT	2	
			Authigenic Con	nponents
Image B	No. di la		Cements (Pore	Fillings):
	· ~ ~		Chlorite	common
			Otz ovgh	
	1		Feldspar ovgh	
fd ovg	h		Calcite	15-16
	and the second	the second	Organic matter	1
	AL AL		Pvrite	1.5
		and the second	Replacement	210
cal		Bar in der	Chlorite	tr
cal	A Prove		Calcite	2-3
cal	and the state	a A	Pyrite	1
			i ynte	
			Porosity (Visua	l Estimate):
				,
			Intergranular:	
cel 🔪	Contraction of the second	all	Secondary:	
30069			Fracture:	
	A State		-	
	1 . S. S. S.		Microporosity:	common
			Microporosity: Others:	common

Image A shows a massive, fine to coarse grained lithic arkose is similar to sample 46 in texture and fabric, but contains more quartz and lesser feldspars and rock fragments (chert, shale clasts, VRF etc.). The subangular framework grains are poorly sorted, size ranging from very fine (50um) to coarse sand (1100um). Grain-supported fabric is tight and non-porous due to extensive calcite cementation. Image B shows calcite cement (Cal) occluding intergranular pore spaces after feldspar and quartz overgrowth. Note calcite also filled secondary porosity (sp) within some unstable grains (feldspar, VRF) or moldic pores from dissolution (image B).

Coological Survey of Canada		
Geological Survey of Canada	Well ID:	
Sample ID: 50	Deptn:	100.67m
Image A:		Composition: (visual estimate)
cht	and the second	Grains:
A STATE AND A STATE	sh	Q% 36-38
	VRF	F% 31-32
	A Contraction	R% 26-28
	Ser St	Others: 1% mica, trace: glau,
She She	at the second	Matrix: 18-19
	· PRAN	Rock Type:
cht glau		Lithic Arkose
The state of the state	fd	Texture
Sold Prover States	A Lot	Grain size fine to coarse
PRE AND A REAL PRE	- And	Sorting: poorly
		Roundness: subangsubroun.
mica	BIO	Fabric: grain supported
A A A A A A A A A A A A A A A A A A A	fd	Structure
500um		Massive
and the second s	ANT IN	A THE
	THE REAL	Authigenic Components
Image B		
	Che Of	Cements (Pore Fillings):
	A NEW	Chlorite common
fd ovgh		Qtz ovgh tr
A CONTRACTOR		Feldspar ovgh 0.5-1
Tygetgro	a when	Calcite
OTOL: TOTOL: TOTOC		Organic matter 0.5-1
fd ovgh		Pyrite 0.5
		Replacement
chi	The second	SiO2
		Chlorite tr
Contraction of the second	fd ovgh	Calcite
the second second		Pyrite 2
	1 Starl	Porosity (Visual Estimate):
and the second s		Intergranular:
And	AN A COMPANY STREET, ST	Canadamu
the second se		Secondary:
100um chi	chi	Fracture:
100um chi	chi	Fracture: Microporosity: common
100um chi	chi	Fracture: Microporosity: common Others:

Image A is an overview of a massive, non-porous, fine to coarse grained lithic arkose. Grain-supported fabric is poorly sorted. Grains are subangular to subrounded, size ranging from very fine (50um) to coarse sand (2000um), consist mainly of quartz, feldspar and rock fragments (chert, shale clasts, VRF, etc.) (image A). The original primary pores are reduced by moderate compaction and further blocked by 18-19% clay matrix. Image B shows major diagenesis sequences: chlorite (chl) lining pores - feldspar overgrowth (fd ovgh)- chlorite filling - later stage organic matter (bitumen?) filling (image B). Note organic matter (bitumen?) also filled the dissolution pores within a feldspar grain (image B).

Description of Thin Section Photomicrograph					
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WE	ELL 390	
Sample ID: 51	Depth:	96.00m			
Image A:	25.00 FE		Composition	: (visual estimate)	
	时代	147- J-			
	Carlos B.	28	Grains:		
	and the	fd	Q%	50-52	
	3		F%	23-25	
	FA.	A A	R%	15-18	
	the same	2165	Others: 5-6% mi	ca, trace glau,	
			Matrix:	25-26	
A Subsection of the second	这一个		Rock Type:		
fd	and and		Lithic A	rkose	
sh	- Japp	and a	Texture		
RADE AND AND AND		1 22	Grain size	very fine-fine	
A PARTY AND A PART	A LAN		Sorting:	moderately well	
A GAY		and a	Roundness:	subangsubroun.	
	A State	Ang	Fabric:	grain supported	
a fel and the second	the state				
the second s	The states		Structure		
250um	T.	1	Massive	e, bioturbated	
	to the second	1	Authigenic Com	ponents	
Image B				-	
and a state of the	4 All	HE LAK	Cements (Pore F	illings):	
and the second s	and the second	6	Chlorite	common	
and the The stand " have	法を一次に		Qtz ovgh	tr	
fol	the t	EPART .	Feldspar ovgh	tr	
PERSONAL PROPERTY OF THE PROPE		cht	Calcite		
chi	K.	CALLS STORY	Organic matter	5-6	
	Contraction of the second	all	Pyrite	1	
chi the second se		chi			
	chi	TEN	Replacement		
erg		2000	Chlorite	tr	
org 4	where the	And it	Calcite		
			Pyrite	2	
The state of the second	> C		Porosity (Visual	Estimate):	
	CIII V	chi			
Letter and the second	1237	Y Let	Intergranular:		
and the second s	THEN	and to	Secondary:		
the second se	So fee	the Martin	Fracture:		
	Ser.	the state of	Microporosity:	common	
	ALL R	and the second second	Others:		

A very fine to fine grained lithic arkose shows an overall massive texture combined with bioturbated structure, indicated by rotated sand grains and rip-up shale clasts (image A). Moderately well sorted framework grains are subangular to subrounded, consist mainly of quartz with lesser amounts of rock fragments (chert, shale clasts, VRF, etc.) and feldspars. The 25-26% clay matrix and 5-6% organic matter (bitumen?) had blocked interstitial pore spaces (image A), and formed a tight, non-porous fabric. Image B shows the early authigenic chlorite (chl) coating grain surfaces (image B). Abundant black organic matter (bitumen?) mixed with pyrite occurred as thin strips paralleling to bedding planes (image B). Microporosity are abundant and exist in the clay minerals.

Description of Thin Section Photomicrograph				
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS W	ELL 390
Sample ID: 52	Depth:	89.50m		
Image A:			Composition Grains:	n: (visual estimate)
fd	A Cart		Q%	28-30
		and the	F%	26-27
cht	ANCE		R%	38-40
A A A A A A A A A A A A A A A A A A A	Free Carton	C. S.	Others: 2% mica	a, trace glau,
	cht	States 1	Matrix:	18-19
	Classing	act of	Rock Type:	
org	the the	ava	Feldspa	thic Litharenite
A CARA	P-200	sh	Texture	
	A It's	HAR.F	Grain size	medium-coarse
cht Cht	A COMPANY	pr the	Sorting:	poorly-moderately
org	Cht	K.	Roundness:	subangsubroun.
VRF	sh		Fabric:	grain supported
	FOR P	5700		
	A CARE	574	Structure	
cht	Date State			Massive
A A A A	A A	2 × 1	Authigenic Com	ponents
Image B		10.0	Cements (Pore	Fillings):
	-	Sector State	Chlorite	common
			Otz ovgh	tr
			Feldsnar ovøh	tr
			Feldspar filling	
Cal Cal	A CON		Calcite	1
	And a state		Organic matter	1
	A A M		Pvrite	0.5
qtz ovgh			Replacement	
		2	Chlorite	tr
cal		1100	Calcite	0.5
	cal		Pyrite	1-2
Color March Color	1 And Nor		Porosity (Visual	Estimate):
	C. A.S.			·
		A State	Intergranular:	
and the second sec		States 1	Secondary:	
100um matrix	MAR SAN		Fracture:	
	A.C.	Aller I.	Microporosity:	common
	A Partie		Others:	

Image A is an overview of a massive, medium to coarse grained feldspathic litharenite with a grain-supported, nonporous fabric. The poorly - moderately sorted, subangular to subrounded framework grains, size ranging from very fine (50um) to coarse sand (1600um), consist mainly of rock fragments (chert, shale clasts, VRF, PRF, MRF etc.) with subequal amounts of quartz and feldspars. The original primary pores are reduced by moderate compaction and further blocked by 18-19% clay matrix. Image B shows calcite cement (Cal) locally occluding intergranular pore spaces after feldspar overgrowth. Note calcite also filled secondary porosity (sp) within some unstable grains (feldspar, VRF) (image B). Abundant clay matrix plugged majority pore spaces (image B).

Description of Thin Section Photomicrograph				
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WI	ELL 390
Sample ID: 53	Depth:	78.50m		
Image A:			Compositior Grains:	n: (visual estimate)
and the second of the second o	1 × 12:		Q%	38-40
A A A A		Contra	F%	25-26
CRI	i Gui		R%	29-30
sh		cht	Others: 3-4% mi	ca, 0.5-1% glau,
			Matrix:	15-17
Der hand to a	-	- APTS	Rock Type:	
Sh	E C		Feldspa	thic Litharenite
		Sec. 1	Texture	
			Grain size	fine to medium
fd	Contract in	The Ar	Sorting:	moderaterly
			Roundness:	subrounded
sh	and the second	CO 100	Fabric:	grain supported
		A CO		
A state of the sta	- Alt	E	Structure	
250um	10	i de	1	Massive
AND A PARAMAN	-	State	Authigenic Com	ponents
Image B			Cements (Pore F	Fillings):
and the state of		A CONTRACTOR	Otzovah	tr
	-C MI		Qlz Ovgi Foldspar ovgh	0 5 1
	2hh		Feldspar Ovgil	0.5-1
All courts		The second		1
cal h	CAL ROOM	0	Organic matter	
		and the second	Durito	0.5-1
		1 pm	Pyrile	T
cal		and the	Chlorito	+-
			Chlorite	1
cal		1	Calcile	
	and the second	Cherry Contraction	Pyrite Dorosity (Visual	U.J-1
	THE REAL		Porosity (visual	Estimate):
Martin Pills .	1	1.	Intergranular:	
fd ovgh			Secondary:	
	- 5 STZ	A Real Provide State	Fracture:	
			Microporosity:	common
	No. AND		Others:	

A massive, fine to medium grained feldspathic litharenite exhibits a grain-supported, tightly packed, non-porous fabric, The subrounded framework grains are moderately sorted, consisting mainly of quartz with subequal amounts of rock fragments (chert, shale clasts, VRF, PRF, MRF etc.) and feldspars (image A). The original primary pores are reduced by moderate compaction and further blocked by 15-17% clay matrix. Image B shows calcite (Cal) locally occluded intergranular pore spaces and also filled dissolution pores within feldspar and chert grains (image B). Note feldspar overgrowth developed on the grains.

Description of Thin Section Photomicrograph				
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WE	ELL 390
Sample ID: 55	Depth:	73.33m		
Image A:	X	0/4	Composition Grains:	ı: (visual estimate)
No. I have the second second		12 19 12	Q%	33-35
sh	2N	cht	F%	25-26
cht	A B	* LA	R%	35-37
and the second se	SA	atta.	Others: 1-2% mi	ca, 0.5-1% glau,
Org	A.T	the last	Matrix:	20-22
Call Martin		the way	Rock Type:	
		11.2	Feldspa	thic Litharenite
			Texture	
		San L	Grain size	fine to coarse
How And And And			Sorting:	poorly
cht		4 GAOR	Roundness:	subang.
Rand March March March	the .	Clark A	Fabric:	grain supported
	PRF	×		0 11
VRE	2	001	Structure	
250um org vrr	A.	12	Massive	e, bioturbated
	1 Car	ELM.	Authigenic Com	ponents
Image B			Cements (Pore F Chlorite Qtz ovgh	Fillings): common
				1
matrixclay			Organic matter	2 4
	and the	1	Diganic matter	5-4
metholic alexy			Pyrite	0.5
		and the state	Chlorito	+-
and the second is	Cal.		Chlorite	u O F
	1.2 Parts	and the second	Calcile	0.5
cal	cal		Pyrite	0.5
	ALL!	1	Porosity (Visual	Estimate):
methyday		ale -		
Construction of the second s		A AND	Intergranular:	
			Secondary:	
10000			Fracture:	
A CONTRACT OF A CONTRACT. OF A CONTRACT OF A		A CONTRACT OF A	Microporosity:	common
	and in	Se Ga	Others:	

A fine to coarse grained feldspathic litharenite shows an overall massive texture was disturbed by bioturbation (image A). The poorly sorted, subangular framework grains, consist of subequal amounts of quartz and rock fragments (chert, shale clasts, VRF, PRF, etc.) with lesser feldspars. The intergranular pores reduced by compaction and 20-22% clay matrix. Minor organic matter or (bitumen) filled dissolution pores within feldspar and VRF or remaining original pore spaces (image A), and formed a tight, non-porous fabric. Image B shows calcite (Cal) locally occluded intergranular pore spaces and also filled dissolution pores within feldspar grains (image B). Note abundant matrix clay between grains blocked primary pores.

Description of Thir	Description of Thin Section Photomicrograph					
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WE	LL 390		
Sample ID: 56	Depth:	68.50m				
Image A:	JA.		Composition Grains:	: (visual estimate)		
to the second seco		mica	0%	43-45		
mica	The second	A CARLE	F%	29-30		
A A A A A A A A A A A A A A A A A A A	· CALA	and a	R%	21-23		
chtt	and the second	0	Others: 1-2% mi	ca. trace: glau.		
VRF	fd.	12	Matrix:	28-30		
	ALC: N	Van A	Rock Type:			
	Carr	A CONTRACT	Lithic A	kose		
fill fill for	til start		Texture			
The second second			Grain size	very fine to fine		
A A A A A A A A A A A A A A A A A A A	- AL		Sorting:	moderaterly		
sh (d	A CARLES	室。行入之	Roundness:	subangsubroun.		
Sh	Contraction of		Fabric:	grain supported		
		To have				
	100	24.52	Structure			
250um	XX	13.3	Massiv	ve, laminated		
See Manage Brown where	- A -	A A	Authigenic Com	ponents		
Image B		1. Andread Street	o			
a find the second sta	AT The	Care and	Cements (Pore F	illings):		
	and a	and the state	Chionite Ota ouch	common		
chi	AL AL		Ql2 Ovgn	ur tr		
e parts density brook of	Se P		Feldspar ovgn Calcito	ur		
	3	3036	Organic matter	3-4		
1 and the second	An and		Pvrite	1		
gtz ovgh gtz ovg	jh	chi	Replacement	-		
matrix clay	and the second	PAR A	Chlorite	tr		
chi	april 6	The state	Calcite			
Contraction of the second s	1. St.		Pyrite	1		
	a la p		Porosity (Visual	Estimate):		
chi	1		Intergranular:			
A CONTRACTOR	ALL X	and the second	Secondary:			
50m	De?	A F CO	Fracture:			
chi			Microporosity: Others:	common		

A very fine to fine grained lithic arkose shows an overall massive texture with dark brown to black organic matter-rich laminae. The framework grains are subangular to subrounded, moderately sorted, consist mainly of quartz and feldspars with lesser rock fragments (chert, shale clasts, VRF, etc.). This sample contains 28-30% clay matrix and 3-4% organic matter (bitumen?) which blocked interstitial pore spaces (image A), indicated by tight, non-porous fabric. Image B shows the early diagenetic phases: chlorite lining pores and followed by quartz overgrowth. Later stage organic matter (bitumen?) plugged remaining pore spaces (image B). Microporosity are abundant and exist in the matrix clays.

Description of Thin Section Photomicrograph				
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WI	ELL 390
Sample ID: 57	Depth:	62.00m		
Image A:		A	Composition	n: (visual estimate)
			Grains:	20.40
	org+pyr		Q%	38-40
Org+pyr		N R	F%	33-35
			R%	22-23
fd and the second secon			Others: 1-2% mi	ca, trace: glau,
ord+bAt		CARE -	Matrix:	18-20
milea	184 M	1 mill	Rock Type:	
		A DE	Lithic A	rkose
	td	1317	Texture	
	lau	1 200	Grain size	fine to medium
	ar and	S. Che	Sorting:	moderately-well
			Roundness:	subang subroun.
	1 mak	AN	Fabric:	grain supported
JAN AND THE	HXXX	Ser ve		
	A.A.		Structure	
	Rd			Massive
		and a	Authigenic Com	ponents
Image B	4.0.59	the state of the state	Cements (Pore I	
Contraction of the		1. 16 2 5 6	Chlorite	common
All - Est - 1 far at 1	- Base		Otz ovgh	
to an a start of the start of the	14		Feldspar ovgh	
fdiovab			Calcite	
A CAA	No. F Pro	Z V	Organic matter	1
LAN / V MACA AN /		TO DAY	Pvrite	1.5-2
	1	- all	Replacement	
cr@obyg	1997 - A	THE REAL	Chlorite	tr
and the second second	org*pyr		Calcite	
chi			Pyrite	0.5
		chi	i ynte	0.5
	fdiovgh		Porosity (Visual	Estimate):
qtzoxgh grao	A State of			,
THE AND A THE P	A.F.		Intergranular:	
1	Relay.		Secondary:	
Chi	- Le		, Fracture:	
THE PARTY IS	New 1	201	Microporosity:	common
ALANDALA	「「		Others:	
	And and the second second	A STATE OF A	1	

Image A is an overview of a massive, fine to medium grained lithic arkose with a grain-supported, non-porous fabric. The moderately to well sorted, subangular to subrounded framework grains consist mainly of quartz and feldspars with lesser rock fragments (chert, shale clasts, VRF, etc.). No visible porosity was observed due to moderate compaction and 18-20% clay matrix. Image B shows major diagenesis sequences: chlorite (chl) lining pores - feldspar overgrowth (fd ovgh)- chlorite filling - later stage organic matter (bitumen?) filling (image B). Note organic matter (bitumen?) also filled the dissolution pores within a feldspar grain (image B).

Desc	ription of Thin Section P	notomicrograph		
Geological Survey of Canada	Well ID:	OW-11-01-NA	NAIMO OBS WI	ELL 390
Sample ID: 60	Depth:	47.75m		
Image A:	An L	A	Composition	n: (visual estimate)
CTARE THE	世界などの		Grains:	
ADAT AT STATE		Charles Contraction	2%	30-32
fd	fd	F	%	26-28
	No. 2 AND	-	8%	33-35
	Same	Cher of	Others: 2-3% mi	ca, 0.5-1% glau,
giau	ch		Matrix:	16-18
A TA KANA	State of the second sec	S PLATE	Rock Type:	
chí	A ALANTA	is the	Feldspa	thic Litharenite
Y AND S	VRF	A CONTRACT	exture	
SN	and a low	sh	Grain size	fine to medium
cht		S	Sorting:	poorly-moderately
	VE Contraction	F	Roundness:	subangsubroun.
	cht 🔪	C. C. F	abric:	grain supported
A PARTICIPACION	Partie and the	3. Yak		
ALC: A DE	and send	S	Structure	
250um	the A way		I	Massive
	A COM		uthigonic Com	nononts
Image B		SAT SAT	atingenie com	ponents
			Cements (Pore I	Fillings):
2 Charles Charles		Constant Con	Chlorite	common
	C.A. C. C. C.	C	Qtz ovgh	2
	chl	And product	eldspar ovgh	0.5-1
Contraction of the second second		Children Children	Calcite	
and the second sec	CAN LONG	C	Organic matter	1
org	DXXT	(The party of the	Pyrite	0.5-1
Contraction of		F	Replacement	
til the second second	(gro	- 12 M		
chi	A DAY - CAR	C C	Chlorite	tr
a state for an all	chl Pyr	C C C	Calcite	
ALS SALES	chl	F	Pyrite	1-1.5
A AR UN DECLAR	Real	P U	Porosity (Visual	Estimate):
经公司 化文化 子里子 小市 人				
and set in a set of			ntergranular:	
and the second s	A L	S	econdary:	
100000	A Day	F	racture:	
chi			Aicroporosity:	common
	the second second second	State 1	Others:	
	the second se	and the second se		

Image A is an overview of a massive, non-porous, fine to medium grained feldspathic litharenite. Grain-supported fabric is poorly to moderately sorted. Grains are subangular to subrounded, size ranging from very fine (50um) to coarse sand (1000um), consist of subequal amounts of quartz and rock fragments (chert, shale clasts, VRF, etc.) with lesser feldspar (image A). No visible porosity was observed due to compaction and abundant interstitial matrix clay (16-18%). Image B was taken under reflective lights, it displays that pyrite (with golden shinny dots) filled intergranular porosity from pore edges and followed by later stage organic matter (black) or (bitumen) in pore center (image B). Note extensive greenish chlorite (chl) coating.

Description of Thir	Description of Thin Section Photomicrograph				
Geological Survey of Canada	Well ID:	OW-11-01-N	ANAIMO OBS WI	ELL 390	
Sample ID: 62	Depth:	33m			
Image A:		1.20	Composition	n: (visual estimate)	
	104	A Para	Grains:		
A A A A A A A A A A A A A A A A A A A	CALLER	The ADAR	Q%	55-56	
la fd	NI	A A	F%	20-23	
AND	Jac-	THE I	R%	13-14	
fd	AL-R		Others: 5-6% mi	ca, trace glau,	
A CAR A CAR A	X De	SEI 3	Matrix:	15-16	
	12 Day	HALL Y	Rock Type:		
fd sh		A DET	Subarko	ose	
OFQ VRF	THEFE	VAL 2	Texture		
	Contraction of the second		Grain size	very fine-fine	
VI CONTRACTOR			Sorting:	poorly-moderately	
	2 Arry	A Trank	Roundness:	subangsubroun.	
28	and A	And the second	Fabric:	grain supported	
eile contraction of the second se	207				
glau	1 Kon	A ALA DA	Structure		
250um		Carl	Massiv	e, bioturbated	
	3 A Frank		Authigenic Com	ponents	
Image B					
	E. P. P.	A State	Cements (Pore I	illings):	
	and the		Chlorite	common	
A CONTRACTOR			Qtz ovgh	tr	
	and the second	2 Contraction	Feldspar ovgh	1	
	Atom	A ABA A	Calcite		
	A State	chl	Organic matter	1-2	
A. A	N. 423	A State	Pyrite	0.5-1	
	No. Sa	2			
chi			Replacement		
chi fd ovah			Chlorite	tr	
RANK C 12 1	and -	Tonin and	Calcite		
	1500		Pyrite	1	
	The state	The	Porosity (Visual	Estimate):	
the second secon	ALL!	C. Star			
ra, ovgn	the 1	The state	Intergranular:		
Chi		AND A	Secondary:		
100um	1 Acres		Fracture:		
	a star	18 month	Microporosity:	common	
qtz ovgn	and	- In - a	Others:		

A very fine to fine grained subarkose displays an overall massive texture locally with bioturbated structure (image A). The poorly to moderately sorted fabric is subangular to subrounded. Grain composition was characterized by 55-56% quartz with lesser feldspars and rock fragments (shale clasts, chert, VRF, etc.). The intergranular pores reduced by compaction and 15-16% clay matrix, and indicated by a tight, non-porous fabric. Image B shows that after the early chlorite (chl) coating grain(image B), feldspar and quartz overgrowth had locally developed (image B). Note considerable matrix clay plugged intergranular pores.

Description of Thin Section Photomicrograph				
Geological Survey of Canada Wo	ell ID:	OW-11-01-Na	ainamo OBS well	390
Sample ID: 63 De	epth:	30.5m		
Image A:	C d	が	Composition Grains:	n: (visual estimate)
TO CONCEPTY	the w	AL AL	Q%	45-46
	Ant Page	A A A	F%	18-20
MIRE CONTRACTOR		ht	R%	32-33
	the second	8 100	Others: 1% mica	. 0.5% glau.
	The second	A Car	Matrix:	10-12
a second and a second as	112	A	Rock Type:	-
A I A A A A A A A A A A A A A A A A A A	00		Feldspa	thic Litharenite
Cht VRF	37 ···	1111	Texture	
The the second	7	A strange	Grain size	medium-coarse
CARD CAL	-	the second	Sorting:	moderately
A MARCAN I	20	· July F	Roundness:	subangsubroun.
	and the	and the second	Fabric:	grain supported
A STATE	11	a star	Structure	
250um org or bitm? MRF		org or bitm?	I	Massive
	AN THE	75	Authigenic Com	ponents
Image B			Cements (Pore F	illings):
chl		A STATE A	Chlorite	abundant
			Qtz ovgh	tr
			Feldspar ovgh	tr
	100	- spone	Feldspar filling	
	and the second	Se Se	Calcite	0.5
CIII			Organic matter	1
sp	in the	1	Pyrite	2-3
	and the second		Replacement	
org or bitm	Section 2	L.A.	Chlorite	minor
	The state of the s		Calcite	0.5-1
The state of the s	1		Pyrite	1
org or bitm	g and	Fr	Porosity (Visual	Estimate):
1-2-11		ANT	Intergranular:	
SP SP		1 53	Secondary:	2-3
180uto	the state	Asis Trians	Fracture:	
A Proventing the second second	4		Microporosity:	common
	1-18-3	an array of the State	Others:	

Image A is an overview of a massive, medium to coarse grained feldsparthic litharenite. Grain composition was dominated by quartz and rock fragments (chert, shale clasts, VRF, PRF, MRF etc.) with lesser feldspars. Grain-supported, moderately sorted fabric was low mature in texture with 10-12% matrix clay. The original intergranular pores are not preserved. Image B is closer view showing minor secondary inter or intragranular pores with relict of chlorite thin rims, they are formed by the leaching of unstable grains (image B). Black organic matter or bitumen (image B) filled secondary porosity or lined pore walls and left some space open.
Description of Thin Section Photomicrograph						
Geological Survey of Canada	Well ID:	OW-11-01-NANAIMO OBS WELL 390				
Sample ID: 64	Depth:	26.25m				
Image A:	A A		Composition	: (visual estimate)		
MARKEN LA	TIP:	Post,	Grains:			
fd	A. Bert	North He	Q%	48-50		
	19-20-4		F%	25-27		
fd	Jan I	Charles .	R%	18-20		
	The second	OLO	Others: 3% mica	, 1% glau,		
Elo Elo	A	The mail	Matrix:	20-23		
	A Property	6 12	Rock Type:			
		And An	Lithic Arkose			
fd org	Thest	The same	Texture			
	247 1	ALC T	Grain size	very fine to fine		
sh	in	ASK.	Sorting:	well		
	any s	mica	Roundness:	subangu subroun.		
glau		Profest 1	Fabric:	grain supported		
	1014	AL-				
A CARLEN AND A CARLEN	10 m	A state	Structure			
250um		and the second	Massiv	e, Laminated		
	5	- Charles	Authigenic Com	ponents		
Image B						
CAP LEADER SAN	(mg		Cements (Pore Fillings):			
	N CH	Mr. F	Chlorite	common		
atz ovelb	T. A.A	C.C.	Qtz ovgh	tr		
	chi	10.58	Feldspar ovgh	tr		
	met l		Feldspar filling			
	Stalk	Prover -	Calcite			
		" The	Organic matter	1-2		
	- AL		Pyrite	1		
NO DEPENDENCE			Replacement			
chi			Chlorite	tr		
chi chi	qtz ovg		Calcite			
A DOWN	and the second second	+J.T.	Pyrite	1		
	C BOXY	- AL	Porosity (Visual	Estimate):		
	T	· Start				
	fd ovgh		Intergranular:			
chi		137-1	Secondary:			
100um	025	THE REC	Fracture:			
	11	a my	Microporosity:	common		
			Others:			

A massive, very fine to fine grained lithic arkose exhibits a grain-supported, tightly packed, non-porous fabric. The well sorted framework grains are subangular to subrounded, consisting mainly of quartz with subequal amounts of feldspars and rock fragments (chert, shale clasts, VRF, PRF, MRF etc.) (image A). The original primary pores are reduced by moderate compaction and further blocked by 20-23% clay matrix. Image B shows some early diagenetic phases: chlorite grain coating, quartz and feldspar overgrowths (image B) (image B). Note black organic matter mixed with pyrite between grains.

Description of Thin Section Photomicrograph							
Geological Survey of Canada	Well ID:	OW-11-01-N	W-11-01-NANAIMO OBS WELL 390				
Sample ID: 66	Depth:	19.42m					
Image A:	- bol	A A	Composition: (visual estimate) Grains:				
cht Cht	7 Fell	17/2	0%	45-47			
	A.L	- and	F%	22-23			
	silty sh	Org	R%	26-28			
VRF		A A A	Others: 1% mic	a, 0.5-1% glau,			
VRF		HO F	Matrix:	11-13			
and the second second	the second	-	Rock Type:	-			
- Pio		and the	Feldspathic Litharenite				
	sign to	SAL-	Texture				
A A A A A A A A A A A A A A A A A A A	A	This a	Grain size	medium to coarse			
giau	1 10	1	Sorting:	Moderately - well			
A A A A A A A A A A A A A A A A A A A	1	- 1	Roundness:	subrounded.			
		- la	Fabric:	grain supported			
men the set	glau			• · ·			
500um	183	A CAN	Structure				
A THE AL		2 5		Massive			
	2.7	the first state					
	27	1	Authigenic Con	nponents			
Image B	2.4		Authigenic Con	ponents			
Image B			Authigenic Con Cements (Pore	nponents Fillings):			
Image B			Authigenic Con Cements (Pore Chlorite	Fillings): abundant			
Image B			Authigenic Con Cements (Pore Chlorite Qtz ovgh	Fillings): abundant 0.5			
Image B org or bitm			Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh	Fillings): abundant 0.5 tr			
Image B org or bitm			Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite	Fillings): abundant 0.5 tr			
Image B			Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter	Fillings): abundant 0.5 tr 1			
Image B			Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite	Fillings): abundant 0.5 tr 1 2			
Image B		chi	Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement	Fillings): abundant 0.5 tr 1 2			
Image B chl org or bitm org or bitm		chi	Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement Chlorite	Fillings): abundant 0.5 tr 1 2 minor			
Image B		chi	Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement Chlorite Calcite	Fillings): abundant 0.5 tr 1 2 minor			
Image B		chi	Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement Chlorite Calcite Pyrite	Fillings): abundant 0.5 tr 1 2 minor 1			
Image B		chi	Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement Chlorite Calcite Pyrite	Fillings): abundant 0.5 tr 1 2 minor 1			
Image B		chi	Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement Chlorite Calcite Pyrite Pyrite	Fillings): abundant 0.5 tr 1 2 minor 1			
Image B		chi	Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement Chlorite Calcite Pyrite Pyrite	Fillings): abundant 0.5 tr 1 2 minor 1 1 Estimate):			
Image B		chi	Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement Chlorite Calcite Pyrite Porosity (Visua Intergranular:	Fillings): abundant 0.5 tr 1 2 minor 1 1 Estimate):			
Image B		chi	Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement Chlorite Calcite Pyrite Porosity (Visua Intergranular: Secondary:	Fillings): abundant 0.5 tr 1 2 minor 1 I Estimate):			
Image B		chi	Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement Chlorite Calcite Pyrite Porosity (Visua Intergranular: Secondary: Fracture:	Fillings): abundant 0.5 tr 1 2 minor 1 I Estimate): 1-1.5			
Image B		chi	Authigenic Con Cements (Pore Chlorite Qtz ovgh Feldspar ovgh Calcite Organic matter Pyrite Replacement Chlorite Calcite Pyrite Porosity (Visua Intergranular: Secondary: Fracture: Microporosity:	Fillings): abundant 0.5 tr 1 2 minor 1 Estimate): 1-1.5 common			

This massive, medium to coarse grained feldspathic litharenite was characterized by a significant amounts of feldspar and rock fragments (chert, shale clasts, VRF, PRF, MRF etc.). Grain-supported, moderately to well sorted fabric was low mature in texture with 11-13% matrix clay. The original intergranular pores are not preserved due to moderate compaction and considerable matrix clay. Image B is closer view showing secondary intragranular pores within grains or secondary intergranular pores between grains were the dissolution products of unstable grains (image B), they were partially occluded or completely filled by minor calcite and black organic matter or bitumen (image B). Note the greenish chlorite thin films cast grain shapes (image B).