Destruction of Reservoir Quality by Soil-Imprinting, Mannville Cutbank Sandstones, Lower Cretaceous, Claresholm Region, Southern Alberta

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Abstract

Pebbly channel sandstones of the Mannville Cutbank in southern Alberta have a distinctive character because of their bleached whitish range of colours as well as having common milky blue-green chert grains. These sandstones are important gas producers in the Claresholm, Parkland and High River areas, however, production is extremely variable as is the thickness of the sandstones. Another important factor influencing the quality and/or presence of production is the influence of soil imprinting on the sandstones. As determined by core examinations, paleosols here occur in two different associations: usually at the tops of fluvial channel sandstones, or less commonly as soily "off-channel" deposits.

<u>Facies descriptions for channels and paleosols</u>

1. Fluvial Channel Sand Facies

- med – coarse grained but often varies to fine or granular, commonly pebbly especially as small cms think interbed and dm to several dm-thick basal clast-supported pebble lags,
- quartz litharenite composition, often friable, mainly high-angle tabular cross-bedded
- commonly fining-up, locally even-grained, often with several dms to metres-thick fining-up "channel" cycles within one sand, local normally-graded beds
- typically capped by soils imprinted on the tops of the sand bodies (see below), locally soil-imprinted throughout
- typically poorly sorted, generally angular grains
- beige, milky-white, pale bleached colours, salt & pepper appearance common
- quartz-rich but with common to abundant lithic & chert grains. Rare glauconite, bitumen and mica, locally sideritic
- light & dark chert grains & pebbles, < 2 cm in size, often light blue-milky colours, local carbonaceous grains and leaf fragments
- often very clay-rich with white milky clays (kaolinites)
- erosive irregular basal contacts on underlying Jurassic Rierdon or Swift formations, common basal pebble lag deposits with shale, soil and coal clasts

- mineralogy from petrography: mainly chalcedonic chert (43% average) and also quartz (36%), lesser tripolitic chert (7%), cemented with quartz (5%) and kaolinite (3%) (see other minerals, percent details and averages in table below)
- 3 to 20% Ø, 0.1 to 1000 mD, highly variable from well to well. Typically 8% Ø & 5-10 mD.

Table 1. Fluvial Channel Sand Petrography

facies	channel	channel	channel	channel	channel	channel	channel	averages
position	basal	basal	lower	lower	middle	upper	upper	
Framework Grains								
Monocrystalline Quartz	52	11	34	42	42	32	41	36.3
Polycrystalline Quartz	2	1	1	1	2	1	2	1.4
Chalcedonic Chert	29	59	53	39	39	45	43	43.9
Tripolitic Chert (White)	3	14	6	8	4	12	4	7.3
Argillaceous Chert (Dark)	1	1			1		1	1.0
Alkali Feldspar								
Plagioclase Feldspar								
Clay-Rich Sedimentary Lithoclasts								
Qtz-Rich Sedimentary Lithoclasts	2	1	1	1		2	2	1.5
Dolomite Lithoclasts								
Metamorphic Lithoclasts								
Siderite Lithoclasts								
Phosphate								
Carbonaceous Material								
Muscovite								
Heavy Minerals	trace		trace					trace
Cements								
Quartz	9		1	3	6		5	4.8
Ferroan Calcite		trace						0 to trace
Ferroan Dolomite			2	1				1.5
Siderite		7		2	4	4	1	3.6
Barite								
Pore Lining Clay	trace		trace	1	trace		trace	trace to 1
Bitumen	trace							
Kaolinite	2	6	2	2	2	3	1	2.6
Pyrite	trace		trace	trace	trace	1	trace	trace

Matrix

Detrital Clay								

Texture

Grain Size	mL	mU-cU	mL-cL	fU-mU	fL-cL	mL-cL	mL-pbL	
Sorting	mod well	moderate	mod well	moderate	moderate	moderate	moderate	
Roundness	subang-subrnd	subang-subrnd	subang-subrnd	subang-subrnd	subang-subrnd	subang-subrnd	subang-subrnd	

Pore Types

Intergranular	main	minor	main	main	main		main	main
Secondary Dissolution								
Intragranular Microporosity	common	common	common	common	minor	main	minor	common
Clay Microporosity	minor	main	minor	minor	minor	main	minor	

Reservoir Quality

Thin Section (Effective) Porosity (%)	9	2	11	10	10	<1	13	9.1
Core (Total) Porosity (%)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
Permeability (Kmax-md)	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	
Reservoir Quality	Fair	Poor	Good	Good	Good	Poor	Good	usu good

2. Cutbank Paleosol Facies

- mixed homogenized (locally weakly-bedded) poorly-sorted variable grain sizes, generally fine to silt grain sizes, very clayey, locally medium-grained, rarely pebbly. Generally angular grains.
- white clay (kaolinite) matrix around all grains, very clayey
- beige, white, very pale bleached colours, locally reddish beige to brick-red, brown, also common mottled colours
- quartz-rich silcretes (quartz-cemented soils),
- roots, fractures, cracks (one occurrence of soily sand infill in a large crack), clayey peds, mudcracks, churned grain sizes, contorted bedding, nodular fabrics, “structureless” (i.e., lacks physical sedimentary bedding structures such as ripples, cross-beds, etc.)
- locally sideritic, spherulitic siderite (pisolites?), locally hematitic
- usually grades over a metre or more from channel sand facies below
- the soil fabrics such as fractures, slickensides, peds and drab colours may represent Vertisol and Gleysol soil types. The less well-developed soils here by definition would be termed Inceptisols (immature soils). Vertisols are common in modern tropical and subtropical regions

such as in India, sub-Saharan Africa, Mexico, Mississippi, California, Venezuela (Brady, 1974, 1990). Many of these regions are subject to strong seasonal and monsoonal conditions (Fanning and Fanning, 1989) providing the alternate wetting and drying periods and particle movement required for the development of Vertisols. Modern Gleysols develop in permanently waterlogged areas.

- mineralogy from petrography: mainly quartz (36% average), chalcedonic chert (30%) and also lesser tripolitic chert (4%), cemented with detrital clays (17%), siderite (10%), calcite (9%), dolomite (4%), kaolinite (2%) (see other minerals, percent details and averages in table below)
- porosities range from 1 to 6%, typically around 3%. Permeabilities are typically much less than 1 mD.

Table 2. Cutbank Soil Petrography

facies	soil	soil	soil	soil	soil	averages
position	off-channel facies	off-channel facies	top channel	top channel	top channel	
Framework Grains						
Monocrystalline Quartz	37	36	41	35	34	36.6
Polycrystalline Quartz	1	1	1	1	1	1.0
Chalcedonic Chert	32	25	40	21	33	30.2
Tripolitic Chert (White)	4	1	13	2	1	4.2
Argillaceous Chert (Dark)		3				
Alkali Feldspar						
Plagioclase Feldspar						
Clay-Rich Sedimentary Lithoclasts				3		3.0
Qtz-Rich Sedimentary Lithoclasts						
Dolomite Lithoclasts						
Metamorphic Lithoclasts						
Siderite Lithoclasts						
Phosphate						
Carbonaceous Material						
Muscovite				trace		trace
Heavy Minerals	trace	trace	trace	trace	trace	trace
Cements						
Quartz						
Ferroan Calcite					9	9.0
Ferroan Dolomite	4					4.0
Siderite	9			1	20	10.0
Barite						
Pore Lining Clay						

Bitumen						
Kaolinite			3	2	1	2.0
Pyrite		1	trace	trace	trace	
Matrix						
Detrital Clay	14	33	2	35	1	17.0
Texture						
Grain Size	fU-mU	vfU-mU	fU-mU	vfL-cU	vfL-mL	
Sorting	moderate	poor	moderate	very poor	poor	v poor-moderate
Roundness	subang-subrnd	subang-subrnd	subang-subrnd	subang-subrnd	subang-subrnd	
Pore Types						
Intergranular			minor			
Secondary Dissolution						
Intragranular Microporosity	minor	common	main	minor	minor	
Clay Microporosity	main	main	main	main	main	
Reservoir Quality						
Thin Section (Effective) Porosity (%)	<1	<1	2	<1	<1	<1
Core (Total) Porosity (%)	n.a.	n.a.	n.a.	n.a.	n.a.	
Permeability (Kmax-md)	n.a.	n.a.	n.a.	n.a.	n.a.	
Reservoir Quality	Poor	Poor	Poor	Poor	Poor	Poor

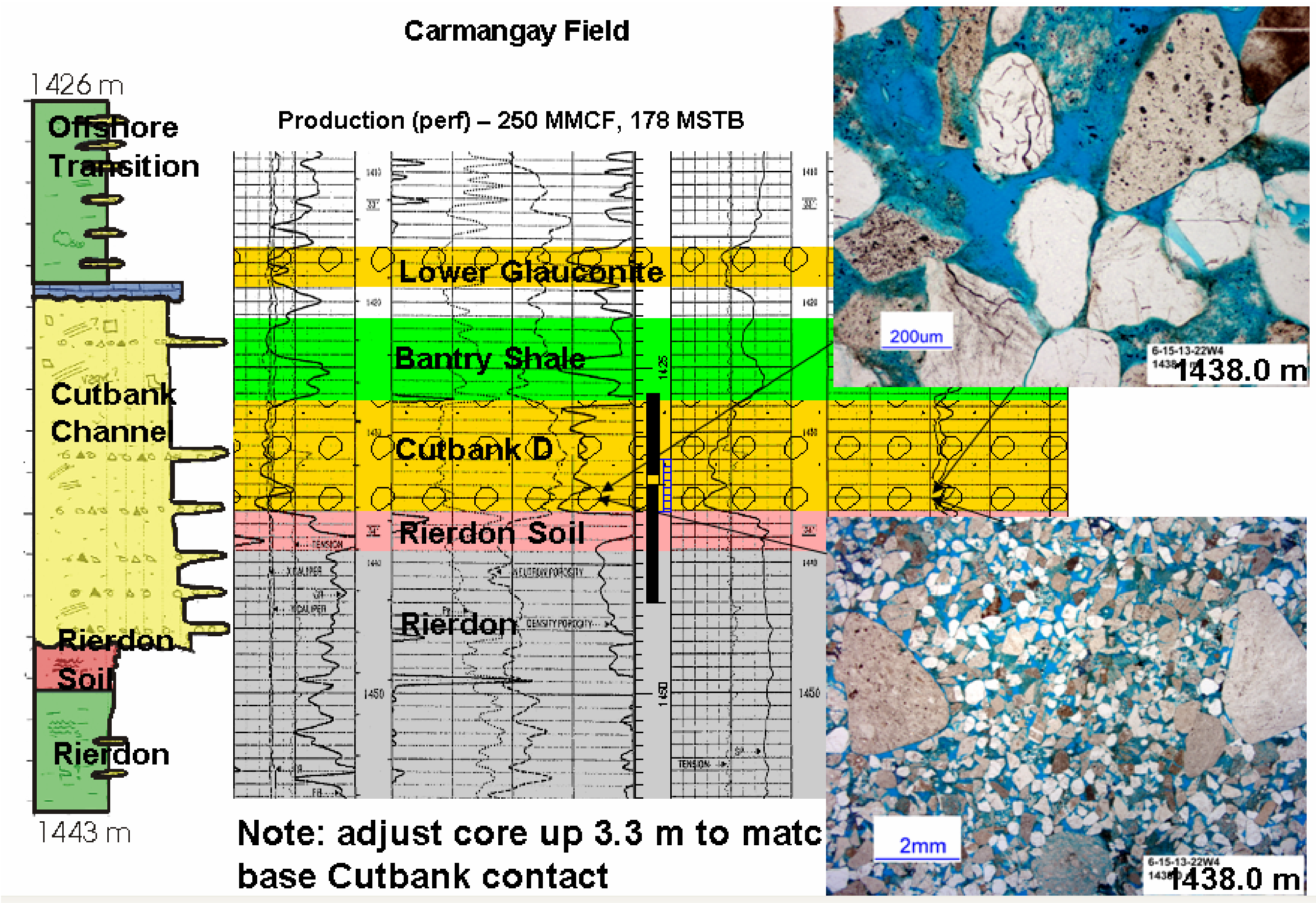

Figure 2. Core Log 06-15-13-22W4 of Cutbank channel sand facies with thin section photos taken from unaltered (non-soily) basal channel position characterised by coarse-grained to pebbly grain sizes as well as good porosity (blue colours).

Editors Note: Fig.2 is placed before Fig.1 by authors request.

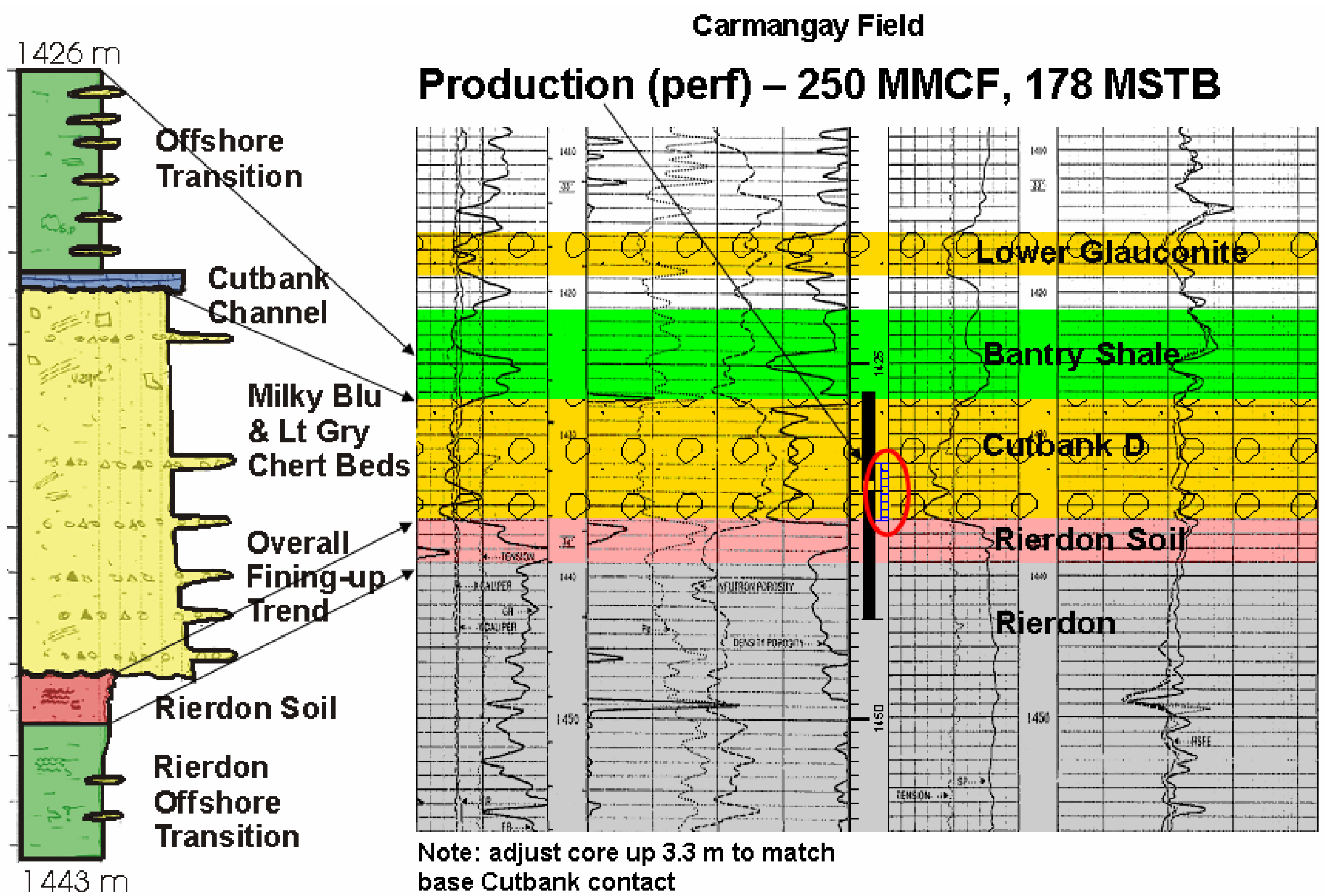

Figure 1. Core Log 06-15-13-22W4 of Cutbank channel sand facies with good porosity and good production.

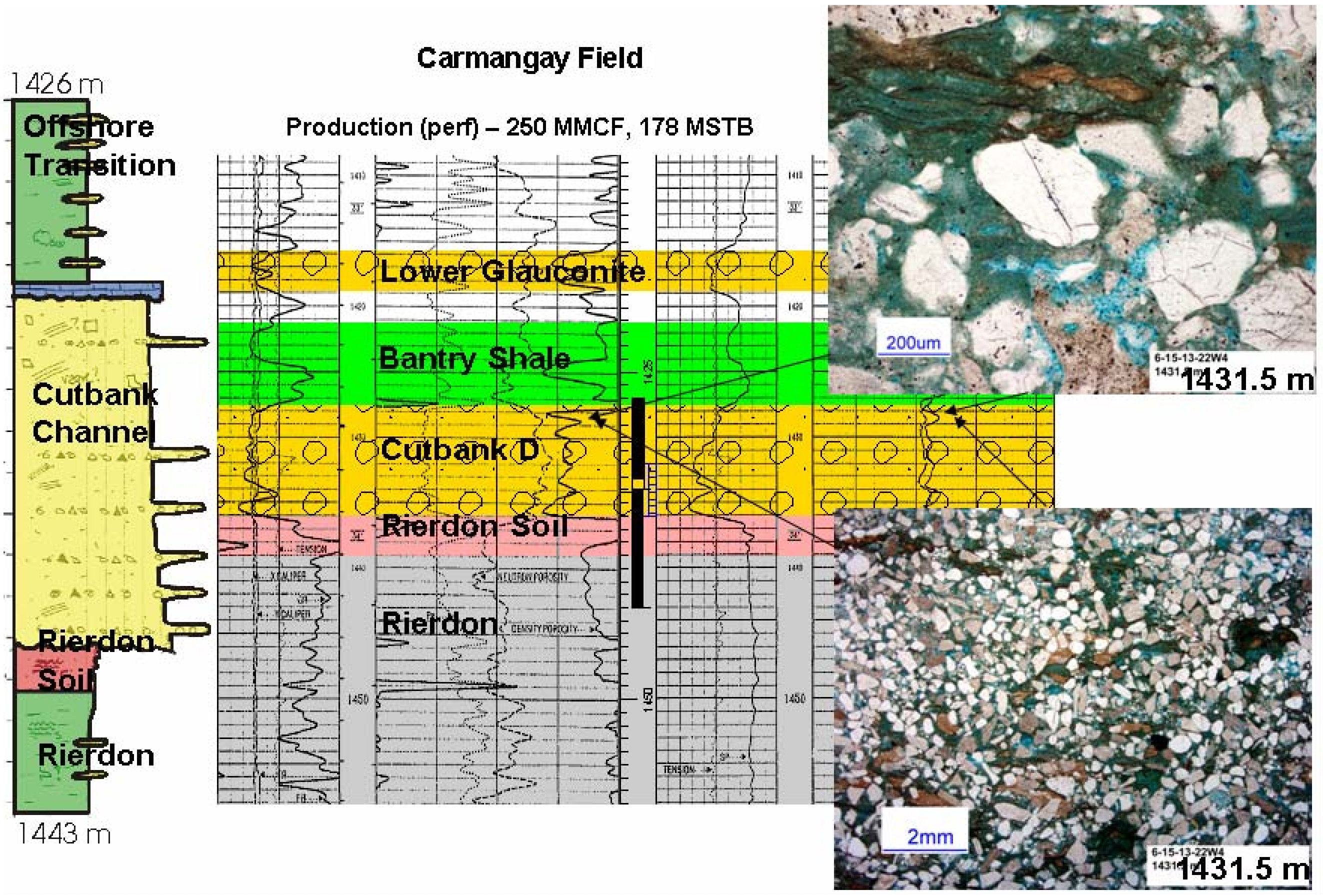

Figure 3. Core Log 06-15-13-22W4 of Cutbank channel sand facies with thin section photos taken from top channel position that is lightly soil-imprinted. Note finer grain sizes and modest porosity (blue colours).

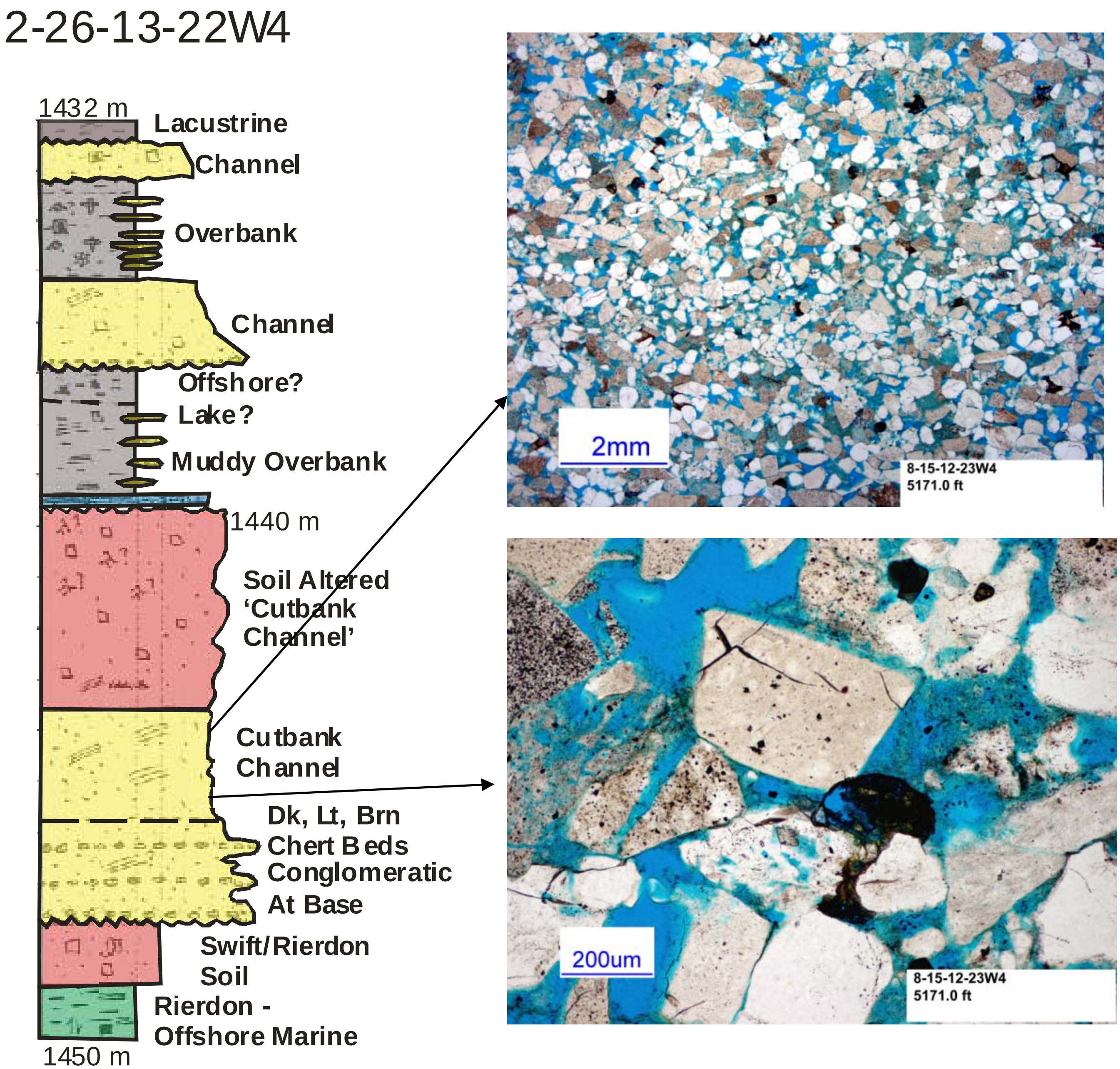

Figure 4. Core Log 2-26-13-22W4 of Cutbank channel sand facies with thin section photos taken from unaltered (non-soily) basal channel position characterised by coarse-grained to pebbly grain sizes as well as good porosity (blue colours). Note: thin sections taken from a different nearby well (8-15-12-23W4), but from same lithology & position as in the 2-26-13-22W4 core log here.

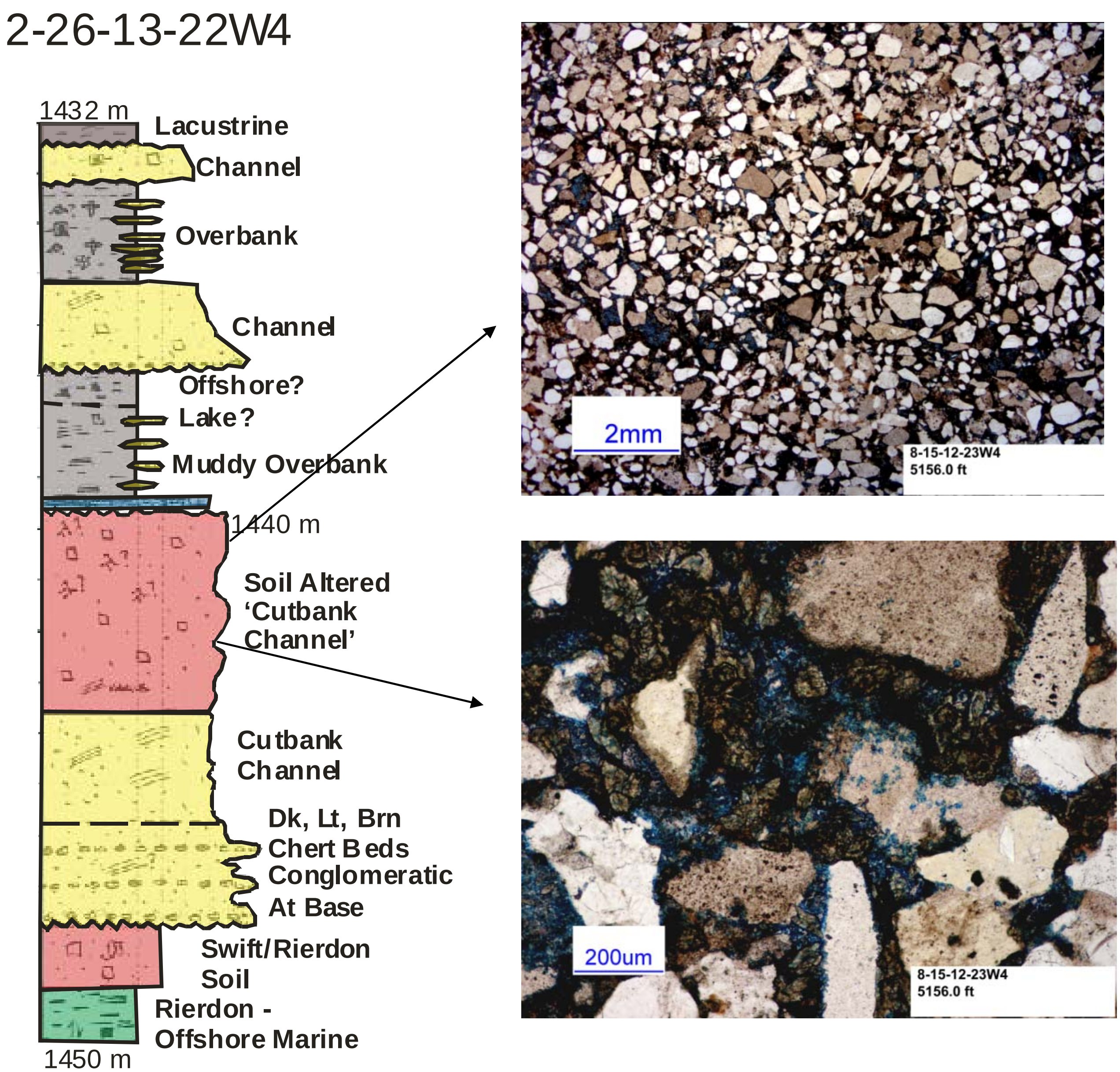

Figure 5. Core Log 2-26-13-22W4 of Cutbank soil-imprinted top-channel sand facies with thin section photos taken from top channel. Note finer grain sizes, abundant infiltrated detrital clays, and poor porosity (blue colours). Note: thin sections taken from a different nearby well (8-15-12-23W4), but from same lithology & position as in the 2-26-13-22W4 core log here.

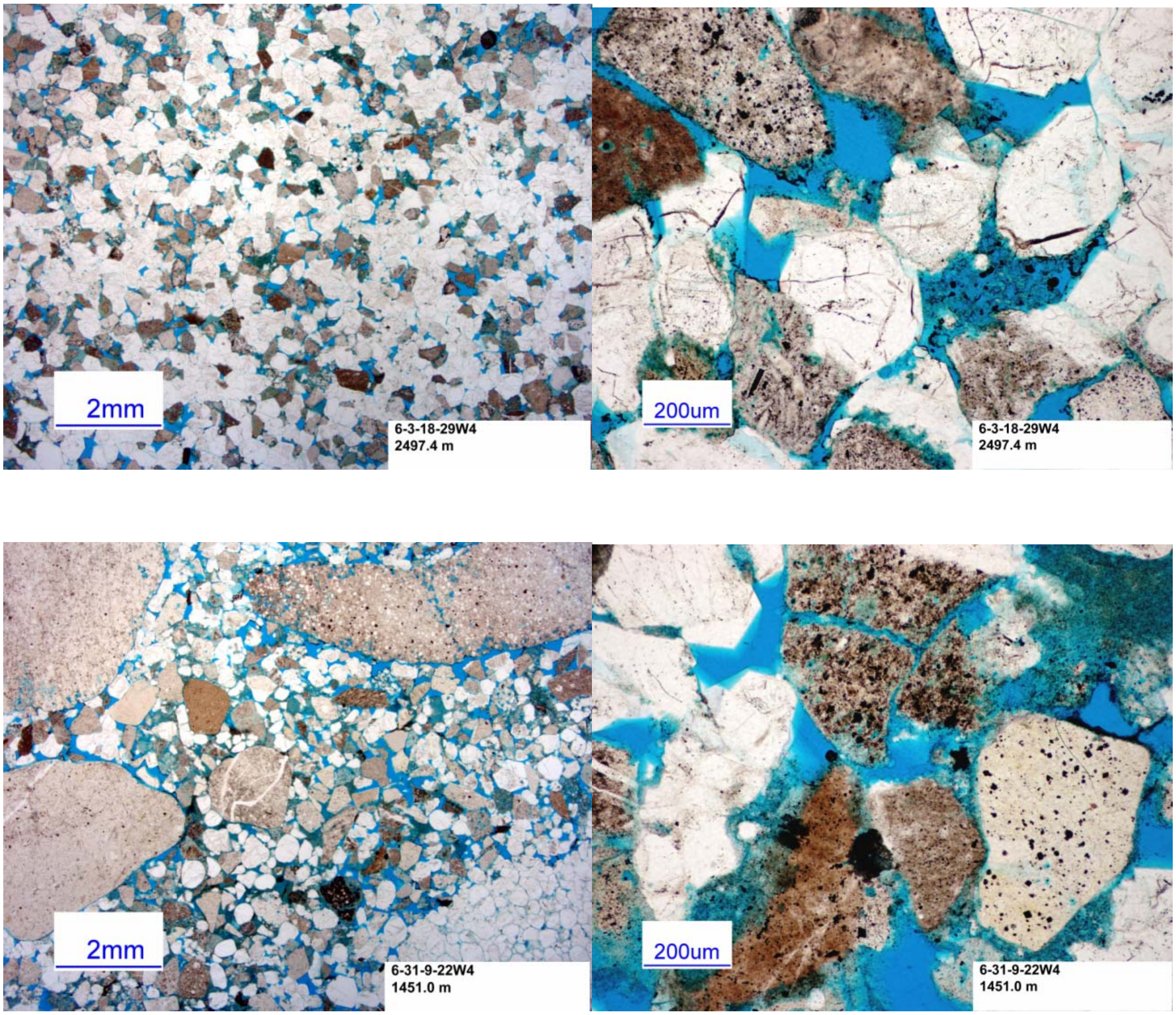

Figure 6. Examples of Cutbank fluvial channel sand facies characterised by coarse to pebbly grains, good porosity and a lack of infiltrated detrital clays.

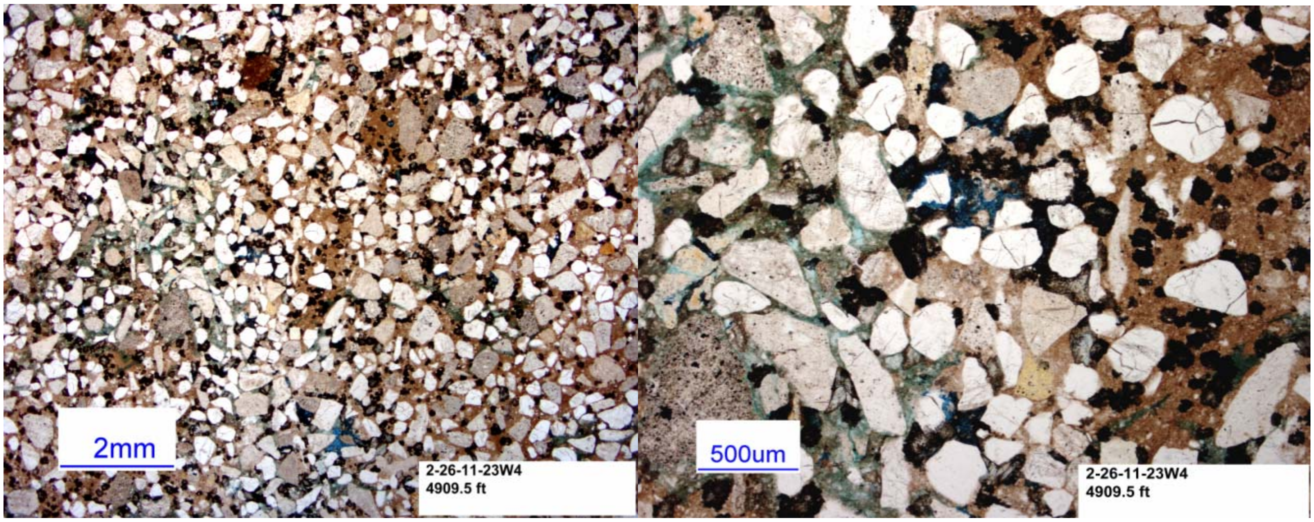

Figure 7. Example of Cutbank off-channel soil facies characterised by fine-grained nature, abundant infiltrated detrital clays (brown masses between grains) and low porosity (blue colours).