Ministry of Energy, Mines and Petroleum Resources
Oil and Gas Division
Resource Development and Geoscience Branch

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FOREWORD

The BC Energy Plan calls for the provincial government to partner with industry, the federal government, and Geoscience BC to undertake comprehensive research in the Nechako Basin and establish new data concerning the petroleum resource potential there. *The Nechako Initiative - Geoscience Update*, Open File 2007-1, presents interim reports on some of the geoscience projects that the Resource Development and Geoscience Branch of the Ministry of Energy, Mines and Petroleum Resources, Oil and Gas Division, continues to conduct and support in the Nechako region.

Energy geoscience work is difficult to conduct in the Nechako region due to the extensive blanket of Eocene and Neogene volcanics and glacial cover, which mask the rocks with hydrocarbon potential.

Exploration wells drilled in the 1960s and 1980s provide a rare and valuable glimpse into the subsurface geology of the Nechako. Much of the work reported in this volume has come from our efforts to extract new data from old exploration well records, cores and drill cuttings. Filippo Ferri and Janet Riddell report on some initial results of analyses conducted on the old drill cuttings and core, including contributions from Paul O'Sullivan of Apatite to Zircon Incorporated on new radiometric age data and apatite fission track analyses and Arthur Sweet of Geological Survey of Canada, Calgary, on new subsurface palynology results. This report also describes the surface geological field work that continues in the Nechako. Peter Mustard and James MacEachern of Simon Fraser University have conducted a detailed facies evaluation of the archived cores based on observations of sedimentological and ichnological features. Ian Smith has compiled and standardized the existing downhole petrophysical data and conducted a log analysis of each of the wells from surface casing to total depth, incorporating core, cuttings and reservoir data.

Adaptation of geophysical methods to the challenging geological conditions of the Nechako region is a key component of the strategy for improving our understanding of the subsurface. John Cassidy and Issam Al-Khoubi of the Geological Survey of Canada, Sidney, have contributed an introduction to one of the passive seismic investigations that is underway. Other Nechako geophysical pilot projects, funded by Geoscience BC and/or the Resource Development and Geoscience Branch, that are underway or beginning in 2007 include reprocessing of the 1980s-era seismic data by Arcis of Calgary, a new conventional seismic survey led by Andy Calvert of Simon Fraser University, a new magnetotelluric survey led by Jim Craven of the Geological Survey of Canada, Ottawa, and a passive microseismic test survey led by Mel Best of Bemex Consulting Limited. Updates on those projects can be found both on the Geoscience BC website and in *Geological Fieldwork*, an annual publication of the Ministry of Energy, Mines and Petroleum Resources.

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CONTENTS

A Passive Seismic Investigation of the Geological Structure within the Nechako Basin

By John Cassidy[1] and Issam Al-Khoubi[1]

Reflection seismic surveying in the Nechako basin has been difficult in the past because of basalt flows at or near the surface. Canadian Hunter carried out a significant seismic, gravity, and drilling program in the Nechako basin in the early 1980s but they abandoned the play after drilling several dry holes. Reprocessing this older 2D reflection data does help to improve data quality, but there are regions where data quality remains poor. Reflection seismic data acquired with modern acquisition and processing techniques is expected to be significantly better than the earlier 2D seismic data.

In this study, we are using passive seismic methods to map geological structure within the Nechako basin. A collaborative project of GSC Pacific, the BC Ministry of Energy, Mines and Petroleum Resources, and the University of Manitoba has involved deploying seven broadband seismograph stations across the Nechako Basin (Figures 1, 2, and 3). These stations, covering an area of about 33 000 km^2, began operation in September, 2006, and will be in place until the summer of 2008. Recordings of distant and regional earthquakes will be used to map the sedimentary structure and crustal thickness within the basin.

Specifically, waveforms from distant earthquakes (Figure 4) will be used to resolve the shear-wave velocity structure beneath the Nechako Basin and provide information on both the thickness and nature of basin-fill sedimentary rocks and on the thickness of the underlying crust. The advantages of this method are numerous—using natural earthquake sources means that permitting and explosions are unnecessary; the energy originates from below the blanketing basalts that have degraded the quality of active-source seismic data, and this enables us to see the underlying prospective units; and the S-wave information obtained complements the P-wave information obtained from active-source seismic studies. The combination of P- and S-wave velocity information provides constraints on Poisson's ratio, which is indicative of lithologic composition.

During the first two months of operation, more than a dozen useful events were recorded (for example, the Hawaii earthquake of October 15, 2006; Figure 4).

One of the methods that will be used in this study is receiver-function analysis of P-waves from distant earthquakes. As a P-wave crosses velocity boundaries beneath a seismic station, some of the energy is converted to a shear-wave (Ps) followed by a variety of free-surface multiples (Figure 5, top). The Ps phases and multiples can be identified as they dominate the horizontal recordings (whereas the direct P-wave dominates the vertical component). The arrival time and amplitude of the Ps phases (and multiples) provides information on the S-wave velocity and the depth and dip of the boundary. A sample receiver function for this example is shown in Figure 5 (bottom).

A sample of receiver functions from a single earthquake (November 15, 2006, M = 8.3 Kuril Islands earthquake) are shown in Figure 6. The arrival at Time = 30 s is, in all cases, the direct P-wave. Later-arriving phases are locally-generated Ps conversions and multiples. Rock sites (in this case, Whitehorse and Bella Bella, BC) show simple waveforms. Stations within the Nechako Basin (labelled "Basin") show more complex signals, with many large arrivals early in the wavetrain. These are consistent with sedimentary structure. The lowermost trace is for station "EDM" situated on a 2-km–thick package of sediments in the Western Canada Sedimentary Basin.

Receiver functions across the Coast Mountains batholith, extending from the coast (near Bella Bella) on the left to the westernmost edge of the Nechako Basin (near Anahim Lake) on the right, are illustrated by Figure 7. The large red signal near 20–30 km is the Moho. This signal abruptly terminates at the western edge of the Nechako Basin (figure provided by Joshua Calkins, University of Arizona). These preliminary receiver functions show evidence for an abrupt change in structure in the basin (relative to the Coast batholith) and evidence for sediments and near-surface structure within the basin.

Concurrently, a second project investigated the utility of measuring microseismic activity (small, local seismic events) to aid subsurface imaging. The pilot project was conducted in the southeast corner of the Nechako Basin in late 2006. For details of that project, see Best and Lakings (2007).

These new passive-source seismic datasets will complement other geophysical datasets (such as active-source seismic, gravity, and magneto-telluric) being collected in the Nechako Basin and will provide unprecedented images of the sediments and basin structure below the basalts in this region. These data are critical to assessing the hydrocarbon and mineral potential of the Nechako Basin.

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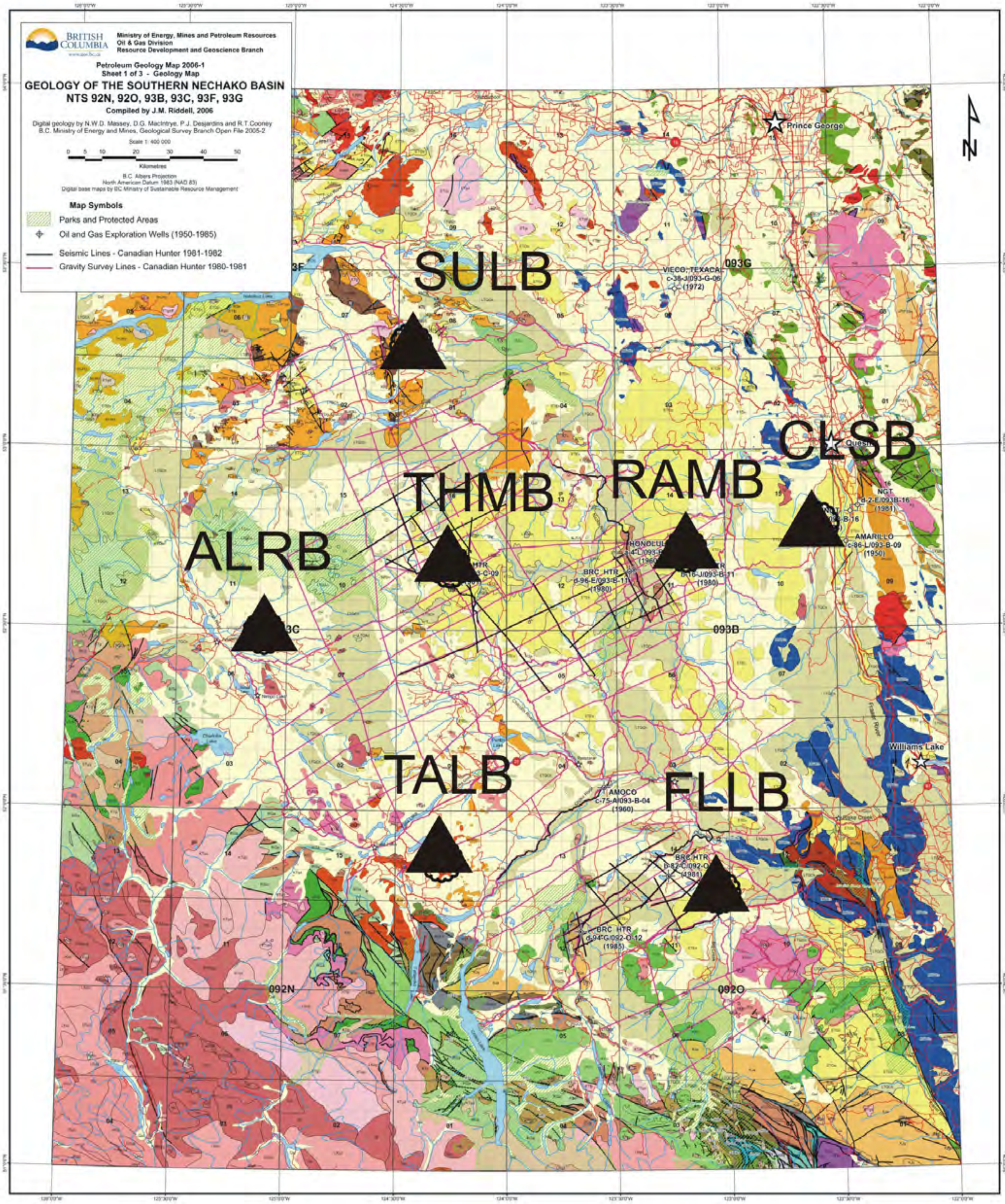

Figure 1. Map of POLARIS seismic stations. Location of the POLARIS broadband seismic stations (solid triangles, with station names shown), location of seismic lines (thin black lines), gravity lines (pink), and oil and gas exploration wells (labelled). Base map adapted from Riddell (2006).

Figure 2. Typical POLARIS seismic station configuration. The seismograph is powered by solar energy and data are transmitted in real-time via satellite to GSC offices in Ottawa, ON and Sidney, BC. This photo shows the seismic station CLSB (Figure 1).

Figure 3. Typical POLARIS seismic station configuration (station FLLB), showing the "seismic vault". The seismometer is within this steel case and is protected from the elements (and animals).

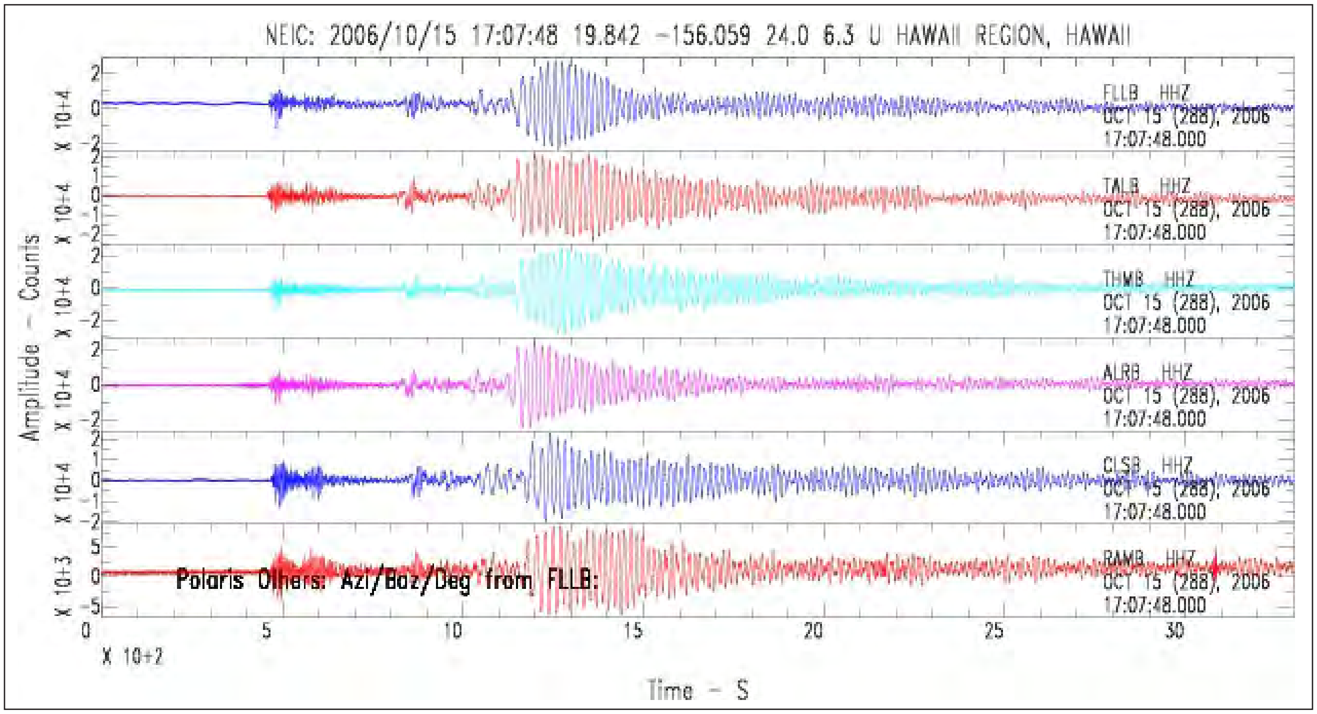

Figure 4. Recordings of the October, 2007, M=6.3 Hawaii earthquake at the seven temporary seismic stations operating in the Nechako Basin. The P-waves are visible at about 500 s, the S-waves at about 850 s, and the large amplitude surface waves beginning at about 1100 s. Each of these wave types contains information on the structure of the basin.

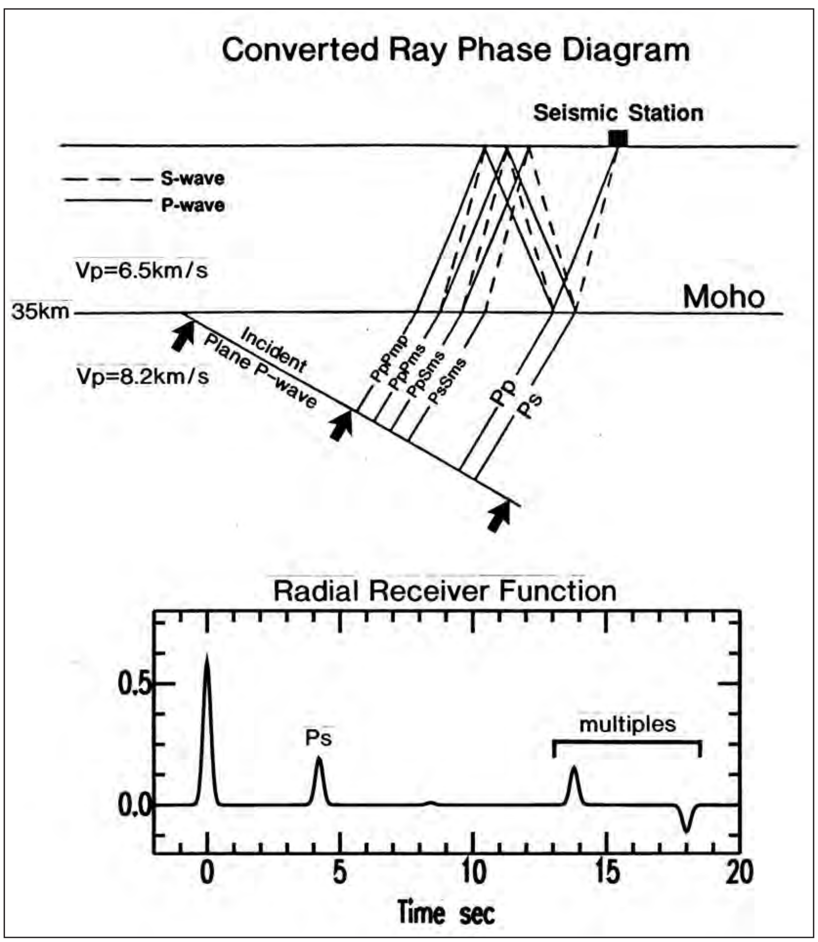

Figure 5. Receiver-function cartoon

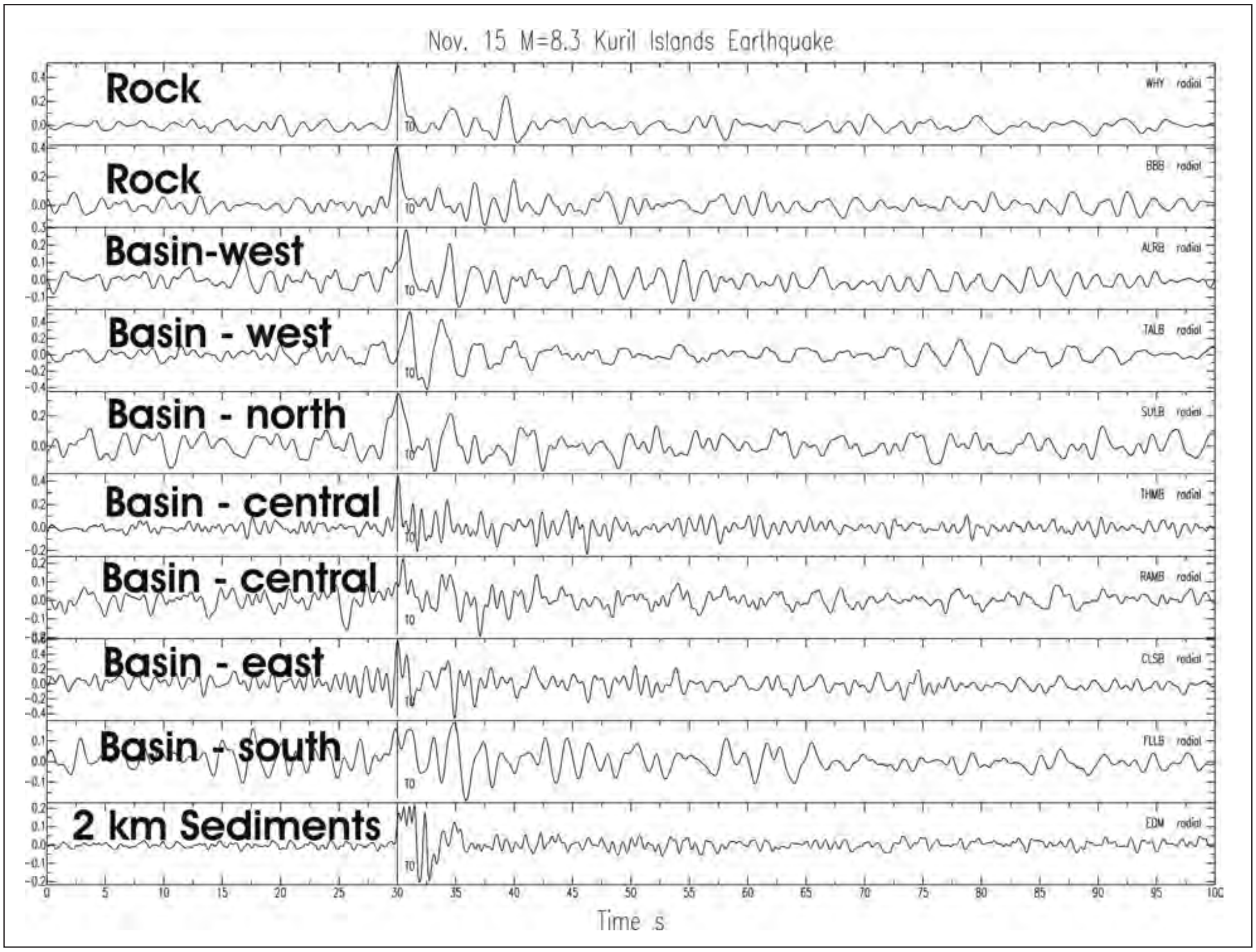

Figure 6. Sample receiver functions for the Nechako Basin

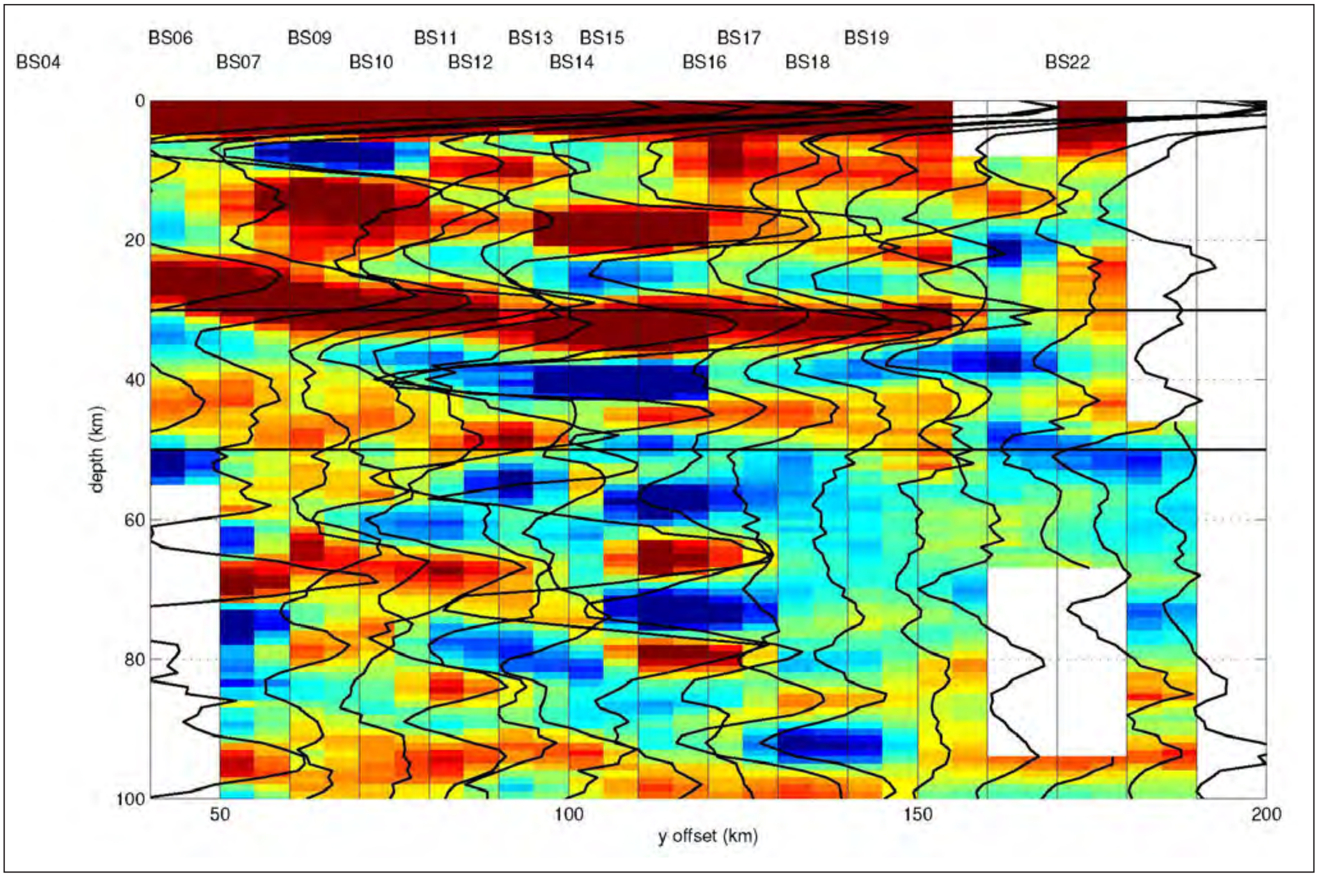

Figure 7. Sample receiver functions across the Coast Mountains

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A Detailed Facies (Sedimentological and Ichnological) Evaluation of Archived Hydrocarbon Exploration Drill Core from the Nechako Basin, B.C.

By Peter S. Mustard[1] and James A. MacEachern[1]

Summary

The extant hydrocarbon exploration drill core available from the Nechako Basin of west central B.C. comprise approximately 691 ft (211 m) from 7 wells, although only 6 had significant recovery and missing core boxes from some wells decrease this total to about 662 ft (~202 m). All core are currently archived at the BCEMPR Core Facility at Charlie Lake, B.C. Core from an eighth well reported as originally archived at the core facility is currently missing and presumed lost (totaling about 65 ft or 20 metres). Detailed logging of all existing core was completed, focusing on descriptions of the sedimentary rock types, sedimentary structures, and ichnologic features (trace fossil analysis). We are convinced the single cored interval from the Canadian Hunter Redstone 1981 well (location b-22-C) was placed into the core boxes in reverse order and have logged this core in the original upright stratigraphic position. The core features are used to provide preliminary depositional environment interpretations and identify any genetic stratigraphic discontinuities. Most of the core indicated non-marine fluvial, lacustrine and floodplain environments of deposition, with extensive paleosol development preserved in several cores. Some of these cores comprise repeated cycles of fining-upward pebble conglomerate and sandstone successions, which could serve as relatively thick and clean possible reservoir rocks for hydrocarbons. The second most common depositional setting is any of several shallow marine environments (brackish marginal marine bays, open shoreface and more rarely possible deltaic environments). In some examples, this includes relatively thick intervals of relatively clean sandstone, which potentially could serve as significant reservoir rock for hydrocarbons, although no evidence of oil staining or other hydrocarbon presence was observed in any of the cores logged. None of the core indicated deposition below fair-weather wave base (e.g., open shelf or deeper marine environments). The Canadian Hunter et al Nazko (d-96-E) well was the sole well which contained significant cored intervals of moderately well-sorted sandstone from shallow marine environments, although the single cored interval from the Canadian Hunter Redstone 1981 well also represents a marginal marine environment with a few thick "clean" sandstone intervals.

INTRODUCTION

The Nechako Basin is located in west-central B.C., and comprises a complex mix of Mesozoic and Tertiary sedimentary and volcanic successions that overlie accreted oceanic terranes of the western Canadian Cordillera (Fig. 1). Hydrocarbon exploration has been conducted to a limited extent in the basin since the early 1930's, with 12 exploration wells drilled in the 1960's to early 1980's (Fig. 2). Renewed interest in the hydrocarbon potential of this interior basin in the past several years has resulted in a number of recent studies, as well as proposed studies of the area (*e.g.*, Hannigan *et al*., 1994, Hayes *et al*., 2004).

A common practice for the evaluation of any sedimentary basin is to examine existing datasets, and re-evaluate them using current interpretations and levels of understanding of the science. This study provides a re-evaluation of the currently available dataset of cored intervals from the exploration wells of the Nechako Basin, in terms of the current understanding of sedimentary facies models, including the use of ichnological characteristics (trace fossils) within the core. The integration of trace fossils with conventional facies analysis leads to much more detailed paleoenvironmental reconstructions, and helps to place both sedimentological and paleontological elements into a more refined depositional context.

Cored intervals from 8 of the Nechako Basin exploration wells were originally archived at the B.C. Ministry of Energy Mine and Petroleum Resource Core Facility at Charlie Lake B.C. (Table 1). Approximately 699 ft (213 m) are reported as present from 7 wells, although only 6 had significant recovery. Archived material from one well, Amarillo Kersley 1951 (location H of Figure 2), consists only of 5 bags of rubble, containing mixes of dried drilling mud and fragments of what appears to be altered volcanic rock. Consequently, no core log is presented for this well. Core from a eighth well, (location c-84-D, well G of Figure 2) was originally reported as archived at the core facility, but is currently missing and presumed lost (totaling about 65 ft or 20 metres of core). Of the remaining 6 wells,

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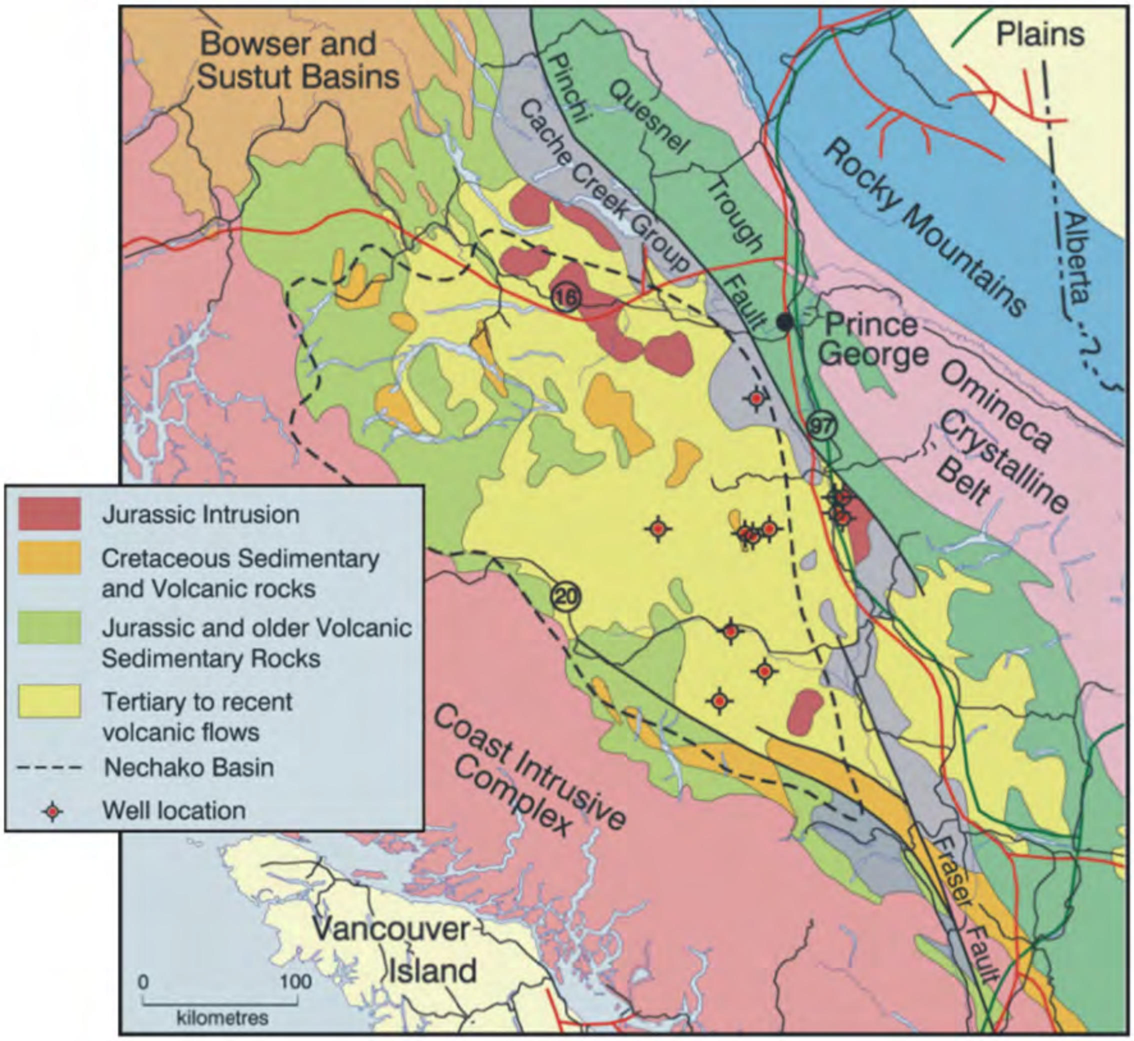

Figure 1. Regional geological location map with boundaries of 1:250,000 map areas discussed in the project proposal (map modified from a BC Oil and Gas Division website figure).

recovery is generally good, typically about 80-90% of reported cored intervals are present, but several core boxes are missing from one well (Honolulu Nazko 1960), totaling about 37 ft (11.4 m). Actual cored intervals remaining at the core library when logging was conducted in June, 2006 totaled about 662 ft (~202 m). Core condition is generally fair to good. Some intervals are broken and somewhat rubbly (especially intervals through mudstones and weathered rock as well as paleosols or incipient paleosols), but generally recovery was sufficient to allow the stratigraphic interval to be reconstructed with confidence.

Detailed lithologic logs for the six wells with significant recovery are presented here as Figures 3 to 9. The logs include descriptions of the main lithofacies and ichnological suites along with relevant core photos. Because of space restrictions on the page-sized figures, interpretations of depositional environments for the cored intervals are provided separately below.

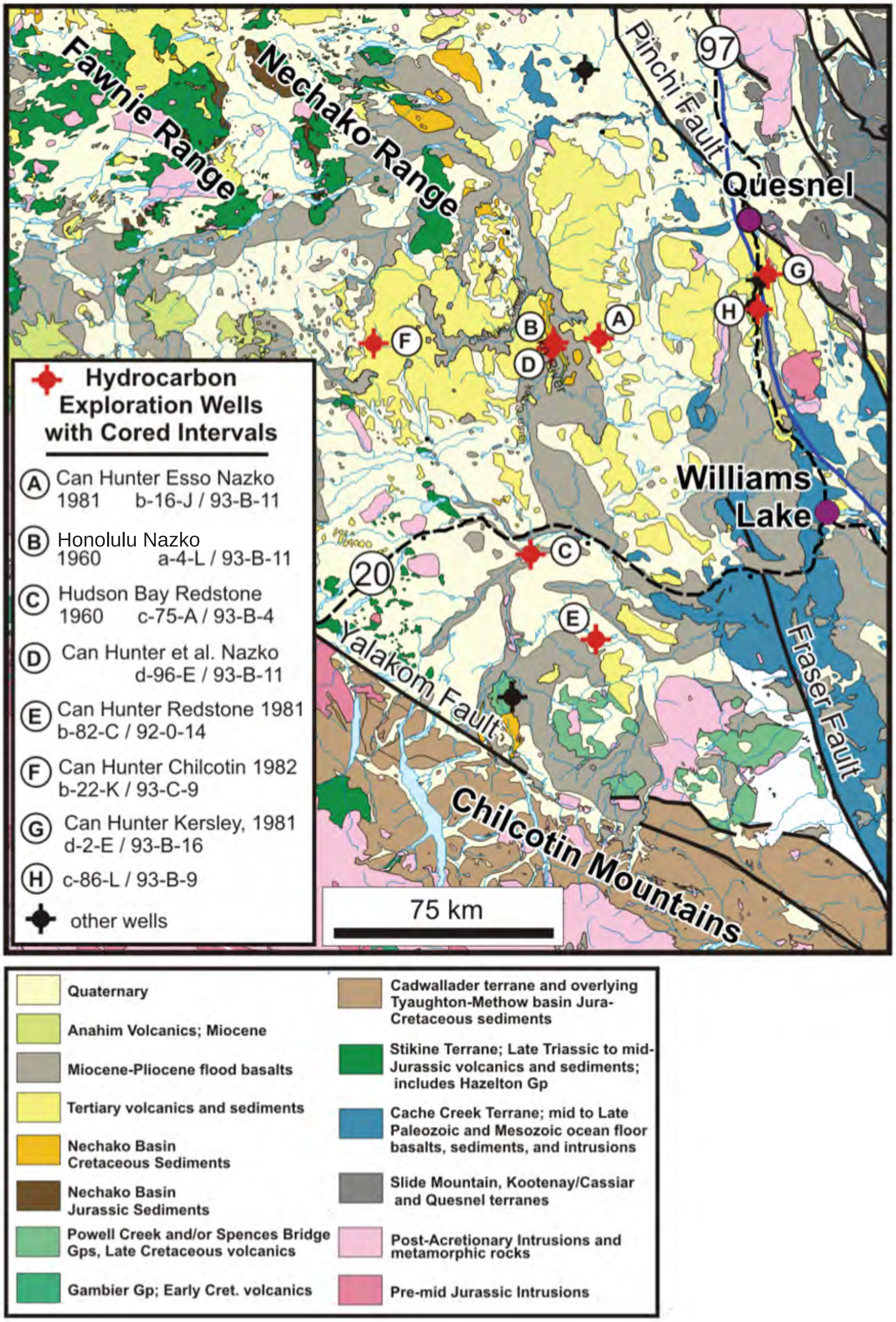

Figure 2. Regional geological framework and location of hydrocarbon exploration wells, including those which contain cored intervals (modification from a compilation figure provided by F. Ferri 2006, used with permission).

Table 1. Cored intervals from Nechako Basin wells archived at BCEMPR Charlie Lake core facility. Shaded intervals are for reported cored intervals that are currently missing.

Well (and remarks)	Core Interval	Core - Start - metres	Core - Finish - metres	Length - metres	Start - feet	Core - Finish -feet	Length - feet
Canadian Hunter							
Esso Nazko 1981	1	1270	1277	7	4165.6	4188.6	23.0
b-16-J/93-B-11	2	2500	2502.8	2.8	8200.0	8209.2	9.2
missing	1	225.8	228	2.1	740.8	748.0	6.9
	2	303	306.6	3.6	994.1	1005.9	11.8
Honolulu Nazko	3	399.9	402.9	3	1312.0	1321.8	9.8
1960	4	538.9	540.7	1.8	1768.0	1773.9	5.9
a-4-L/93-B-11	5	701	702.4	1.4	2299.8	2304.4	4.6
	6	702.4	703.5	1	2304.4	2308.0	3.3
missing	7	733.3	734.9	1.5	2405.8	2411.1	4.9
only 0.8 ft recovery	8	883.9	885.4	1.5	2899.9	2904.8	4.9
box 2 missing	10	1156.7	1159.5	2.7	3794.9	3804.1	8.9
labelled 4115-4144 ft + boxes 2,5 missing	11	1254.3	1263.1	8.8	4115.0	4144.0	29.0
	12	1443.2	1446.3	3	4734.9	4745.0	9.8
	13	1566.1	1569.1	3	5138.1	5147.9	9.8
	14	1616.7	1619.1	2.4	5304.1	5311.9	7.9
box 1 missing	15	1768.1	1770.9	2.7	5800.8	5810.0	8.9
	16	1909.3	1912.9	3.7	6264.0	6275.8	12.1
missing	17	2046.4	2047.6	1.2	6713.8	6717.8	3.9
	18	2187.8	2190.3	2.4	7177.7	7185.9	7.9
	19	2241.5	2244.5	3	7353.9	7363.8	9.8
	20	2287.8	2290.9	3	7505.8	7516.0	9.8
missing	21	2476.5	2479.5	3	8124.9	8134.7	9.8
0.7 ft recovery	22	2717	2717.3	0.3	8913.9	8914.9	1.0
missing	23	2889.5	2891.3	1.8	9479.9	9485.8	5.9
missing	24	3071.5	3072.7	1.2	10077.0	10080.9	3.9
missing	25	3306.8	3307.4	0.6	10848.9	10850.9	2.0
missing	26	3311.3	3312.6	1.2	10863.7	10868.0	3.9
Hudson Bay	1	170.7	172.2	1.5	560.0	565.0	4.9
Redstone 1960	2	639.7	645.9	6.2	2098.7	2119.0	20.3
c-75-A/93-B-4	3	805.5	807.4	1.9	2642.7	2648.9	6.2
	4	1085	1086.9	1.9	3559.7	3565.9	6.2
	5	1172.6	1175.3	2.7	3847.0	3856.0	9.0
	6	1304.2	1307.5	3.3	4278.8	4289.6	10.8

Table 1 (cont) Core intervals from Nechako Basin wells archived at BCEMPR Charlie Lake core facility.

Well		Core - Start - metres	Core - Finish - metres	Length - metres		Core - Start - feet	Core - Finish -feet	Length - feet
Canadian Hunter	1	315	321	6		1033.2	1052.9	19.7
et al. Nazko	2	415.4	424.4	9		1362.5	1392.0	29.5
	3	483	485	2		1584.2	1590.8	6.6
d-96-E/93-B-11	4	590.5	600	9.5		1936.8	1968.0	31.2
	5	912.5	921.5	9		2993.0	3022.5	29.5
	6	957	966	9		3139.0	3168.5	29.5
	7	1140	1149	9		3739.2	3768.7	29.5
	8	1370.8	1373.5	2.7		4496.2	4505.1	8.9
	9	1373.5	1374.5	1.1		4505.1	4508.4	3.3
	10	1399.4	1400.3	0.9		4590.0	4593.0	3.0
	11	1550	1559	9		5084.0	5113.5	29.5
	12	1727	1729	2		5664.6	5671.1	6.6
	13	1729	1731.6	2.6		5671.1	5679.6	8.5
	14	1812	1819	7		5943.4	5966.3	23.0
	15	1838	1848	10		6028.6	6061.4	32.8
	16	1883	1891	8		6176.2	6202.5	26.2
	17	2057	2059.5	2.5		6747.0	6755.2	8.2
Canadian Hunter Redstone 1981 b-82-C/92-O-14	1	1293	1302	9		4241.0	4270.6	29.5
Canadian Hunter Chilcotin 1982 b-22-K/93-C-9	1	3119	3124.5	5.5		10230.3	10248.4	18.0
Canadian Hunter Kersley 1981 d-2-E/93-B-16		713.6	725.8	12.2		2340.6	2380.6	40.0
		Note: very poor recovery - minor rubble in bags only						
Total Existing Core				201.9				662.0
c-86-L/93-B-9		487.7	493.8	6.1		1600.0	1620.1	20.0
All Core from		493.8	499.5	5.7		1620.1	1638.8	18.7
this hole missing		594	597.7	3.7		1948.8	1960.9	12.1
at Core Facility		618.7	620.5	1.8		2029.8	2035.7	5.9
		924.7	927.2	2.5		3033.8	3042.0	8.2
missing core, this well				19.8				65.0

Table 2. Abbreviations used in core descriptions.

Abbreviation	Meaning	Size Range (mm)
cgl	conglomerate	
cse	coarse	
dep	depositional	
desic	desiccation	
esp	especially	
fracs	fractures	
lams	laminations	
osc	oscillating	
peb	pebble	
sl	slightly	
sst	sandstone	
sup	supported	
w	with	
vcU	very coarse grained, upper	1.5 - 2.0
vcL	very coarse grained, lower	1.0 - 1.5
cU	coarse grained, upper	0.75 -1.0
cL	coarse grained, lower	0.5 - 1.0
mU	medium grained, upper	0.375 - 0.5
mL	medium grained, lower	0.25 – 0.375
fU	fine grained, upper	0.1875 - 0.25
fL	fine grained, lower	0.125 – 0.1875
vfU	very fine grained, upper	0.09375 - 0.125
vfL	very fine grained, lower	0.0625 - 0.09375

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APPENDIX ONE - CORE INTERPRETATIONS

Canadian Hunter Esso Nazko 1981 Location: b-16-J/93-B-11 (A on figure 2)

Core 1: 1270-1277m

This core consists of about 3m of conglomerate overlain by pebbly sandstone and minor mudstone. The lower conglomerates comprise a stacked succession of probable subaerial debris flows typical of alluvial fan environments, with common hematite alteration suggesting repeated subaerial weathering. Clast types indicate a source dominated by mafic volcanics, but include several chert and sedimentary clasts, suggesting a source area possibly of exposed oceanic terranes (*e.g.*, Cache Creek Terrane). Minor sandstone interbeds may indicate sheetflood deposits capping individual or stacked debris flows. This interval is gradationally overlain by pebbly sandstone and minor mudstone intervals that reflect lower fan to off-fan environments of alluvial fan systems, with deposition dominated by braided stream and sheetflood events. The succession shows minor mudstone deposition recording small ponded areas in the lower fan to off-fan areas. Bioturbation intensities are low, highly sporadic in distribution and largely confined to sandy and silty units. The trace fossils are consistent with the activity of terrestrial organisms, typical of settings prone to long periods of subaerial exposure. Most burrows are diminutive and probably insect- or termite-generated. One structure was sufficiently preserved to suggest the ichnogenus *Macanopsis*. Additionally, rare large structures that are gravel-filled, are probably vertebrate tetrapod burrows. These gravel-filled burrows point to episodic, probably catastrophic depositional events, consistent with debris flows and/or rapid braid channel switching.

Core 2: 2500-2502.8m

This core consisted entirely of altered mafic volcanic (basalt or andesite) breccia and reflects a subaerial volcanic environment of deposition.

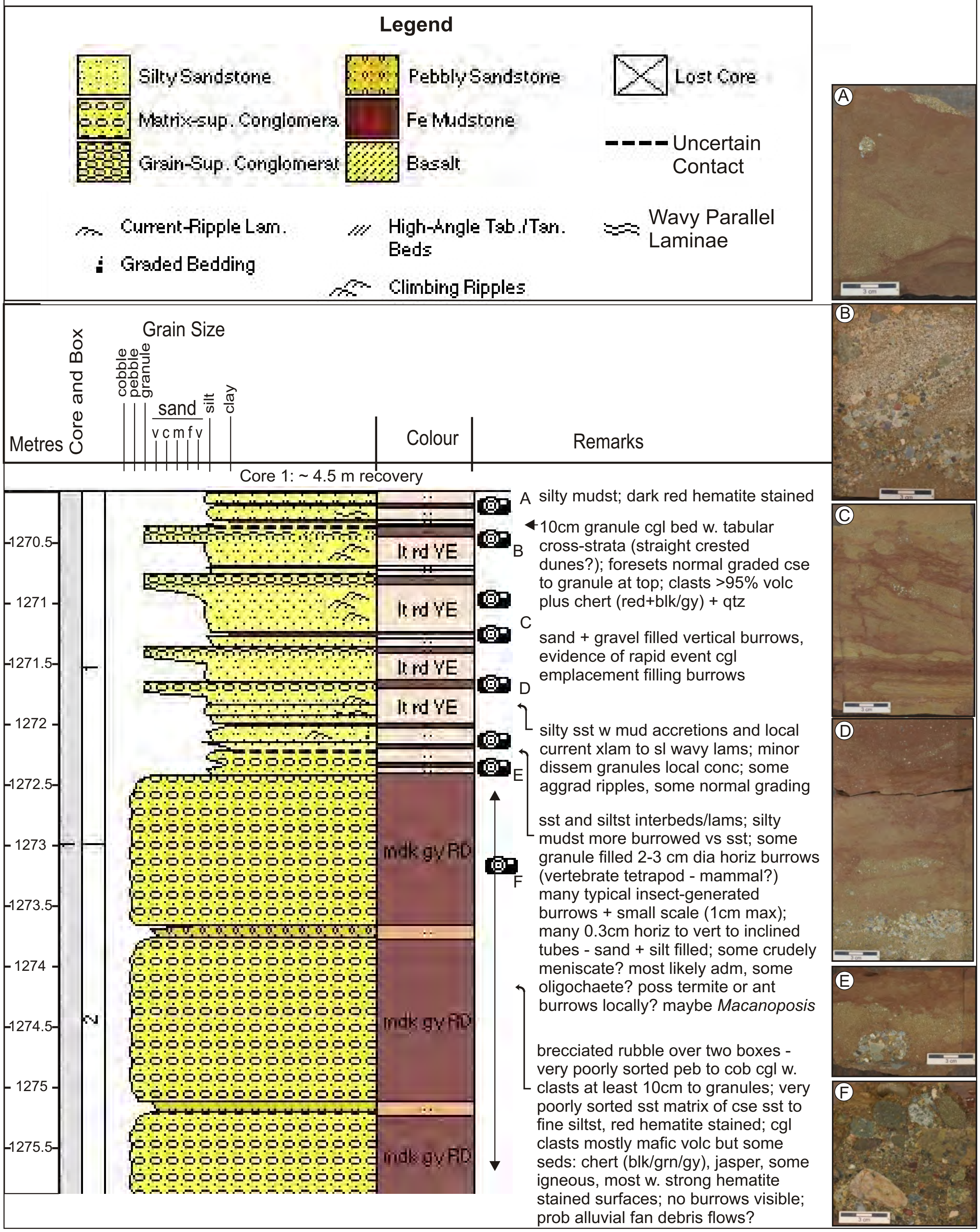
Location: b-16-J / 93-B-11

Canadian Hunter Esso Nazko 1981

Date Logged: June, 2006

Logged by: J. MacEachern, P. Mustard

Remarks:

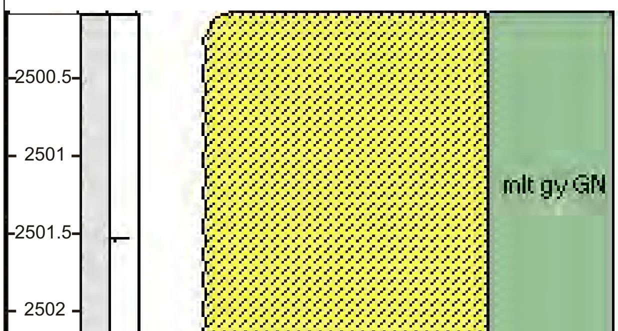


Location: b-16-J / 93-B-11

Canadian Hunter Esso Nazko 1981

Metres	Core and Box	Grain Size (cobble, pebble, granule, sand: v c m f v, silt, clay)	Colour	Remarks

Core 2: ~2.8 m recovery



altered volcanic breccia:
epidote and chlorite
alteration common; some
HCl reaction

Honolulu Nazko 1960 Location: a-4-L/93-B-11 (B of figure 2)

Core 1: missing

Core 2: 303-306.6m (994'-1006')

A very altered red-pink stained sandstone/siltstone, with possible vague horizontal lamination to thin beds but no other preserved sedimentary structures. The general mottled look could be, in part, burrow induced, but no clear ichnogenera could be discerned. Alteration may be due to a nearby igneous intrusion? Original depositional environment is no longer discernable.

Core 3: 399.9-402.9m (1311'-1321')

Lower heterolithic to near lenticular composite bedset of mudstone/sandstone, containing oscillation ripples. Unit changes upward to a more sandstone-rich top. This is typical of very shallow, wave-washed subaqueous environments. The presence of syneresis cracks suggests some saline influence (probably fluctuating) on deposition. Fugichnia (escape structures) support sporadic deposition, but *Planolites* present within the unit are not conclusive of setting; *Planolites* constitutes one of the most broadly facies-crossing trace fossils known. Facies is most likely associated with a brackish-water, sheltered setting, such as a sandy bay margin environment.

Core 4: 538.9-540.7m (1768'-1774')

A lower interlaminated siltstone-mudstone unit with unidirectional current ripples, wavy parallel laminations, root traces, and some pedogenic slickensides, probably reflecting a continental floodplain or ponded area, which was then exposed to weathering. Unit does not display any biogenic structures. This mud-prone unit is sharply overlain by sandstone with current ripples, desiccation cracks and minor mudstone interlaminae. Ichnologically, the unit shows small numbers of *Planolites*, fugichnia, and an isolated, diminutive structure attributable to *Teichichnus*. The unit is interpreted to record part of a small fluvial deposit, possibly a crevasse splay into the floodplain or a small ponded flood basin. One anomalous character is the identification of a possible sand-filled syneresis crack, though the level of certainty on the observation is low.

Cores 5 + 6: 701-703.5m (2300'-2308')

This siltstone and very carbonaceous silty mudstone interval displays pedogenic modification and root structures, suggesting deposition in a continental, low-energy lacustrine or exposed lagoon environment. A very distinctive and clean 4 cm thick ash layer occurs in the middle of this unit, indicating periods of active volcanism in the region.

Core 7: missing

Core 8: 883.9-885.4m but only 0.25m recovery (2900'-2905')

Moderately well-sorted sandstone, composed of vague laminations to thin beds and possible low-angle cross-stratification. No visible trace fossils in the unit. Unit is too enigmatic to permit paleoenvironmental interpretation. Stratification, bedding and grain-sizes can be met in as diverse environments as eolian dune and shoreline (beach?) settings.

Core 9: missing

Core 10: 1156.7-1159.5m but box 2 missing (3795-3804')

Sandstone with rare, thin mudstone stringers, somewhat deformed by probable tectonic fault at base. Some undulatory wavy laminations, carbonaceous detritus, and carbonaceous mudstone rip-ups are common, with slightly mottled rare siltstone interbeds. Unit may contain mottling that could be burrow induced (possibly insect burrowing). Facies may record low-energy fluvial sandstones, disrupted by a tectonic fault.

Core 11: 1254.3-1263.1m (4219'-4249') Boxes 2+5 missing (note boxes are labeled 4115 – 4144 ft)

At least 4 or 5 stacked fining-upward cycles. Units show fine pebble conglomerate bases passing upward to sandstone (possibly silty mudstone in missing boxes?). Moderate to well sorted, sandstone with planar cross-strata, mudstone rip-up clasts, and some root traces near tops of cycles. Carbonaceous material is intercalated. Some pedogenic modification is apparent in some units. These cycles are interpreted as fluvial fining-upward cycles, although more gravel-rich than is typical. Setting may reflect a relatively proximal part of a sand/gravel-rich fluvial environment.

Core 12: 1443.2-1445.3m (4735'-4745')

Massive, blocky silty mudstone with pedogenic slickensides and other structures. Unit may possess isolated burrows (oligochaete-generated?). Probably lacustrine or flood-basin originally, but was subsequently exposed and weathered to form an incipient paleosol.

Core 13: 1566.1-1569.1m (5138'-5148')

Very fine-grained to silty sandstone, badly altered and red-stained with pedogenic slickensides, root traces, and some mottled zones (possible insect burrowing?). Remnant wavy parallel laminations and current ripples suggest moderate- to low-energy deposition of fluvial sand that was subsequently strongly weathered during subaerial exposure (probably prior to lithification).

Core 14: 1616.7-1619.1m (5304'-5312')

Red-stained, muddy siltstone with probable pedogenic structures (including pedogenic slickensides) and rare burrows (oligochaete-generated?). This is a probable, very low-energy flood-basin or small lacustrine deposit, which was subsequently exposed and strongly weathered to generate an incipient paleosol.

Core 15: 1768.1-1770.9m (5801'-5810') Box 1 missing

Slightly fining-upward, vaguely laminated sandstone with carbonaceous detritus, capped by silty mudstone, all containing roots with minor pedogenic structures (slickensides) at top. Unit probably contains some probable oligochaete burrows. This interval is interpreted to record low-energy, sandy fluvial/lacustrine deposit, which was subsequently subaerially exposed and weathered.

Core 16: 1903.3-1912.9m (6264'-6276')

A lower 7 ft thick succession of silty mudstone and very fine-grained sandstone with common blocky fractures and pedogenic structures. This is almost certainly the top of a fluvial fining-upward cycle, and represents off-channel floodplain / lacustrine deposition with subsequent extensive subaerial exposure and paleosol development. Extensive pedogenic modification obscures most of the primary features of the unit. No visible biogenic structures are apparent. This unit is sharply and probably erosively overlain by a few feet of pebble conglomerate, containing basal mudstone rip-up clasts, which is probably the basal part of a fluvial channel migrating across this floodplain. Clasts in the conglomerate are mostly chert and felsic volcanic types.

Core 17: missing

Core 18: 2187.8-2190.3m (7178'-7186')

Two fining-upward cycles with mostly massive medium-grained sandstone, capped by <1ft of silty mudstone to very fine-grained sandstone. Rare plant fragments are present throughout and very rare *Planolites*. Unit is difficult to interpret, but probably records non-marine environments such as a low-energy fluvial / floodplain?

Core 19: 2241.5-2244.5m (7354'-7364')

Unit mostly comprises a silty claystone with minor thin carbonaceous detritus layers, and some pedogenic structures (mainly rubbly weathering and randomly oriented slickensides). Intervals occur in three, subtle fining-upward cycles, the upper two having sharp erosive contacts, and the basal fine-grained silty sandstone that grades into mudstone. This succession probably represents mostly flood-basin deposition in a fluvial floodplain, with several periods of subaerial exposure of the muds and minor sandstone delivery from small fluvial channels as crevasse splays.

Core 20: 2287.8-2290.9m (7506'-7516')

Mostly massive to vaguely laminated muddy siltstone with some root traces and pedogenic structures in the uppermost unit. Central core contains about 3 ft of medium-grained sandstone, which sharply overlies a siltstone bed and fines upward to a muddy siltstone unit similar to most of the cored zone. The sandstone contains some low-angle cross-stratification and some burrowing. Burrows are present, but of low abundance and diversity; mainly small oligochaete-generated burrows and a meniscate backfilled burrow (adm) of insect origin, possibly attributable to *Scoyenia*. This succession probably formed in a floodplain/lacustrine environment, which was intermittently subaerially exposed and weathered to generate an incipient paleosol (especially at top). The sandstone probably represents fluvially derived sands, although possibly slightly reworked. A single 10 cm thick tuffaceous layer occurs at ~7508 ft and indicates active volcanism in the region.

Core 21: missing

Core 22: 2476.5-2479.5m (8125'-8135')

Very poorly recovered, rubbly core with only 0.7 ft of broken core fragments – all particles are purple-green volcaniclastic sst, with some possible whitish lapilli tuff near top rubble. This is a volcaniclastic deposit, probably part of a volcanic unit.

Honolulu Nazko 1960

Location: a-4-L / 93-B-11

Date Logged: June, 2006

Logged by: J. MacEachern, P. Mustard

Remarks: missing Cores: 1, 7, 9, 17, 22-26

Legend

Sandstone
Silty Sandstone
Shaly Sandstone
Shaly Siltstone
Silty Shale
Sandy Shale
Mudstone
Organic Shale
Grain-Sup. Conglomerat
Pebbly Sandstone
tuffaceous
Lost Core

CONTACTS

Sharp
Erosional

PHYSICAL STRUCTURES

Current-Ripple Lam.
High-Angle Tab./Tan. Beds
Lenticular Bedding
Synaeresis Cracks
Inj./Flame Struc.
Cracked
Symmetrical Ripple
Gently Inclined Lam.
Convolute Bedding
UFR Horizontal Parallel Lam.
R -Rubble
Low-Angle Tab./Tan Beds
Wavy Parallel Lam
Desiccation Cracks
Indistinct
-Horiz. Slicks.

LITHOLOGIC ACCESSORIES

Silt Lamina
Organic Lamina
Rip Up Clasts
Plant Remains
Shale Lamina
Calcareous
Carbonaceous Debris
Mottled
Coal Fragments
Py Pyrite
Palsl Paleosol Horizon
PED Pedogenic Slickenside

ICHNOFOSSILS

Rootlets
Teichichnus
Skolithos
Planolites

Feet	Core and Box	Grain Size: cobble, pebble, granule, sand (v c m f v), silt, clay	Colour	Remarks

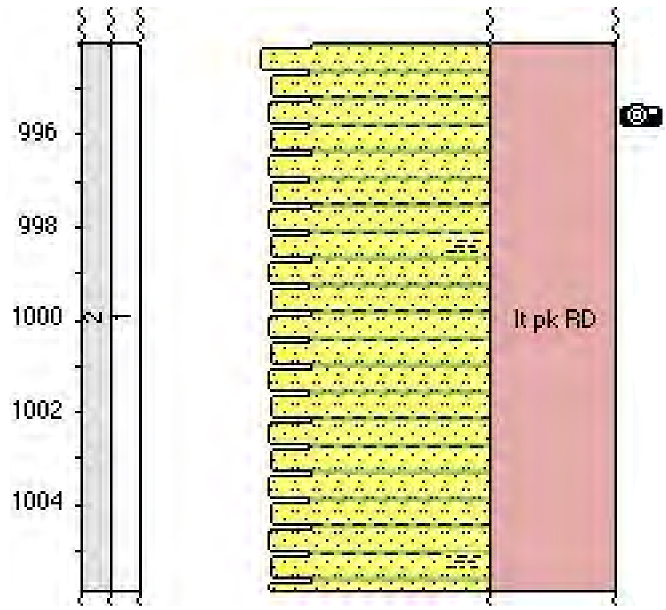
Honolulu Nazko 1960

Location: a-4-L / 93-B-11

Feet	Core and Box	Grain Size: cobble, pebble, granule, sand (v c m f v), silt, clay	Colour	Remarks

Core 1 missing

Core 2: 3.5 ft recovery

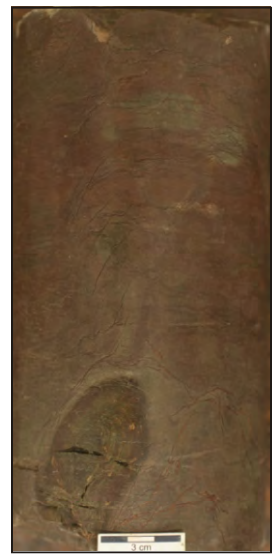


red-pink stained sst/siltst with thin silty mudstone lams;

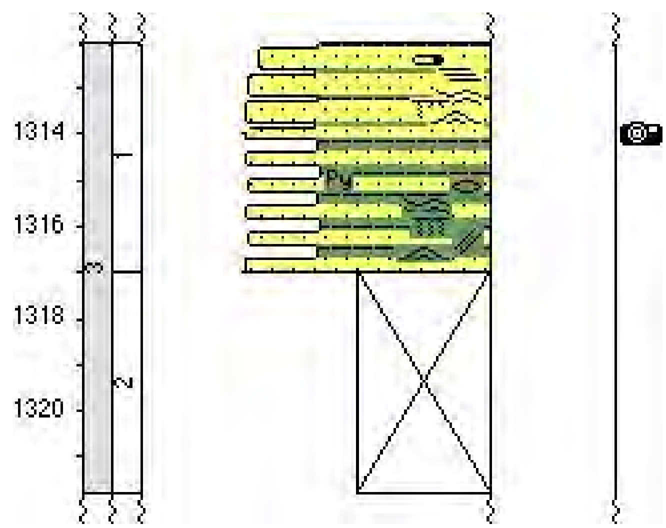
strong diagenetic mottling and post-dep "crackling" with many small fracs, some calcite filled.

has a "baked look" - poss close to intrusive?

variegated mottling may in part be burrow induced?
some vague remnant lamination; one concentric nodule



Core 3: 9 ft recovery, box 1 of 2 only, lower 5 ft missing



sst increases markedly in upper 2 ft; likely subaqueous

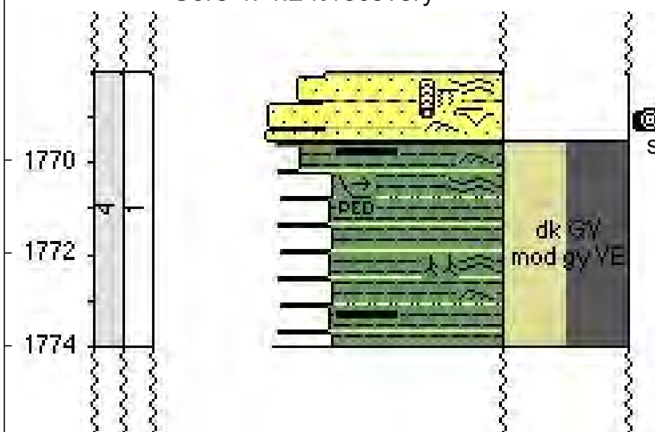
thin mudst with mL sst with irregular lobes of mudst pulled up into base; heterolithic and locally almost lenticular bedding; some syneresis cracks to rare poss dessication (prob not); isolated *Planolites,* fugichnia; rare isolated pyrite crystals

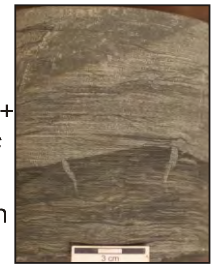
Honolulu Nazko 1960

Location: a-4-L / 93-B-11

Feet | Core and Box | Grain Size: cobble, pebble, granule, sand (v c m f v), silt, clay | Colour | Remarks

Core 4: 4.2 ft recovery



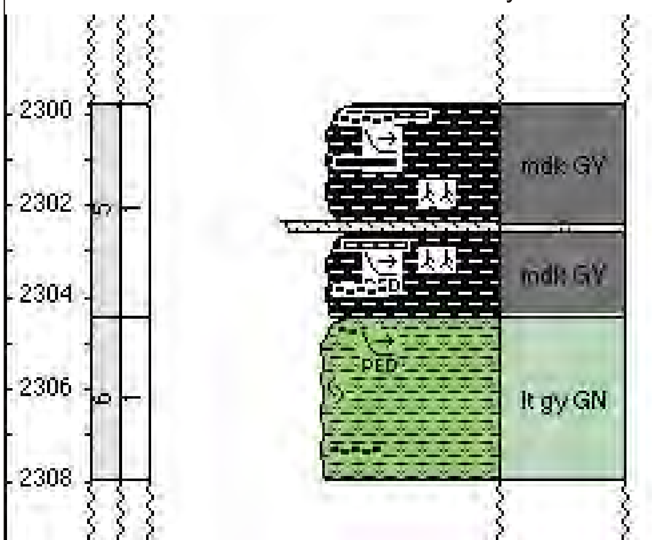


wavy // lam to current rippled fg sst w rare mud lams; some desic cracks and one poss syneresis, isolated *Planolites* + fugichnia, *1* small *Teichichnus*

sharp contact

mudst + some silt to fg sst thin interbeds w current rippled lams to wavy // lams; lower mudstones are dense, blocky and dark grey w. rare siderite cemented zones and glossy pedogenic slickensides, but also some tectonic fractures; coaly frags locally, some root traces

Cores 5 and 6: 7.1 ft recovery



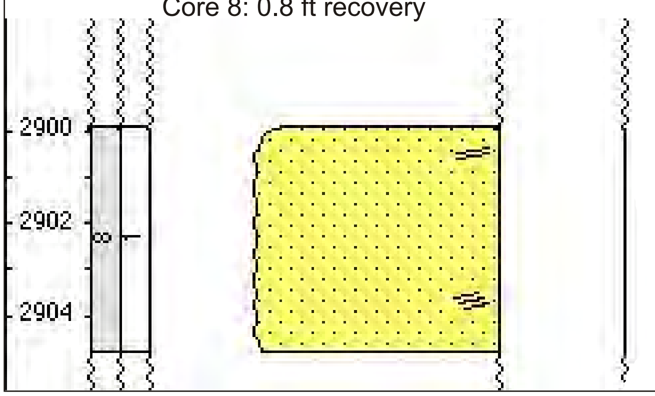
same silty mudst as below ash, but more organic; common carb detritus, root traces, coaly partings near top

- probable 4cm ash layer. white-cream colour

dk grey to grey-green mottled siltstone; strongly blocky fractured with common waxy pedogenic slickensides, some carb detritus and poss root traces

Core 7 - missing

Core 8: 0.8 ft recovery



feldpathic chert litharenite; thick lams to thin beds; some possible low angle cross-strata

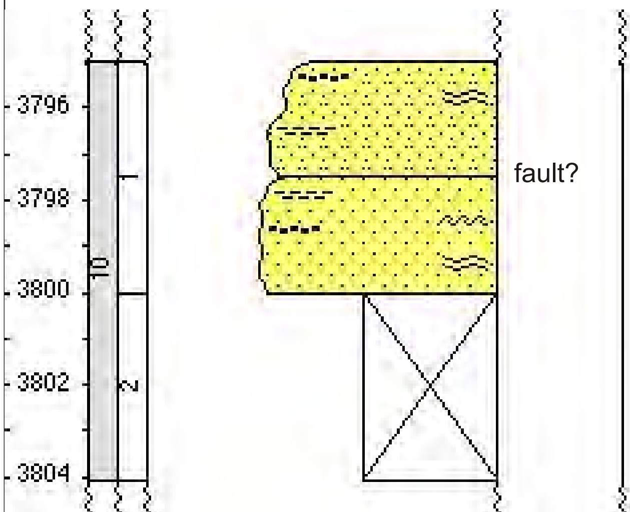
Honolulu Nazko 1960

Location: a-4-L / 93-B-11

Feet	Core and Box	Grain Size (cobble, pebble, granule, sand: v c m f v, silt, clay)	Colour	Remarks

Core 9 - missing

Core 10: 7.9 ft recovery but box 2 of 2 missing



sst: fL-mL, mainly fU, thin mudst stringers locally, abund fractures, some Ca filled; faulted and deformed, sst locally fine lams but most deformed undulatory wavy lams; local carb detritus upward, mostly carbonaceous siltst ripups? siltst mottled, may be burrow-induced but enhanced by diagenesis?

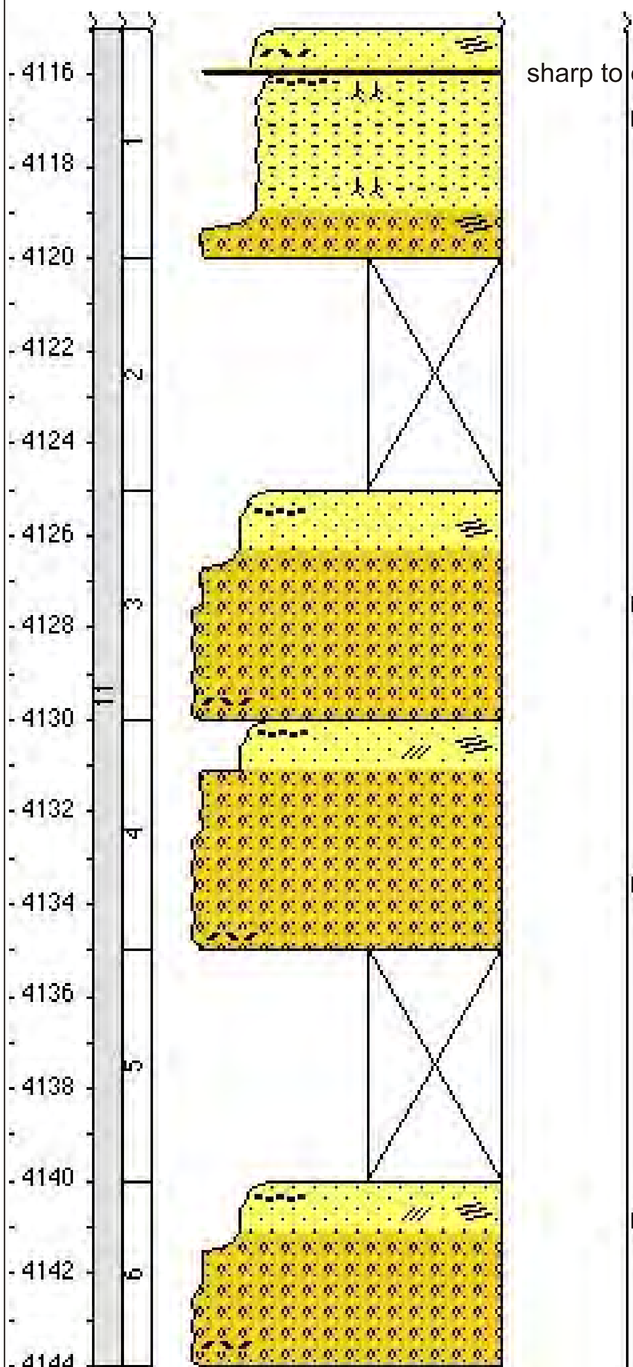
tectonic fault disruption at 3797 ft

Honolulu Nazko 1960

Location: a-4-L / 93-B-11

Feet | Core and Box | Grain Size (cobble, pebble, granule, sand: v c m f v, silt, clay) | Colour | Remarks

Core 11: 23.5 ft recovery but boxes 2 + 5 missing



mostly sst but granule/small peb cgl base w. mudst ripups , clasts: chert, qtz, fspar, mafic volcs, sst is thin-bedded + crudely stratified to low angle // x-strata

sharp to erosive contact

A 3 ft bleached and altered sst, common root traces, carb detritus, easily broken - prob incipient paleosol

B all Core 11 is repeated fining up cycles in ~5 ft thick intervals; sharp to erosive bases overlain by granule to fine peb cgl - well stratified to bedded in internally sl fine up bedsets? mainly low angle planar x-strat but some high angle planar x-strata, mudst ripups at bases; fines up to main cL to mL sst, w low and high angle planar x-strata; rare vfg sst to siltst tops; some coaly detritus and mudst ripups in sst; rare root traces

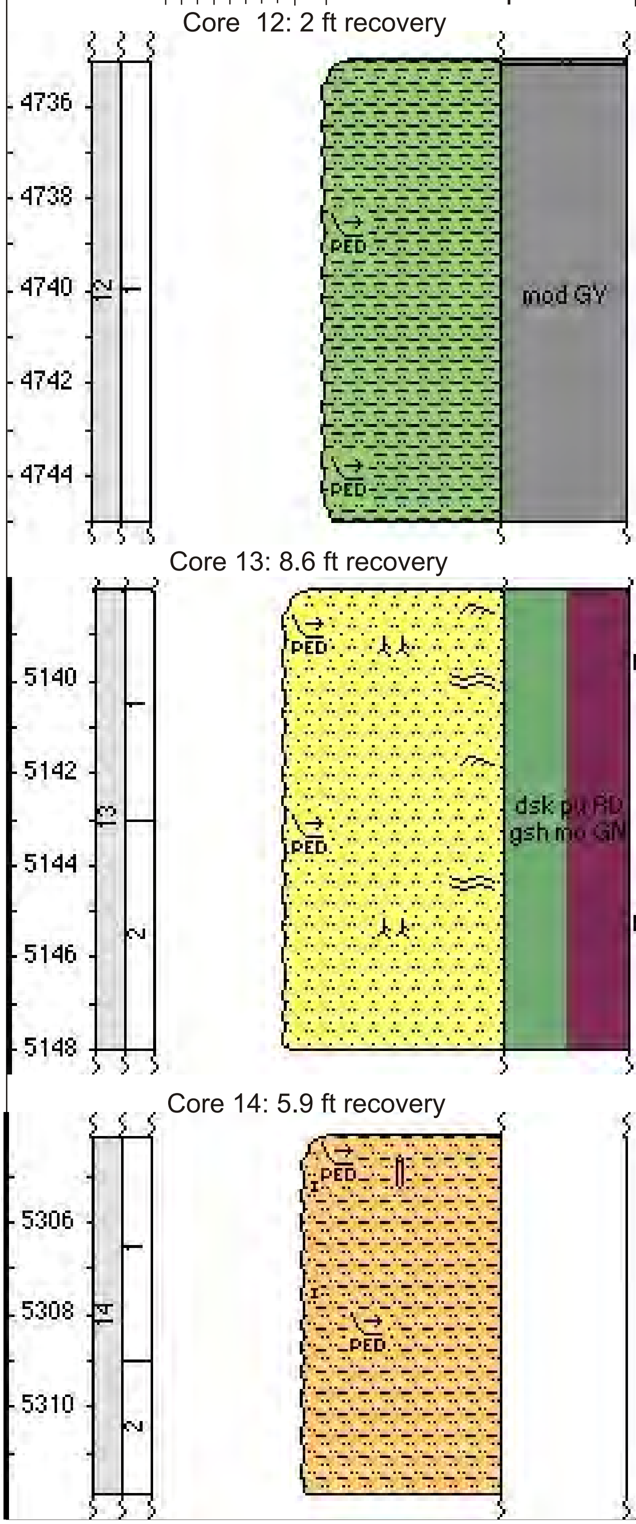
C

D

Honolulu Nazko 1960

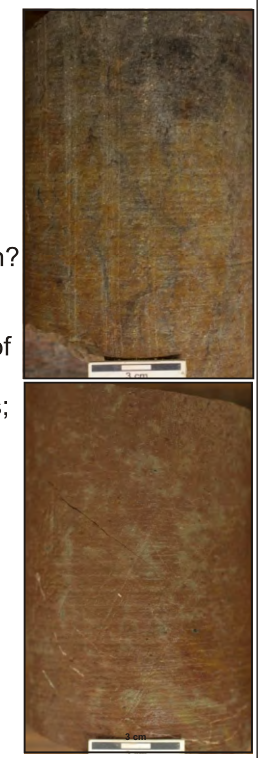
Location: a-4-L / 93-B-11

Feet	Core and Box	Grain Size: cobble, pebble, granule, sand (v c m f v), silt, clay	Colour	Remarks



med grey silty mudstone; blocky fractured with common glossy pedogenic slickensides; isolated dark clay and silt filled tubes - possibly oligochaete-generated?

red stained silty vf to fine sst, some zeolite alteration? prob subaerially exposed with common reduction spots and green mottling of variable lite to dark red colour, some rooted layers; very rare pedogenic slickensides on fractures; some possible insect-generated mottled zones? some remnants of poss wavy // to current rippled sst thin beds



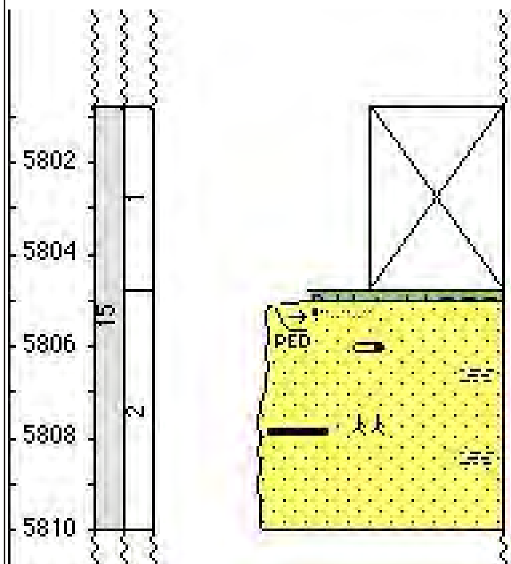
red stained muddy siltstone; small variable slickensided blocky fractures (prob pedogenic), rare Ca filled fractures; very massive looking, esp towards top; some rare isolated burrows (very poorly preserved, poss worm burrows?)

Honolulu Nazko 1960

Location: a-4-L / 93-B-11

Feet | Core and Box | Grain Size: cobble, pebble, granule, sand (v c m f v), silt, clay | Colour | Remarks

Core 15: 9 ft recovery but box 1 missing (only lower 5 ft present)

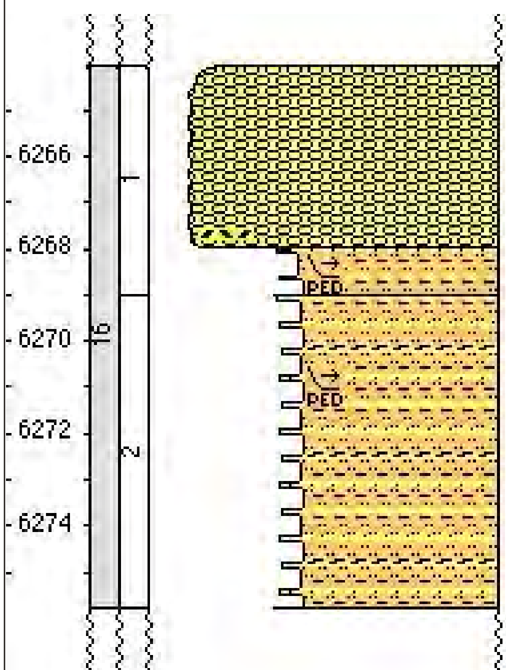


gradational

silty mudst paleosol; contains organic mud-filled oligochaete burrows

mL to fU sst, mod sorted, vaguely laminated, fines up slightly and carb detritus near top, some isolated small roots and sand-filled horiz burrows

Core 16: 6.6 ft recovery



clast-sup cgl of small pebbles to granules in cse-grained sst matrix; clasts are sub-ang to round; most are chert or felsic volc, some qtz; larges pebbles 2.4cm dia; some mudst ripups near base, rare pyrite and rare Ca-filled small fractures

sharp, poss erosive contact?

fractured silty mudst and vfg sst; altered to paleosol in general w common blocky fractures with pedogenic slickensides; some Ca filled fractures; unit slightly more sand-rich toward base (overall fining up cycle but all very fine - poss top of much thicker fluvial fine-up succession?)

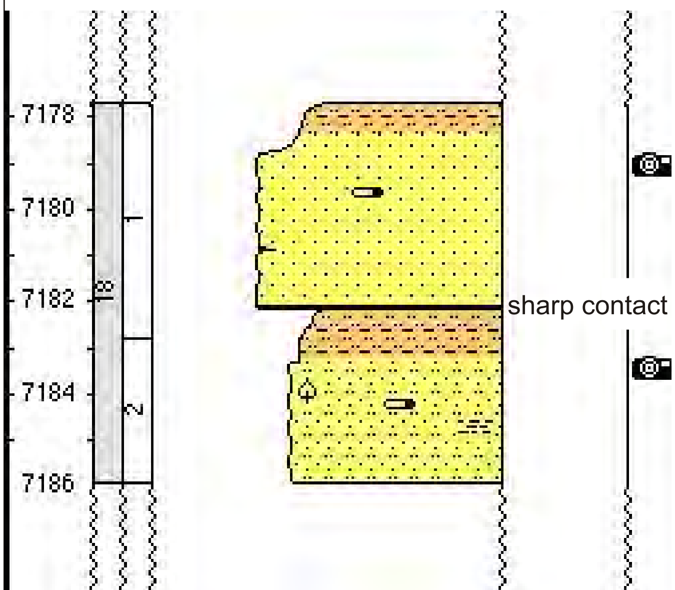
Honolulu Nazko 1960

Location: a-4-L / 93-B-11

Feet	Core and Box	Grain Size: cobble, pebble, granule, sand (v c m f v), silt, clay	Colour	Remarks

Core 17 - missing

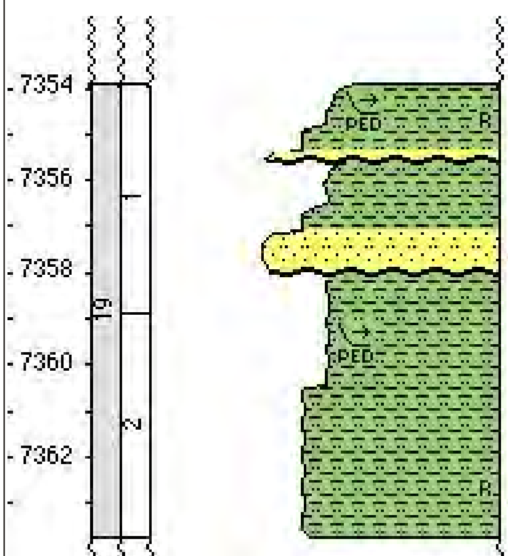
Core 18: 5 ft recovery



two units of massive mU sst in basal 80% grade up to silty mudst to vfg sst at top; sst not obvously stratified, contains rare plant frags, cse sand filled *Planolites*

capping silty mudst to vfg sst is very crudely thin bedded? rare plant frags

Core 19: ~ 9.9 ft reovery



upper 12 cm is silty mudst but altered and pedogenic slicks - paleosol
thin silty fg sst base as below, grades up to mudst

sharp erosive contact

fg silty sst base grades up into massive to vaguely lam silty claystone

sharp erosive contact

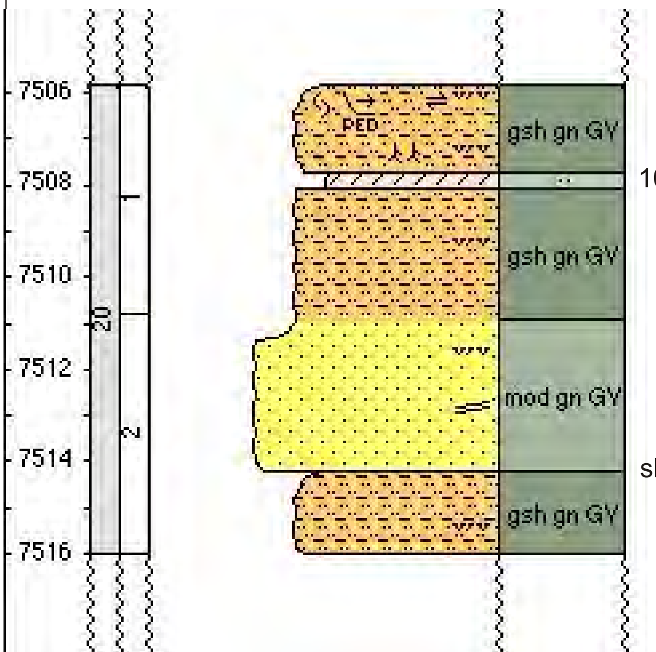
silty claystone w minor thin carbonaceous detritus layers; slightly rubbly, no visible bedding, core broken around 7559 ft with common pedogic slickensides (paleosol)

Honolulu Nazko 1960

Location: a-4-L / 93-B-11

Feet | Core and Box | Grain Size: cobble, pebble, granule, sand (v c m f v), silt, clay | Colour | Remarks

Core 20 ~ 9.5 ft recovery



top 1 ft is mottled, pedogenically altered w some clay-filled burrows (poss oligochaete generated)

10 cm ligt grn-grey tuffaceous layer - poss reworked

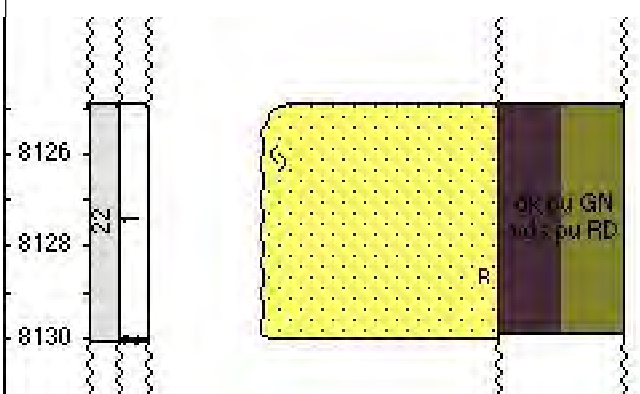
massive muddy siltst as below

~2.5 ft med grained lithic sst, fines up to silty sst at top; crudely low angle x-stratified w. deformation towards top; some adhesive meniscate burrows (*Scoyenia?*); poss oligochaete burrows locally

sharp contact

cse muddy siltst to vfg sst; some volc frags, some Ca filled fractues, sl calcitic, appears mostly massive to very vague lams

Core 21 - 0.7 ft recovery



poor rubbly core and broken core fragments only

- all is volcaniclastic med-cse grained sst; purple-green to some dark red coloured; near top is whitesh-green poss lapilli tuff in rubble

Hudson Bay Redstone 1960 Location: c-75-A / 93-B-4 (C on figure 2)

NOTE: Multiple sedimentary structures in this core indicate it is stratigraphically upside down. Either the strata were tectonically overturned prior to drilling (extremely unlikely given the regional geology of the basin), or the core was mistaken placed in the boxes in reverse order. Given that there is only the single core from this well, the latter seems the more likely explanation. We thus logged this core in what we believe is the correct stratigraphic order, although we did not change the way the core is preserved in the boxes. Thus box 1 here is the log of the core in box 7 in the archive, box 2 is box 6 etc. and the core in the log is shown here in upright stratigraphic position.

Core 1: 170.7-172.2m (560'-565')

Medium- to coarse-grained, massive lithic sandstone with rare faint laminations to thin beds and mudstone rip-up clasts. Facies is difficult to interpret, but may reflect non-marine alluvial fan sand or braided river deposition?

Core 2: 639.7-645.9m (2099'-2119')

Seven stacked cycles of silty mudstone to muddy siltstone, with changes from dark red to purplish silt-rich layers up to 1 ft thick, which pass upward gradationally into more mudstone-rich layers up to 3 feet thick. No primary stratification is preserved, and root traces and some pedogenic structures are present. This appears to be strongly altered flood-basin to floodplain deposit, which was periodically and repeatedly exposed and subject to paleosol development. Unit possibly indicates cyclic changes in climate conditions (wet *vs* dry periods) in a shallow flood-basin setting. Long intervals of pedogenic alteration may have extended paleosol features well into the floodplain deposits.

Core 3: 805.5-807.4m (2643'-2649')

Two fining-upward cycles of fine pebble conglomerate, grading into pebbly sandstone to coarse-grained sandstone. Sharp (probably erosive) base with mudstone rip-ups at base and some trough cross-stratification is present. These are interpreted to record fluvial cycles, probably braided stream deposits. Conglomerate clasts are mostly mafic volcanic types with some chert, suggesting a local volcanic to oceanic terrane source area.

Core 4: 1085-1086.9m (3560'-3566') (Note: only 0.6m recovery)

Variegated green-grey to red-purple muddy siltstone to siltstone, with some carbonaceous detritus, blocky fracturing, and possible pedogenic structures. Unit may record floodplain to flood-basin deposit (though virtually no primary features are preserved, making interpretation uncertain), which was subsequently exposed and altered to an incipient paleosol.

Core 5: 1172.6-1175.3m (3847'-3856')

Massive green sandstone, lack of stratification, and appears volcaniclastic. Unit is fractured, and brecciated, and altered looking, capped by 6" of felsic aplitic intrusive (dyke or sill) at top. Sandstone is “altered” for 10" below intrusive contact. Difficult to interpret due to intrusive alteration.

Core 6: 1304.2-1307.5m (4279'-4290')

Silty mudstone to muddy siltstone with remnant current rippled sandstone. Unit characterized by thin beds in lower part, but common root traces and pedogenic structures occur throughout and is very carbonaceous in the upper 10cm. Some colonial insect burrows (probably ants-generated?) and inclined tubes (oligochaetes-generated?). All intervals are probably originally flood-basin and floodplain, but with several exposure events and extensive paleosol development.

Hudson Bay Redstone 1960

Location: c-75-A / 93-B-4

Date Logged: June, 2006

Logged by: J. MacEachern, P. Mustard

Legend

Sandstone	Sandy Shale	Pebbly Sandstone
Silty Sandstone	Mudstone	tuffaceous
Shaly Sandstone	Organic Shale	Lost Core
Shaly Siltstone	Grain-Sup. Conglomerat	
Silty Shale		

CONTACTS

Sharp	Erosional

PHYSICAL STRUCTURES

Current-Ripple Lam.	Symmetrical Ripple	Low-Angle Tab./Tan Beds
High-Angle Tab./Tan. Beds	Gently Inclined Lam.	Wavy Parallel Lam
Lenticular Bedding	Convolute Bedding	Desiccation Cracks
Synaeresis Cracks	UFR Horizontal Parallel Lam.	Indistinct
Inj./Flame Struc.	R -Rubble	-Horiz. Slicks.
Cracked		

LITHOLOGIC ACCESSORIES

Silt Lamina	Shale Lamina	Coal Fragments
Organic Lamina	Calcareous	Py Pyrite
Rip Up Clasts	Carbonaceous Debris	Palsl Paleosol Horizon
Plant Remains	Mottled	PED Pedogenic Slickenside

ICHNOFOSSILS

Rootlets	Skolithos	Planolites
Teichichnus		

Ⓐ
Ⓑ
Ⓒ
Ⓓ
Ⓔ

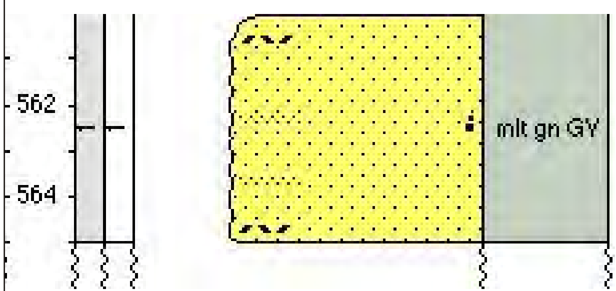
Feet	Core and Box	Grain Size: cobble, pebble, granule, sand (v c m f v), silt, clay	Colour	Remarks

Hudson Bay Redstone 1960

Location: c-75-A / 93-B-4

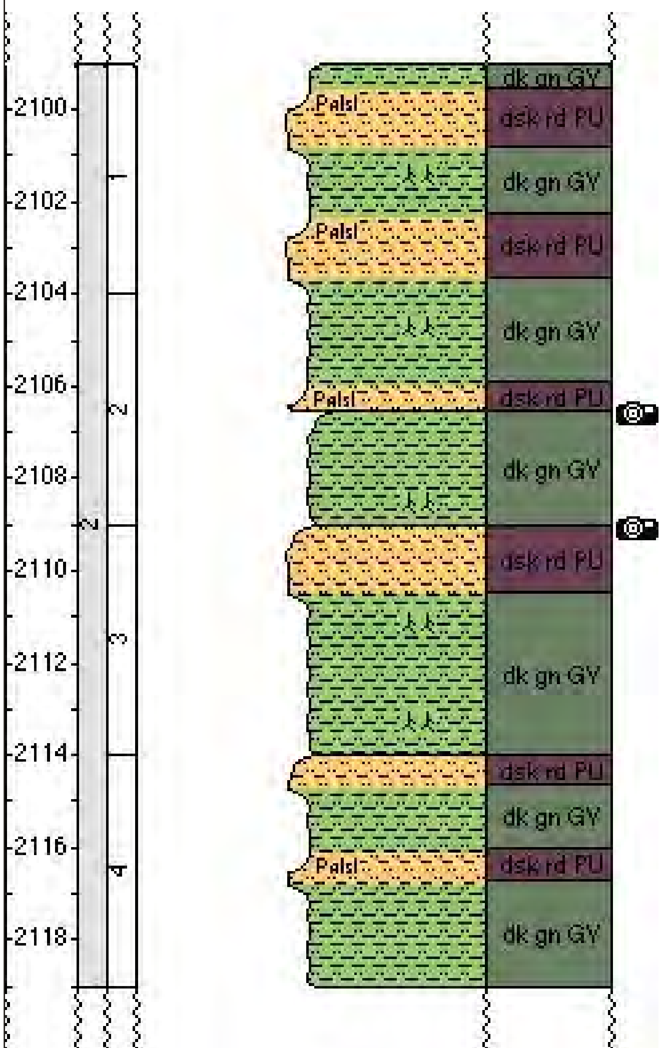
Feet | Core and Box | Grain Size: cobble, pebble, granule, sand (v c m f v), silt, clay | Colour | Remarks

Core 1 - ~ 5 ft recovery



grn-gy volcanic lithic sst - mU to cL, massive to very faint lams to stratified in thin beds (poss vague normal grading) ; rare mudst ripups

Core 2 - ~ 19 ft recovery



silty mudst to muddy siltst; repeated incipient paleosol events, each ~75-200cm thick;

cycles based on colour changes, darker near base, passing through dark grey- green to red-purple

lower parts mainly silty mudst with common root traces, irregular blocky fractures, slightly siltier in dark red parts of cycles ‘

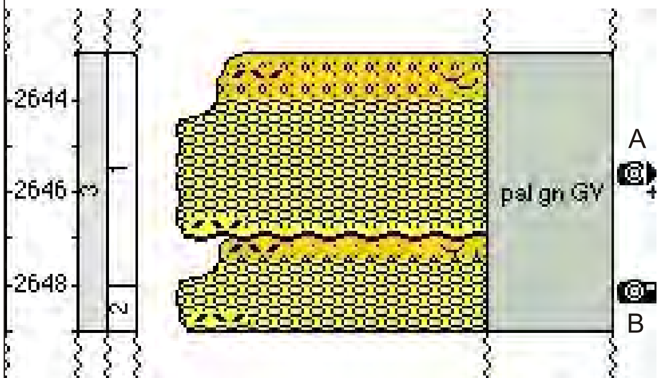
no primary stratification preserved

Hudson Bay Redstone 1960

Location: c-75-A / 93-B-4

Feet	Core and Box	Grain Size (cobble, pebble, granule, sand v c m f v, silt, clay)	Colour	Remarks

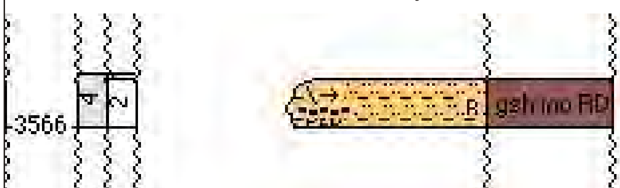
Core 3 - ~ 4.5 ft recovery



cgl to pebbly sst cycles; basal peb-gran clast-sup cgl up to 2 ft thick; mod well sorted, well rd clasts, >90% volcs (grn, red, blk), 10% chert

cgl capped by cse sst with small peb trains and prob trough x-strata, some mudst ripups

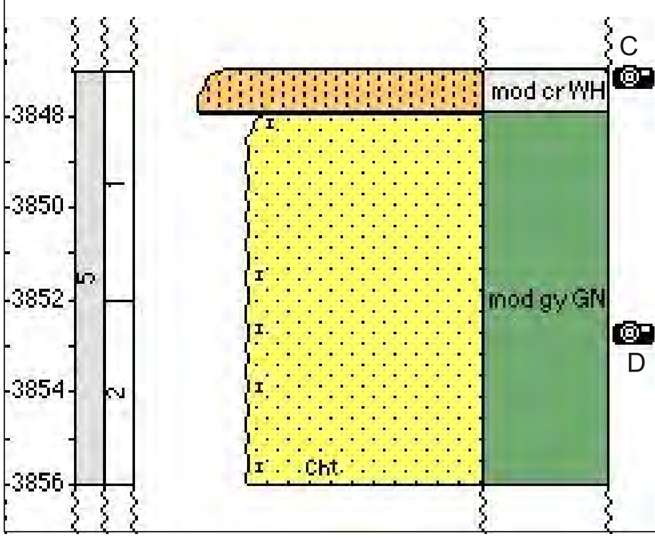
Core 4: ~ 2 ft recovery



muddy siltst to siltst: variegated grn-gy to red-purple, massive, some carb detritus, blocky fracs + some wavy slickensides - prob pedogenic

- all prob incipient paleosol

Core 5: ~ 9 ft recovery



felsic intrusive (dyke/sill?) aplitic, cuts core at low angle

intrusive contact and altered sst for 25 cm below contact

sst: mL-fL, green, fractured and brecciated w Ca infills common + calc throughout, altered looking; appears volcaniclastic?

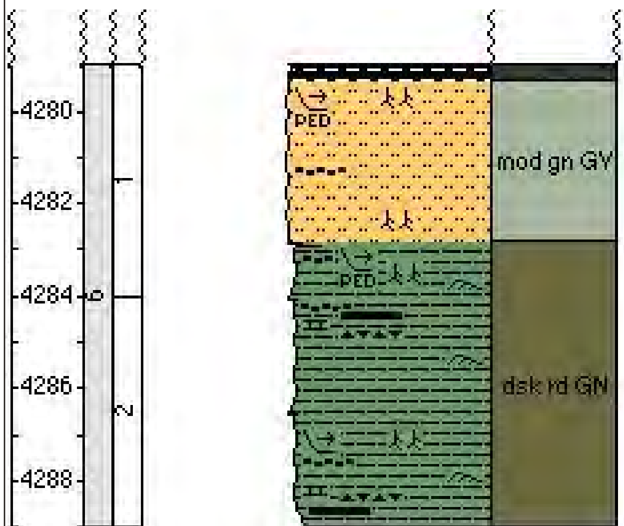
- no stratification

Hudson Bay Redstone 1960

Location: c-75-A / 93-B-4

Feet | Core and Box | Grain Size: cobble, pebble, granule, sand (v c m f v), silt, clay | Colour | Remarks

Core 6: 10 ft recovery



grn-gy siltst; carb detritus and root traces common and increase upward; rare colonial insect burrows (ant?), isolated dark mud-filled horiz to inclined tubes (oligochaetes?); carbonaceous in upper 10cm w smaller, variable waxy slickensides

highly brecciated silty mudst w. rare silty sst stringers, blocky fractured w common wavy pedogenic slickensides; minor fU sst interlams with remnant current ripples, sst feldspathic but green (chloritic?)

Canadian Hunter et al. Nazko Location d-96-E / 93-B-11 (D on figure 2)

Core 1: 315-321m (most of box 3 missing)

Basal 1m is a moderately well-sorted, fine-grained sandstone with low-angle inclined strata (possible SCS?) that probably formed in a high-energy, shallow marine shoreface. The unit is sharply overlain by ~3m of heterolithically intercalated silty mudstone and vfg sandstone beds and laminae. Common oscillation and combined flow ripples and wavy laminations and several ichnogenera characteristic of higher energy (e.g., *Skolithos*, *Rosselia*, fugichnia) alternating with ichnogenera typical of generally lower energy regimes (e.g., *Teichichnus*, *Planolites* and *Chondrites*). Facies is consistent with a moderate diversity suite characteristic of the archetypal *Cruziana* Ichnofacies, but minor amounts of syneresis cracks may suggest some salinity variations occurred. Unit is characteristic of a shallow subaqueous deposition, consistent with a marine shoreface lying along strike of deltaic influx or within a wave-dominated distal delta front. Facies is probably genetically related to the underlying sandstone.

Core 2: 415.4-424.4m

A basal 0.3m of silty mudstone with red-green mottling, probably recording a paleosol. Sharply and probably erosively overlain by >4.5m of interbedded pebble conglomerate and pebbly sandstone in two cycles. The lower cycle fines upward to trough cross-stratified pebbly to coarse-grained sandstone, sharply overlain by a coarsening-upward cycle of medium-grained sandstone capped by an interbedded conglomerate-sandstone unit. The lower fining-upward cycle contains mudstone rip-up clasts and rare carbonaceous detritus. Several conglomerate beds are normal graded, passing into pebbly sandstone. Facies appears to record graded gravity flows changing to sandy fluvial systems at their top (possibly alluvial fan changing to braided fluvial). The upper coarsening-upward sandstone to conglomerate contains wavy laminations, current ripples, and isolated *Planolites,* possible *Skolithos* and fugichnia. Traces are consistent with sandy subaerial burrowing of insects or arachnids. Deposition could represent a subaerial sand dune deposits, which are covered by prograding alluvial fan gravity flows (gravel debris and sheetflows) and minor braided stream deposits.

Clasts in the conglomerates are >80% cherts of various colours plus mafic volcanics and some quartz and possible quartzite clasts? Most clasts suggest an oceanic terrane to volcanic arc sources (but not the quartzites if real).

Core 3: 483-485m

Moderately sorted, pebble conglomerate interbedded with pebbly sandstone in crude beds. Probable facies expression of lower alluvial fan gravity flows (gravelly sheetfloods and minor debris flows). Clasts are >70% chert of many colours with some quartz and possible quartzite clasts. Probably an oceanic terrane source? (but not for quartzite!)

Core 4: 590.5-600m

Basal 0.6m of massive, very coarse sandstone appears weathered and altered, with original sedimentary structures lost. Unit probably is the result of extensive subaerial weathering of an original fluvial sandstone. In the context of the underlying unit, the sandstone may correspond to a crevasse splay unit.

594.6-597.7m interval is dominated silty to clay-rich mudstone, much of it carbonaceous and with some plant fragments and coaly stringers. A 0.6m thick, fine- to medium-grained silty sandstone in the middle of this interval has fine carbonaceous films and common burrows probably insect-generated. This interval as a whole is probably a low-energy lacustrine to lagoonal succession with some fluvial input. The upper half of the core consists of 2.5m of fine-grained sandstone with wavy to flaser bedding, and common ripples, including oscillation, combined-flow and current types. The facies appears to be a moderate-energy, subaqueous environment influenced by waves. In context with the non-marine nature of the enclosing mudstones, and general paucity of biogenic structures (Planolites and fugichnia), this sand was probably deposited as a sandy lacustrine margin setting. This is overlain by >2.5m of dark gray carbonaceous silty mudstone, which is blocky and massive and has some pedogenic structures, some remnant burrows (Planolites) and some siderite nodules. This upper succession most likely represents an organic-rich lacustrine setting that was later subaerially exposed and subject to incipient paleosol development.

Core 5: 912.5-921.5m

One and a half metres of basal sandstone fines upward to several, repeated 1 to 3m thick intervals of massive silty mudstone to siltstone, which becomes increasingly carbonaceous upward. In two places, the unit is capped by ~0.6m thick, highly carbonaceous to coaly mudstone intervals. The sandstone contains wave and oscillation ripples, and some slightly aggradational ripples with mud interlaminae between ripples. It probably represents a moderate-energy shoreline of a non-marine lacustrine environment or a broad flood-basin setting. The unit grades into the thickest silty mudstone containing common plant fragments, root traces, and blocky fracturing with some pedogenic structures. This could correspond either to continued flood-basin or lacustrine deposition. In any event, these units become increasing organic rich, but were periodically and repeatedly subaerially exposed to cause weathering and paleosol development. The cyclic nature may reflect repeating wet/dry climate cycles?

Core 6: 957-966m

Almost 10m of moderately, well-sorted, fine- to medium-grained sandstone. Thin-bedded to laminated units with rare granules at the base of beds and rare mudstone rip-up clasts, as well as rare carbonaceous detritus. Succession appears to consist of subtle, repeated 0.3-0.6m cycles of amalgamated bedsets. Stratification is predominantly parallel planar to undulatory laminations, and some low-angle cross-stratification (possible SCS?). Some intervals also includes rare trough cross-stratification. Top 1m has common oscillatory and combined-flow ripples, with carbonaceous detritus in some ripple troughs. Unit appears to display possible cryptic bioturbation, but no obvious trace fossils preserved as discrete ichnogenera are apparent. This thick and relatively well-sorted and clean sandstone with some wave sedimentary structures probably represents a moderate- to high-energy, subaqueous setting, most likely a shoreface environment though the setting could either be marine or non-marine (e.g., lacustrine margin or a large system). Unit is most likely marine middle shoreface.

Core 7: 1140-1149m

Almost 10m of upper fine- to less common medium-grained sandstone. Sandstone is slightly micaceous and very well-sorted, with local carbonaceous detritus demarcating low-angle cross-stratification (SCS?) and horizontal stratification. Rare trough cross-strata occurs, especially near base and top of the unit. Some possible cryptic bioturbation is present, but no obvious trace fossils preserved as discrete ichnogenera. This relatively clean sandstone probably formed in a moderate- to high-energy, subaqueous shoreface environment (though it is unclear as to whether the facies was deposited in a marine or non-marine environment).

Cores 8+9: 1370.8-1374.5m

About 3.6m of sandstone, which subtly fines upward from coarse to medium grained. Some mudstone rip-up clasts are present, as well as trough cross-stratification. No biogenic structures are present. Hematite staining and remnant root traces occur in upper half of the core, and some oversteepened cross-strata near the top of the core. This is probably a thick fluvial channel deposit, forming part of a meandering fluvial system.

Core 10: 1399.4-1400.3m

Moderately well-sorted, fine pebble conglomerate in a coarse-grained sandstone matrix. Unit appears massive, but with only 50cm of recovery, this is uncertain. Unit is interpreted to be of fluvial origin, due to the sorting, and probably records accumulation near the base of a fluvial channel. Clasts are mostly chert with lesser mafic volcanics, as well as rare quartz and possible quartzite. Probably sourced from oceanic crust terrane source area (but not for the quartzite).

Core 11: 1550-1559m

The lower half of this core comprises a basal 0.6m unit of silty mudstone, with rare vfg sandstone laminations containing small oscillation ripples. Small and rare *Planolites* and fugichnia are present. The facies is likely a brackish-water, subaqueous marginal marine deposit. Above this is ~ 2.5m of fine-grained sandstone and heterolithic sandstone-silty mudstone. Oscillation ripples and wavy subparallel laminae are common, and current ripples are rare. Syneresis cracks are consistent with salinity fluctuations. Trace fossils comprise a facies-crossing (stressed) suite of *Cylindrichnus*, *Planolites*, *Skolithos* and fugichnia, consistent with a salinity stressed setting. This succession corresponds to a subaqueous, brackish-water, moderate-energy marginal marine environment, such as the sandy margins of a sheltered bay.

At 1556.3m, a sharp transition to 2.5m of silty mudstone containing rare vfg sandstone laminae and thin beds. The unit is dense and massive in the lower half, but becomes increasingly laminated with more common sandstone interbeds in the upper half, including some oscillation ripples. Some possible pedogenic structures occur in the lower part, as well as a single possible Planolites. This unit formed in a very quiet-water subaqueous environment, and in context with the overlying unit, may represent muds of the prodelta area of a bay-head delta system. The pedogenic features in the mudstone are enigmatic - may be indicative of periods of post-depositional exposure.

The mudstone unit is sharply overlain by ~2m of moderately well-sorted, fine- to medium-grained sandstone in a subtle coarsening-upward succession. The unit is heterolithic at the base with silty mudstone interlaminae, common oscillation ripples, and slightly carbonaceous mud drapes. The central part of the unit contains low-angle cross-stratification (possibly SCS?), and horizontal parallel lamination changing to high-angle cross-stratification near the top (planar tabular cross-beds?). Trace fossils are sparse, restricted to a few *Planolites* and rare fugchinia. This succession likely represents a wave-dominated, shallow delta-front environment, possibly part of a wave-dominated sandy delta complex.

The upper 2.5m comprises heterolithic, well-sorted, fine-grained sandstone and silty mudstone laminae. Thin beds of sandstone are dominant in the central 5 ft. of the unit. Wavy parallel lamination, combined-flow and oscillation ripples are fairly common, some ripples draped by mud lamina. Some rippled successions are aggradational. Trace fossils are rare, with some *Planolites* present, and possible *Skolithos* and *Thalassinoides* present in the top 0.6m of the core. This interval probably represents a shallow, wave-washed delta-front environment. Deposition could have occurred in brackish-water settings (e.g., bay-head delta) or in a setting characterized by rapid deposition: both settings being conducive of sparse bioturbation.

Cores 12 + 13: 1727-1731.6m

This core comprises three genetically related intervals. A basal ~1.5m interval of interbedded, clast-supported, fine pebble conglomerate and pebbly sandstone in mostly horizontal stratified, crude beds, some with normal grading. Above this lies ~ 1m of massive and non-graded, pebble conglomerate that may be crudely layered into 2 beds. This conglomerate gradationally changes at its top to ~ 2m of progressively fining-upward beds of fine pebble conglomerate, pebbly sandstone, and ultimately very coarse-, coarse-, to medium-grained sandstone with minor pebble stringers. Carbonaceous detritus is locally present, and parts of the sandstone display small trough- and possibly planar cross-stratification. No trace fossils are present in this core. The interval most likely represents lower alluvial fan to proximal braidplain depositional environments, with the conglomerate-rich intervals deposited from gravel sheetfloods and very coarse-grained braided fluvial transport, changing upward to sandy braided systems, including formation of major sandy barforms. Clasts are dominated by chert types, suggesting an oceanic crust terrane source area.

Core 14: 1812-1819m

Interval comprising greater than 6.5m feet of repeated fining-upward cycles of sandstone and silty mudstone. Sandstone is typically medium- to fine-grained (fining-upward slightly in each cycle), stacked in 0.6 to 1.5m thick intervals. Cycles are terminated silty mudstone. All is reddish or mottled red-green altered and with minor pedogenic structure (mainly slickensides) in several layers. Root traces are fairly common, especially in the mudstone, although altered with oxidation haloes around probable traces. An odd vertical fabric of mottled red and light green to cream colours are common in both mudstone and sandstone layers. Most layers appear massive but this probably reflects strong alteration and loss of primary structures. Some small tubes and mottling may reflect insect-generated (adhesive meniscate burrows) and possible worm-generated biogenic structures.

These cycles probably reflect original terrestrial, low-energy fluvial – floodplain systems, which were regularly exposed and deeply weathered between times of renewed wet conditions and fluvial migration. This could reflect cyclic climatic variations or minor tectonically induced uplift and subsidence events.

Core 15: 1838-1848m

The lower 4m of core is red-stained, massive silty mudstone with minor disseminated vfg sandstone stringers. Core is blocky and fractured, with common pedogenic structures and appears “leached” in the upper 1m. Very rare, isolated small burrows may be insect (ant or termite) generated. This succession is a highly weathered mudstone, possibly originally lacustrine, but now mostly altered by deep weathering during subaerial exposure.

A central 1m thick, clast-supported pebble conglomerate sharply overlying the basal mudstone. The conglomerate is moderately well-sorted and crudely stratified into horizontal beds, which grade crudely up to thin but very coarse-grained pebbly sandstone interbeds. These are probably proximal braided stream or gravelly sheetflood deposits, possibly reflecting progradation of a small alluvial fan into the depositional area.

The conglomerate is sharply overlain by ~ 2.5m of silty mudstone that is very similar, overall, to the basal mudstone described above. The unit probably reflects a renewed period of lacustrine or flood basin deposition, followed by extensive subaerial exposure leading to intense and deep weathering. The presence of insect-generated burrows (ant, termite and/or beetle) are consistent with paleosol settings, and may record expressions of the *Coprinisphaera* Ichnofacies.

The top ~2.5m of core comprises ~ 1.5 of very fine-grained sandstone, which sharply overlies the underlying mudstone and grades up to ~ 1m of silty mudstone. The sandstone is altered looking, and is green-grey with rare chert pebbles. It appears massive, but primary structures are likely masked by alteration. Some carbonaceous detritus and root traces are present. The overlying mudstone contains organic detritus and pedogenic structures, and appears more altered near the top of the core. This interval probably represents an original low-energy fluvial fining-upward cycle, which (as for units below) was subsequently exposed and deeply weathered.

Core 16: 1883-1891m

The lower ~ 3.5m consists of medium-grained sandstone, moderately sorted, and in stacked cycles of bedsets 0.3 to 1.2m thick. Beds contain planar and trough cross-stratification, common small mudstone rip-up clasts, and some carbonaceous detritus. Some soft-sediment deformation and minor current ripples are present in the upper part of this interval, which also contains some possible vertical burrows (*Macanopsis*?) and beetle-generated adhesive meniscate burrows (adm). This sandstone unit is probably the deposits of a sandy fluvial system, possibly the amalgamated deposits of rapidly migrating braided stream bar systems.

At ~ 1887m, a sharp and strongly burrowed contact occurs, with a few cm of very fine-grained cream-coloured sandstone, which subtends abruptly into underlying burrowed silty sandstone. Unit changes upward into mudstone laminations that appear to have been biogenically homogenized. This unusual contact probably reflects an important depositional boundary, possibly a flooding surface or transgressive surface of erosion.

The ~1.2m thick unit above this contact is a heterolithic, very fine-grained sandstone and silty mudstone succession, which contains remnant oscillation ripples and some mudstone rip-up clasts. The unit contains moderately abundant trace fossils including *Planolites*, *Chondrites*, and possible *Phycosiphon* - the latter two ichnogenera are more characteristic of marine settings. This interval probably represents shallow water deposition, possibly in a marginal marine environment, for example.

Above this unit occur 0.6m of similar, intercalated silty mudstone and sandstone, but with a mottled gray-green colour and both carbonaceous detritus and root traces. This was probably originally deposited in a similar environment as that below, but was subsequently exposed and altered due to weathering.

The unit at about 1885-1887m is mostly a dark grey, silty mudstone, but again appears slightly altered with pedogenic structures. In the upper 0.6m, unit becomes red-stained and contains more common root traces and pedogenic structures. This was possibly originally a lacustrine or flood-basin mudstone, which was rooted and deeply weathered due to subsequent subaerial exposure.

The top unit consists of ~ 1m of pebble conglomerate and minor coarse-grained sandstone at top. This unit sharply and probably erosively overlies the mudstone below. The conglomerate is clast-supported and massive with no obvious internal stratification (though the core is very broken here). Abundant mudstone rip-up clasts and wood fragments are present at the base. This unit may represent the basal part of a fluvial channel, or alternately debris flow to crude sheetflood deposits of an alluvial fan environment. Clasts are dominated by many types of chert with lesser amounts of mafic volcanic, dolostone, and quartz clasts. This is likely sourced from an oceanic crust terrane (looks like Cache Creek lithologies, actually).

Core 17: 2057-2059.5m

About 2.5m of clast-supported pebble and cobble conglomerate in a coarse-grained to granule matrix. Moderately sorted unit, with some matrix-rich zones, but no obvious stratification or grading internally. Probably alluvial fan debris flow deposition (although a bit better sorted than might be expected). Clasts are chert (many types) and significant orange-altered dolostone, with minor volcanic mafic clasts. Some chert clasts appear to contain radiolarians. Source area is probably oceanic crust terrane (looks like Cache Creek lithologies, actually).

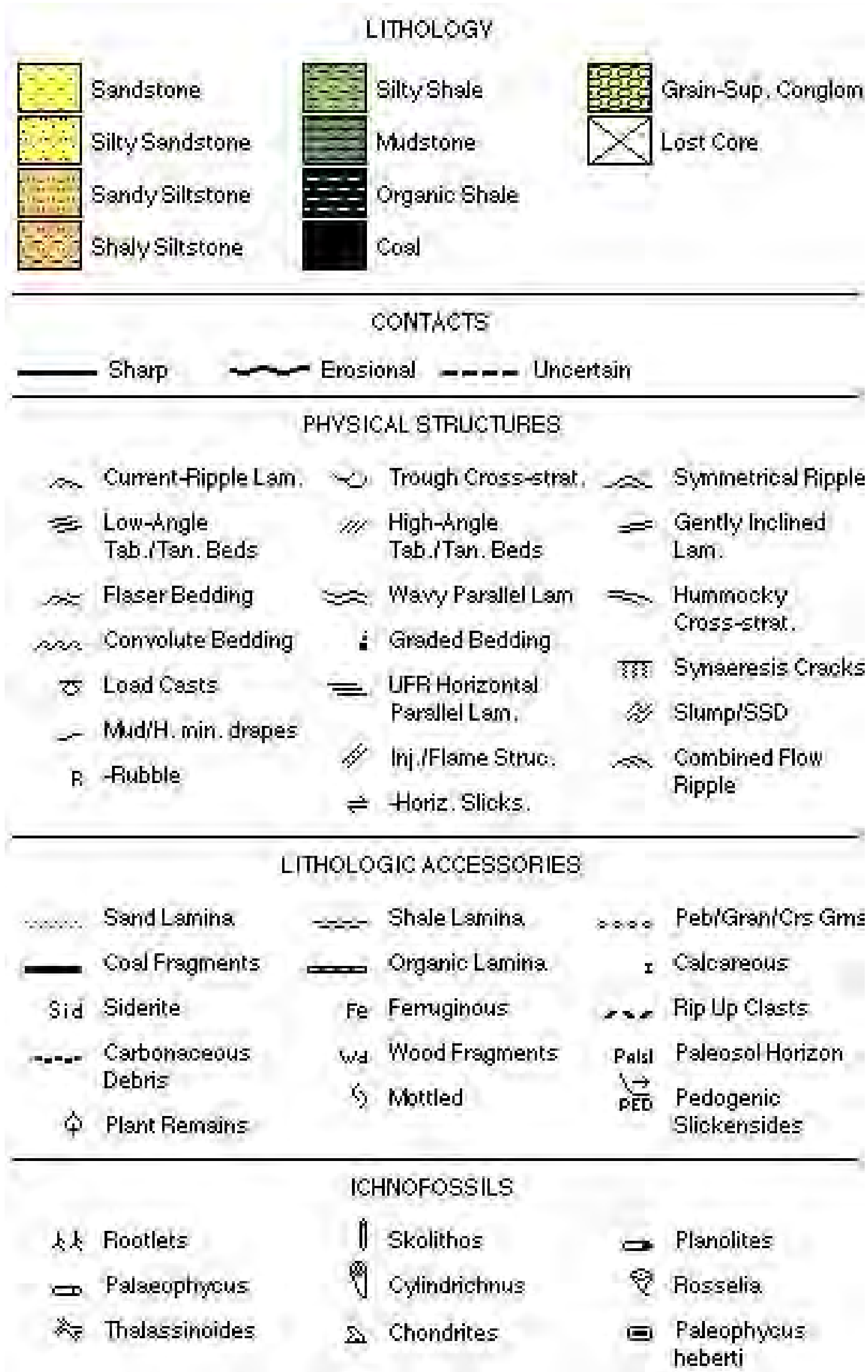
Canadian Hunter et al Nazko

Location: d-96-E / 93-B-11

Date Logged: June, 2006

Logged by: J. MacEachern, P. Mustard

Legend

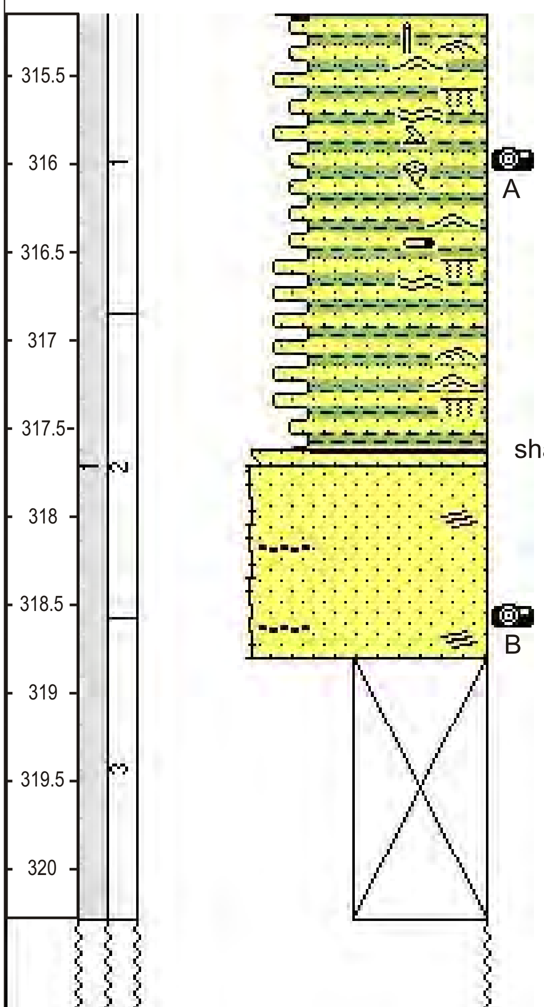


Canadian Hunter et al Nazko

d-96-E / 93-B-11

Metres | Core and Box | Grain Size: cobble, pebble, granule, sand (v c m f v), silt, clay | Photo | Remarks

Core 1: ~4.25 m recovery



heterolithic silty mudst and vfg sst: ~1:1 ratio; some sst beds thicker (to 10cm) w wavy lams to osc ripples, incalated ww cm-scale (lam to thin beds) of sst w wavy lams to osc ripples + some combined flow ripples; mudst are silty and contain rare syneresis cracks:

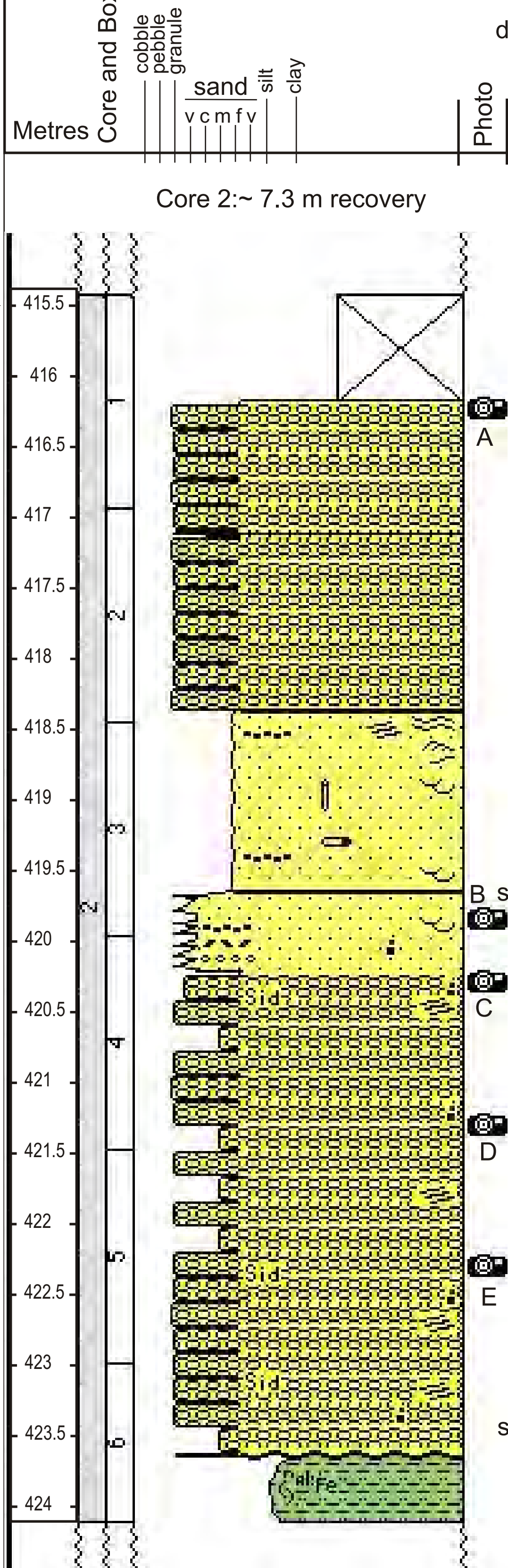
sst layers some some burrowing in the cm scaled intercalated heterolithics; BI 0-2, isolated *Planolites*, *Rosselia* (single), *Skolithos, Teichichnus, Chondrites*, a few elongate tubes they may be *Helminthopsis*?

sharp?

fU sst: mod well sorted; low angle undulatory to // lams showing slight inclination changes (possible SCS?); rare Ca cement filled fracs, some carb detritus, some demarcating lams; BI = 0, one fugichinia trace

Canadian Hunter et al Nazko

d-96-E / 93-B-11



Remarks

pebble cgl; clast-sup with rare v cse sst interbeds; very similar to lower cgl unit; mostly fine pebbles (<2cm dia, rare up to 5cm); crudely bedded

mL-fU sst; well-sorted, beds 7-10cm thick; some carb detritus, rare clayst interbeds draping current ripples and in toesets of trough x-beds, smally wavy lams at top
some low angle x-strata; BI 0-1: isolated fugichnia and *Planolites*, poss *Skolithos*

B sharp

top 50cm orange brn sl pebbly cse to granule sst: rare trough x-beds at top

pebble cgl w pebbly sst interbeds; ~80% clast-sup cgl, 10% pebbly sst + cse grained sst. Typical cgl has cse sst matrix, clasts 30% discoidal // to bedding, clasts >80% chert (dk gy, lite gy, grn,red) some poss qtzite clasts. cgl beds massive and most > 10cm thick in crude horiz beds, very crudely internal stratified; sst interbeds are cL to pebbly in beds 2-40cm thick, some normal graded, rare mudst ripups at bases and rare carb detritus, some siderite and altered orange grains in sst and cgl sst matrix;

sharp, erosional

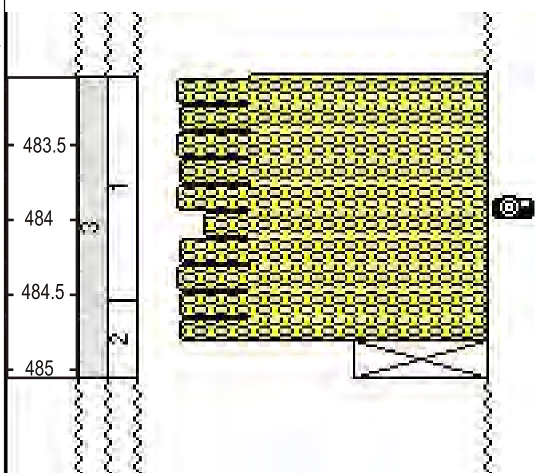
silty mudst: reddish to grn-brn mottled, blocky fractures, no visible carb detritus, hematite stained fracs, highly leached appearence - poss paleosol?

Canadian Hunter et al Nazko

d-96-E / 93-B-11

Metres	Core and Box	Grain Size: cobble, pebble, granule, sand (v c m f v), silt, clay	Photo	Remarks

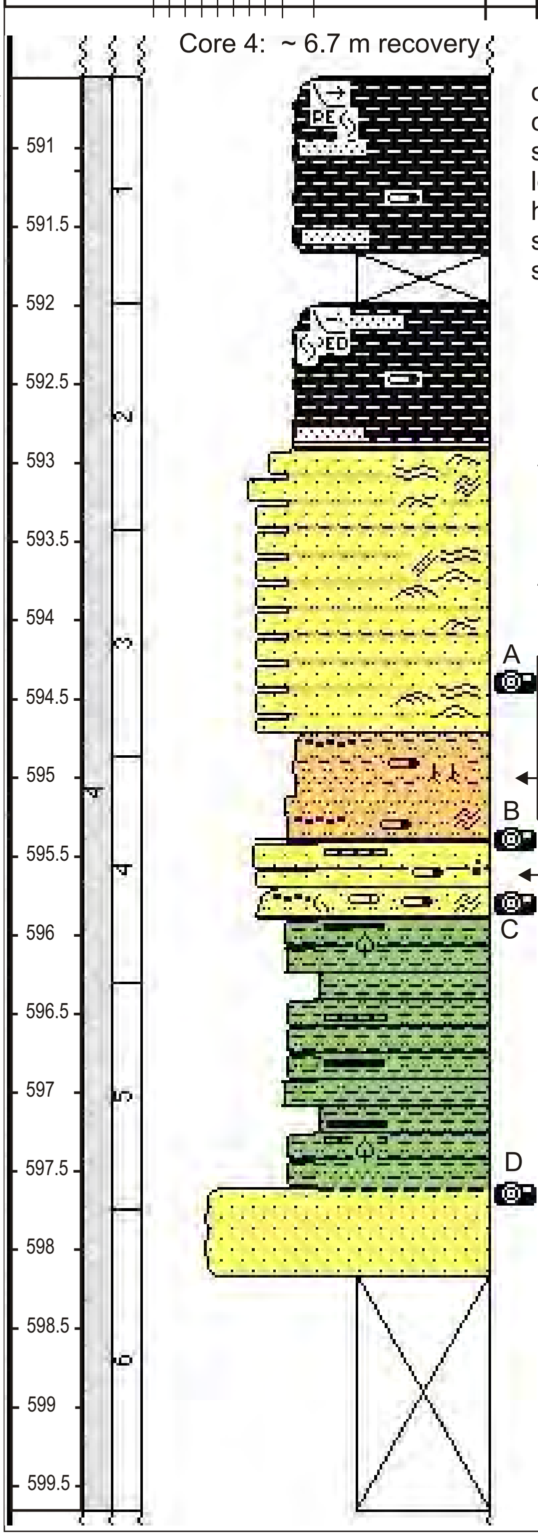
Core 3: ~ 1.5 m recovery



pebble conglomerate; mod sorted, mainly small pebbles (max 5cm dia, most 1-2cm); clast supported in a coarse grained sst matrix; interbedded with minor pebbly sst; crude bedding in layers of larger vs smaller pebble concentrations; clasts 10% subang, mainly round-sub rd, >70% chert clasts (dk gy, blk, red, grn) some poss qtzite and quartzose grains

Canadian Hunter et al Nazko

d-96-E / 93-B-11



Remarks

carbonaceous silty mudst; dk gy, sly clay-rich in part, mottled + massive, some blocky fracs w pedogenic slicks, locally to 30% fg sst lams, unit is heavily contorted / deformed, BI 0-1: soem remnant burrows (*Planolites*), some siderite nodules

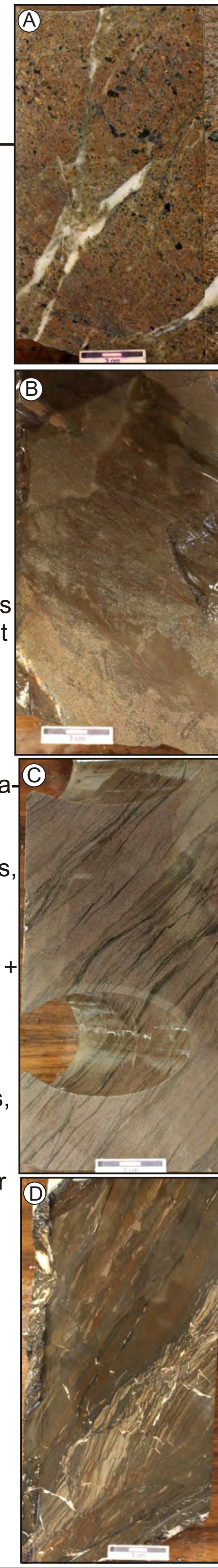
sst: fU w. 15-20% silty mudst, gy brn, wavy to flaser bedded, soft sed def'm and oversteep beds, carbonaceous films and partings to 4mm, comb flow, current and osc ripples in sst, minor gravity faults, loads and flames, upper 1m is mainly mL sst with <3% carb detritus

siltst: clayey w sst base + mudst interbeds, abund coaly debris, some Ca-filled fracs. burrows near base of *Planolites*, fugichnia? some soft sed def'm near base. some poss root traces, no visible burrows in upper part

silty sst: fU-mL crude lams/thin beds, poss norm graded, com soft sed def'm + burrows, com fine carb detritus, BI 2-3: insect generated (sand filled) burrows, rare lined, prob terrestrial

silty mudst: carbonaceous, vague lams, comon plant frags, some very carb to coaly layers to 1cm thick; some hematitie statined sst stringers, sandier in lower 10cm

sst: cU-granule, altered pinkish w Ca filled frac, appears highly weathered, massive, chert, qtz + volc granules

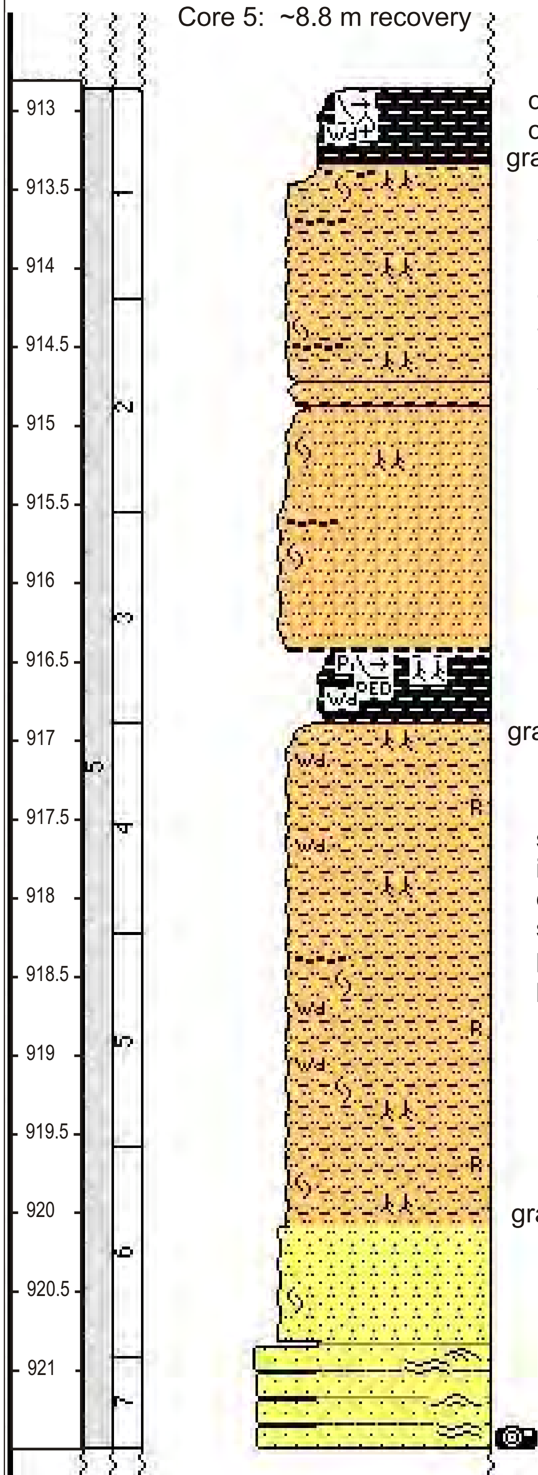


Canadian Hunter et al Nazko

d-96-E / 93-B-11

Metres	Core and Box	Grain Size: cobble, pebble, granule, sand (v c m f v), silt, clay	Photo	Remarks

Core 5: ~8.8 m recovery



carbonaceous mudst; rubbly, very carb to coaly w. bituminous coal frags

gradational

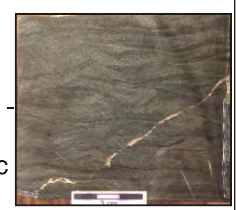
sandy siltst to silty mudst; sandier near base, increasingly brecciated and carbonaceous up, common plant frags and root traces, some brecciated blocky fracs with pedogenic slickensides - incipient paleosol

gradational

siltst to silty mudst; very rubbley, increasingly carbonaceous up, common plant frags and root traces, some brecciated blocky fracs with pedogenic slickensides - incipient paleosol

gradational

silty sst: vfg to silty to clayey, mottled gy - grn, increasingly broken upward, some mottling in upper 40cm, may be biogenic



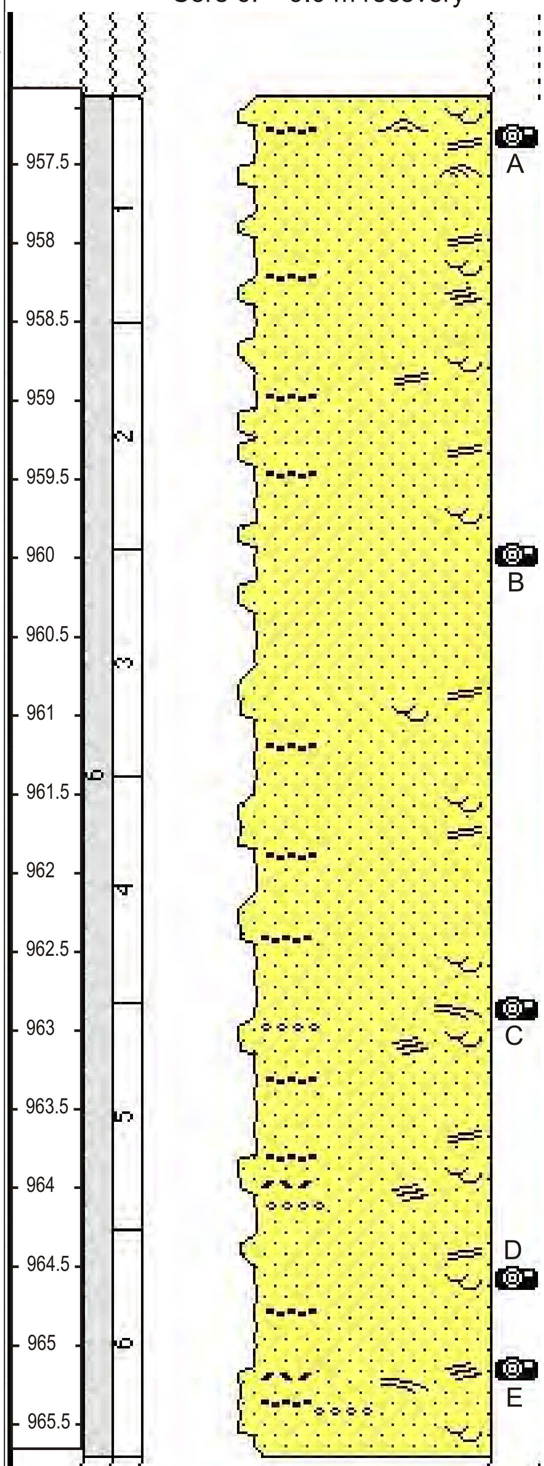
sst: fU-mL, gy-grn w 5% mud interlams between ripples, wavy to osc ripples common, rare comb flow ripples, slightly aggradational, some Ca cement and Ca-filled fracs

Canadian Hunter et al Nazko

d-96-E / 93-B-11

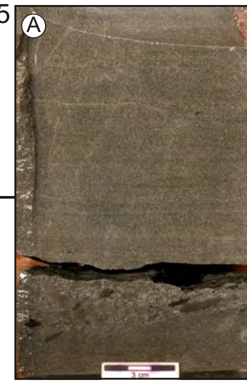
Metres | Core and Box | Grain Size: cobble, pebble, granule, sand (v c m f v), silt, clay | Photo | Remarks

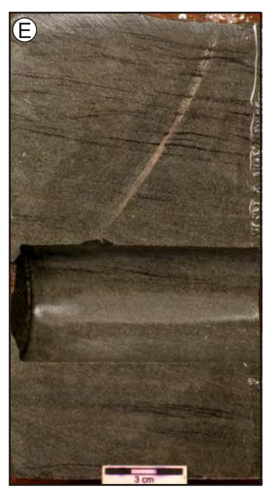
Core 6: ~9.0 m recovery

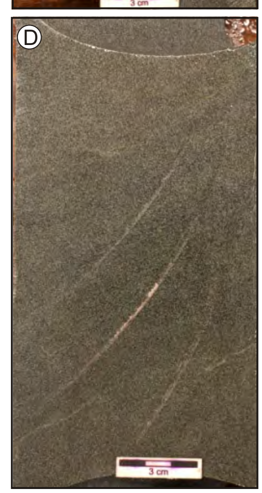


top 1 m has common osc and comb flow ripples w. carb detritus marking lams, rippled zones are finer grained, carb detritus mostly in troughs of ripples

sst, grn-gy, mod well-sorted; sst beds alternate between fU and mU dominate, chert and volc granulates at base of some, rare mudst ripups, most in lower part; cser sst with granule bases have sharp (erosive?) bases, some carb detritus, and are dcm scale, with some trough x-strat; fU sst beds are sl better sorted, w common low angle planar // to undulatory // lams in amalgamated bedsts (poss SCS?) Some // lams sl “fuzzy” - prob cyptic bioturb; BI = 0





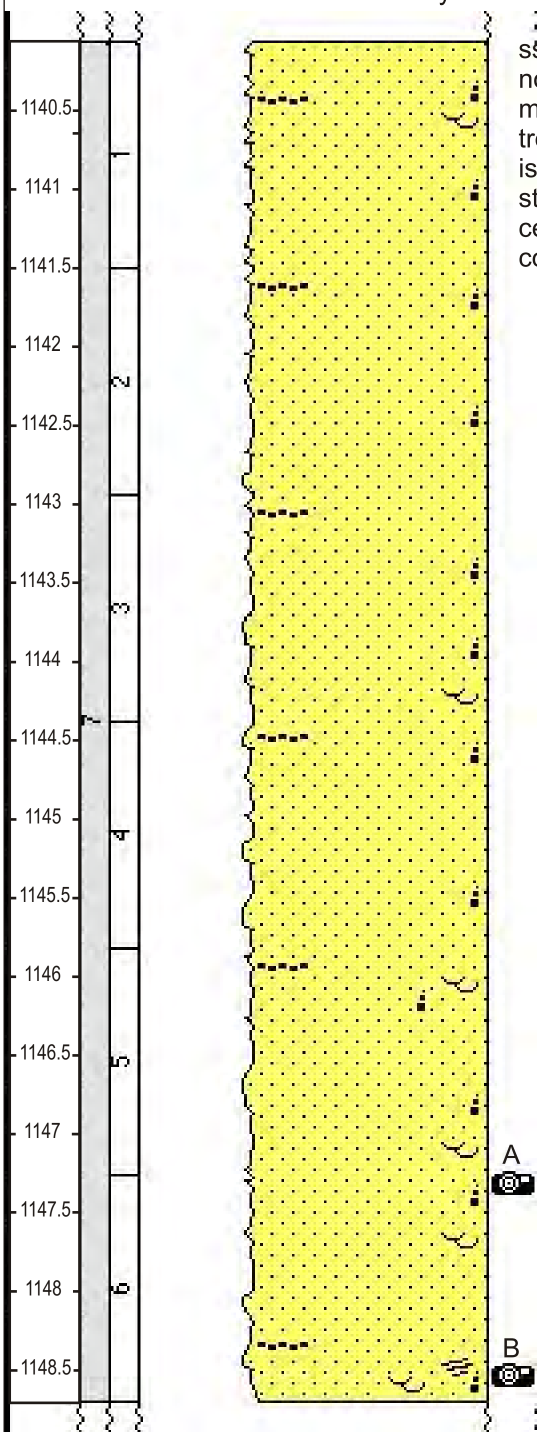


Canadian Hunter et al Nazko

d-96-E / 93-B-11

Metres | Core and Box | Grain Size: cobble, pebble, granule, sand (v c m f v), silt, clay | Photo | Remarks

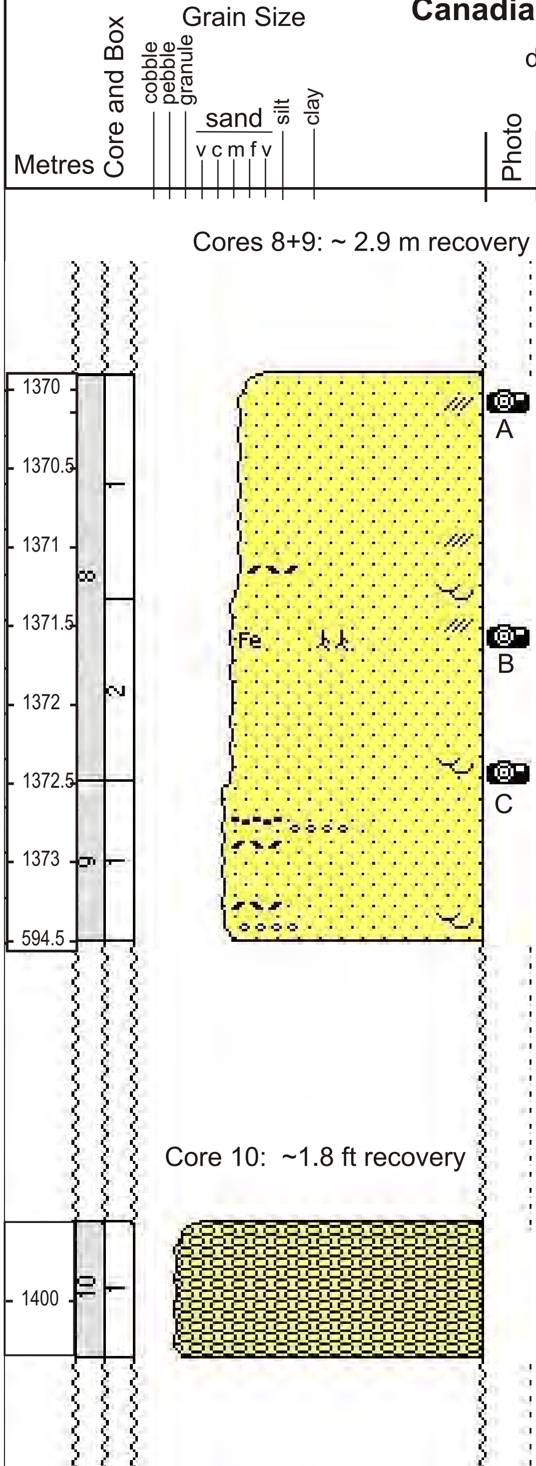
Core 7: ~7.4 m recovery



sst, grn-gy, mostly fU, ~ 20% mL beds - some prob sl normal graded, sst is micaceous, locally carb detritus marks low angle x-strata and horix stratification; rare trough x-strata (mod angle) but only in mL beds; sst is very well sorted, fU sand beds mainly structureless, poss cryptic bioturbated? very sl calc cement, but mostly clay cement trough xstrat most common in basal and top 1m

Canadian Hunter et al Nazko

d-96-E / 93-B-11



Remarks

oversteepened x-strata toward top of unit

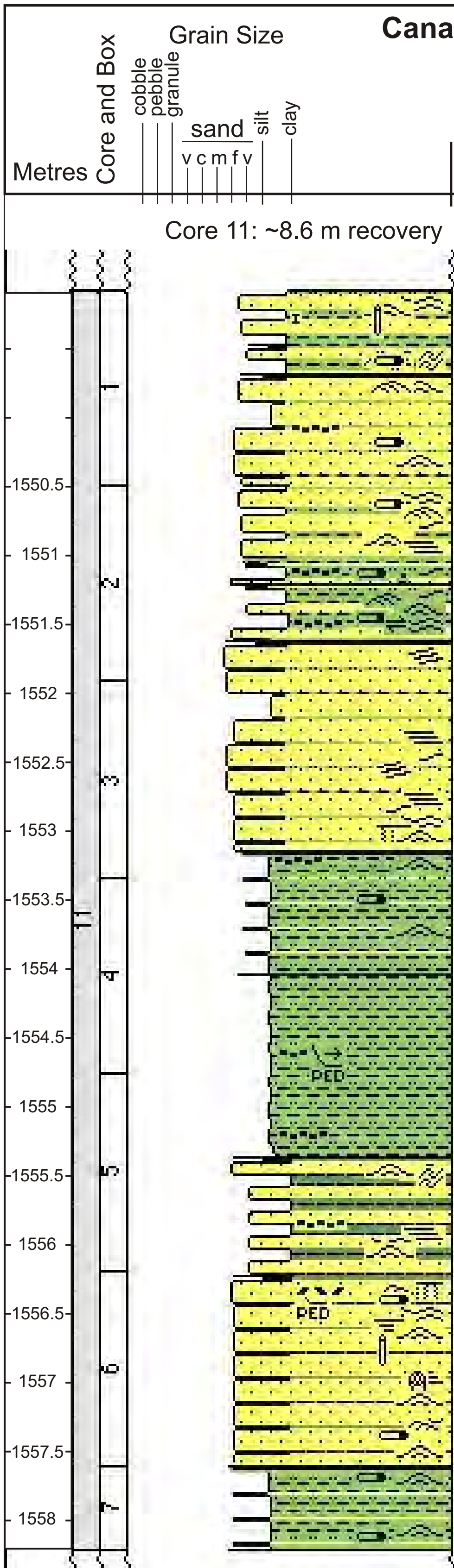
vertical fabrics and remnant root traces, some hematite statins - prob exposed weathered surface alteration

fining up cL sst to mL-mU sst, basal coarser sst has isolated chert granules + some mudst ripups; carb detritus marks lams, some stringers chert granules mark trough x-strata

peb cgl; clast-sup fine pebbles w cse sst matrix: mod well-sorted, clasts rd to very rd, subspherical, clasts >80% chert (grn, gy, blk) <10% mafic volc, <10% qtz; poss rare qtzite; no visible bedding or strat, some sulphides coating some clasts

Canadian Hunter et al Nazko

d-96-E / 93-B-11



Remarks

heterolithc vfg sst + silty mudst: 40% sst increase up but thinner beds, CFR, osc ripples + // lams at top, lower sst have loaded bases + ball+pillow + other soft sed, muds likely fluid, some Ca-filled fracs + poss syneresis, BI 0-1, v rare *Planolites* + fugichnia, poss *Skolithos,* 1 poss *Thalassinoides*

sharp

heterolithic sst / silty mudst: similar to below but sandier, some mudst has ped structures, carb mud drapes osc ripples, wavy // lams, rare CFR, some norm graded + delicate sst-mudst interlams; sst well sorted vfU-fL, finer towards top and aggrad CFR-OSC at top, Ca cemented, BI 0-1, very rare *Planolites*

heterolithic silty mudst / sst, carb mudst drapes~40-50% vfU-fL sst w OSC, rare CFR + // wavy lams BI - 01, rare *Planolites*

sst: fU-mL, coarsens up, hetrolithic near base w rare silty mudst; sst grn gy, mod well sorted + well lam chert lithic, lower part common OSC w carb mudst drapes, middle low angle x-strat to horiz // lams, poss some SCS? poss high angle x-strata near top, some Ca cement BI 0-1, rare fugchinia, *Planolites,* - poss wave dom delta front?

sharp

silty mudst + rare vfg sst; dense mudst as in lower core, brec with blocky fracs in lower 4 ft, poss pedogenic slicks, denser up, rare Interlams vfg sst; poss osc ripples in upper part, B1 0-1, poss isolated *Planolites* - poss prodeltaic muds?

sharp

heterolithic sst / silty mudst; 1:1 ratio; lower sst is grn-gy in 3cm beds interbed w dk gy mudst. sst mod well-sorted w OSC + CFR + low angle // to gently undulatory // lams (prob osc); top is mostly amalg sst beds with rare carb clay drapes - common OSC and // wavy lams

gradational?

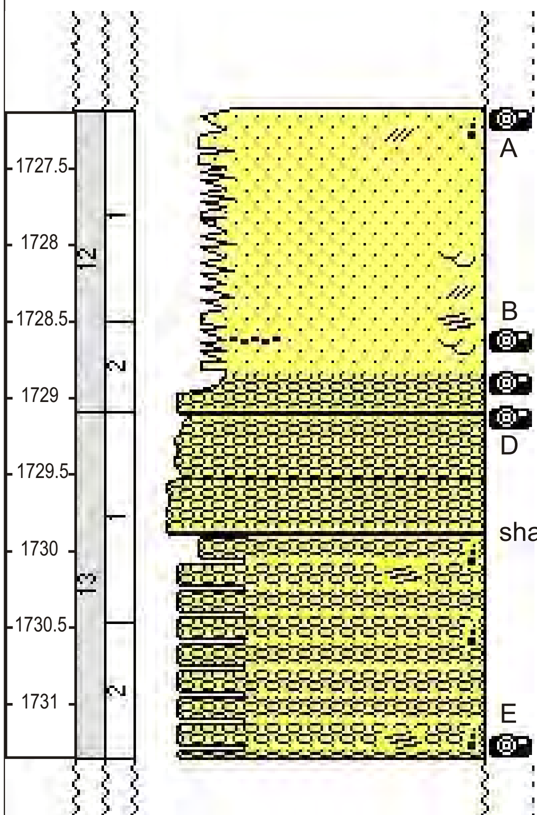
sst: fL-fU , gy-grn, ripple lam, some carb detritus; lower 15cm more carb detritus + heterolithic w ~1cm beds sst draped by 1-3mm silty mudst, most sst near base w osc ripples + wavy // lams, rare CFR; grades up to 3-5cm thin beds, then 10cm beds w // to undulatory lams ,CFR + rare CR, 1 12cm bed mL sst w mudst ripups, rare granules at base, aggrad CR to CFR, ~40+75cm bands silty mudst as below - top mudst has pedogenic struc - prob wthered, BI 0-1, isoloted *Planolites*, 1 poss *Cylindrichnous*, fugichnia, *Skolithos*, mudst ripup poss *Asteroma* - all likely brackish water bay fill?

silty mudst, minor vfg sst; dense gy mudst w. crude fissility, rare <1cm sst lams w. small osc ripples, no pedogenic indicators, rare carb detritus, minor siderite cement , BI 0-1 but BI = 2 near top w dimin *Planolites*, fugichnia - poss brackish water suite?

Canadian Hunter et al Nazko

d-96-E / 93-B-11

Core 13 + 12: ~ 3.9 m recovery



sst + peb cgl: basal 25cm fine chert rich peb cgl, grades up to 50cm pebbly cse sst, then into cse - v cse sst with local mU sst and some granule to fine peb stringers; beds 20-30cm thick, trough x-strat locally with carb detritus marking bed contacts, sst is chert-lithic arenite

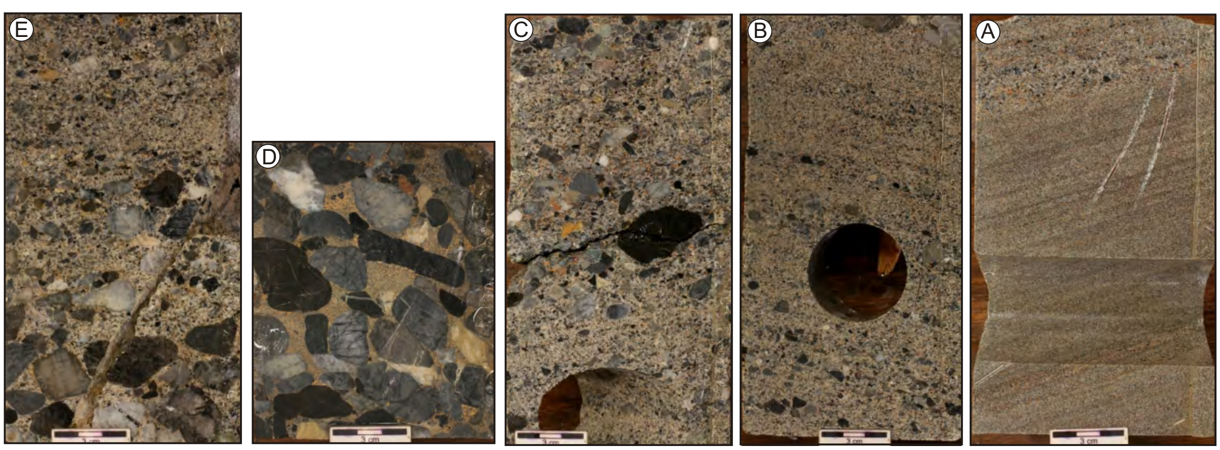
uncertain

peb cgl: 2 crude beds clast sup pebs (to 5cm dia, most 2-3 cm), cse sst matrix, clasts mainly chert, internally massive, no grading

sharp?

peb cgl + peb sst: ~80% small peb cgl, clast-sup, mainly chert pebs rd + subrd, subspheric, in v cse sst matrix, bed 6-12 cm thick; interbed w. very cse sst: 1-10cm thick beds, some norm graded, mainly horiz to low angle strata;

- prob braided stream environ

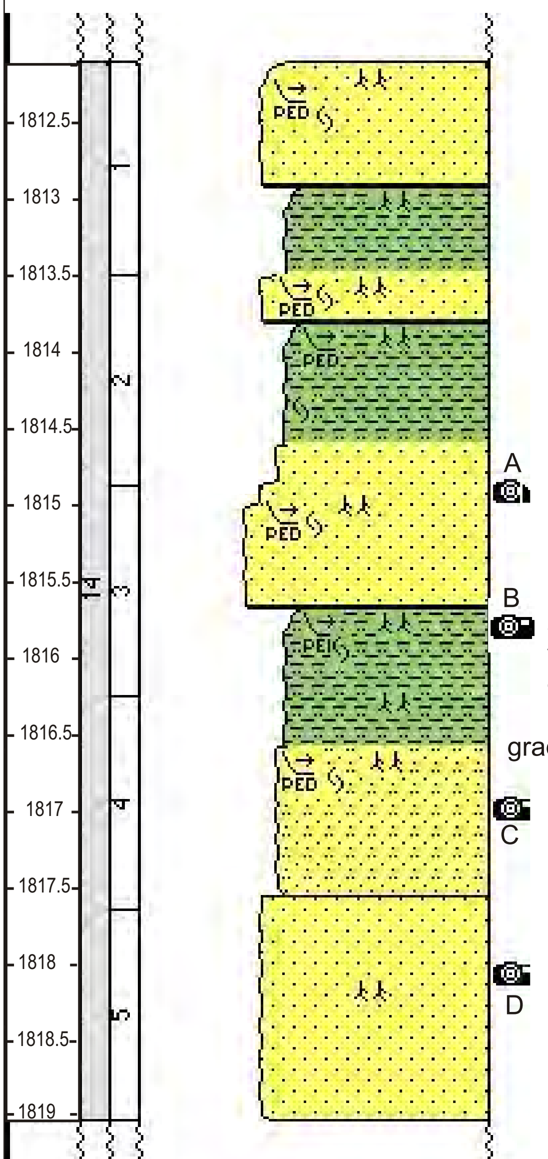


Canadian Hunter et al Nazko

d-96-E / 93-B-11

Metres | Core and Box | Grain Size: cobble, pebble, granule, sand (v c m f v), silt, clay | Photo | Remarks

Core 14: 6.75 m recovery



sst: as below, probably basal sst of another fine up cycle strongly altered due to exposure and paleosol devlopment

thinner but similar fine up cycle as below - strongly altered w pedogenic structures

similar fine up cycle as below w basal f-vfg sst mottled red-grn and massive with faint root traces and ped structures grades up to dark red silty mudst as below

silty mudst: mottled red-grn, strong vertical fabric, poss root traces w oxidation halos, some ADM - possible oligchaete burrows

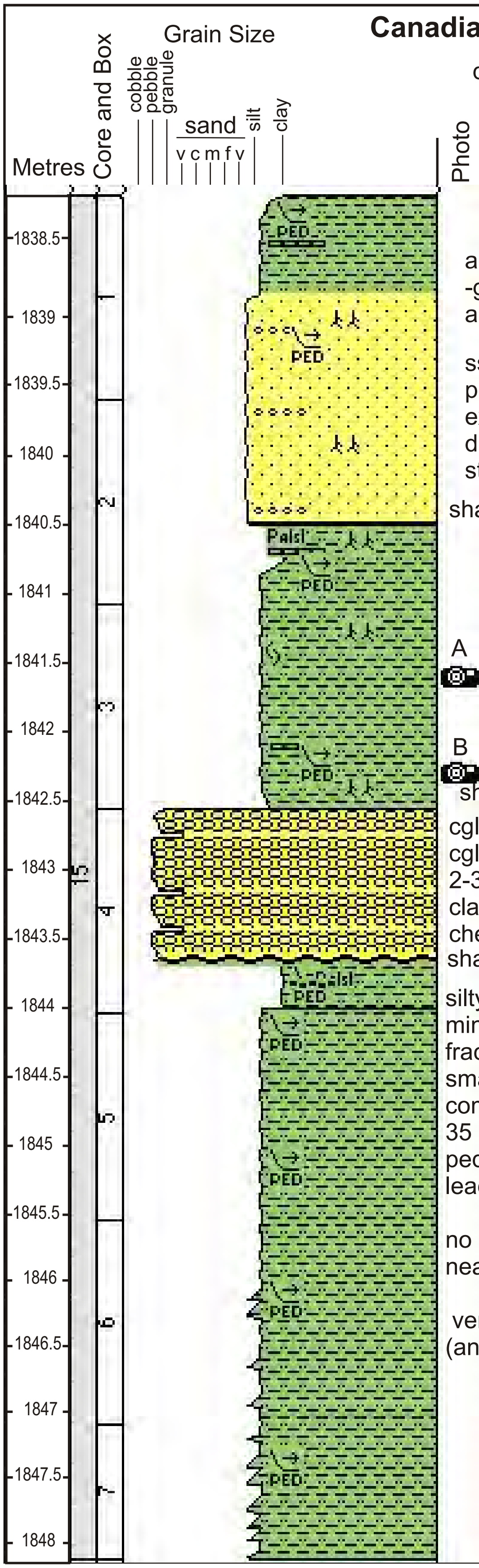
gradational

sst: fL, mottled dark red - dark green (50/50), massive but prob due to alter'n, large irregular patches, at ~ (~5963 changes gradationally into dark red brn dense vfg sst to sandy siltst

- all mottled altered looking w minor pedogenic slicks, poss oxidation halos around vague root traces and small tubes (prob ant or termite)

Canadian Hunter et al Nazko

d-96-E / 93-B-11



Remarks

Core 15: ~ 9.8 m recovery

abrupt but grad change at 6033 to grn -gy silty mudst, w pedogenic slicks and organic detritus, more altered up

sst: vfg grn-gy brn, random rare chert pebbles, appears massive buy may be exposure altered? minor organic detritus and root traces, minor mudst stringers, some ped structures

sharp

top 55cm is sl more clay rich than below + dark gy-grn - leached look

silty mudst / sst: dark red-brown + similar to lower unit, common waxy pedogenic structures, sl more variagated red-grn, more common roots and organic detritus;
Poss small burrows (ant? termite? poss rare beetle ADM?)

sharp?, uncertain

cgl: mod well sorted small to large peb cgl, clast-sup in cse-v cse sst matrix, 2-3 interbeds of v cse sst ~1cm thick, clasts rd-subrd, subspher, most are chert types

sharp, erosive

silty mudst: red-stained (dark brn red), minor dissem sst stringers, Qtz filled fracs, all core fractured into 10cm or small sections, pedogenic slickensides commom w. waxy glassy faces; upper 35 cm is dark grn gy with abund pedogenic structure and slightly leached look,

no visible carb detris except minor near top unit;

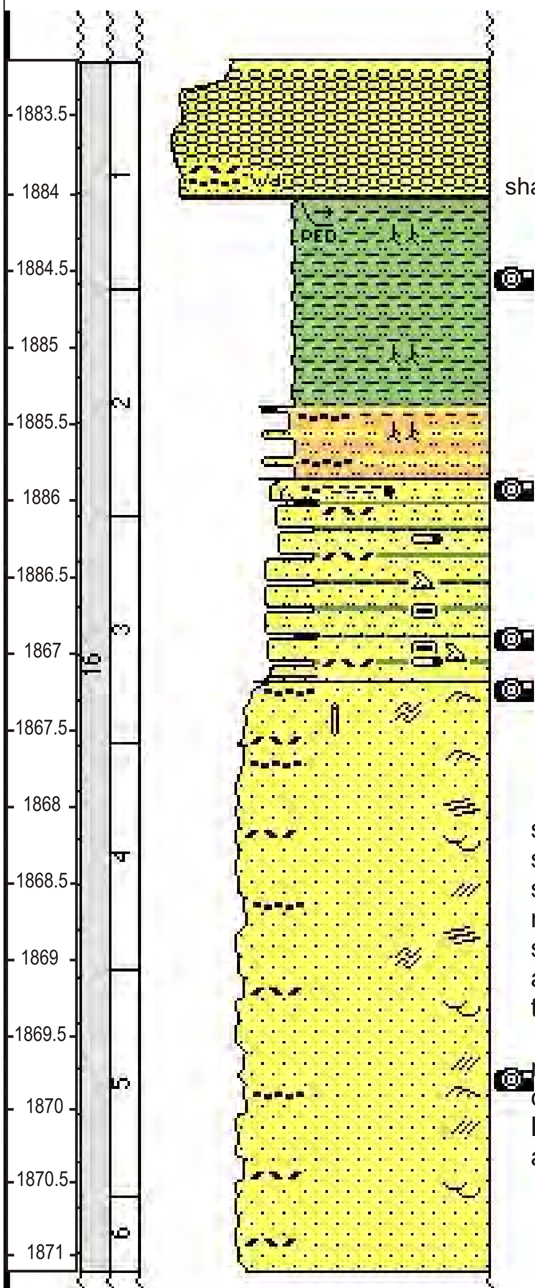
very rare isolated small dia burrows (ant ? termite? not beetle)

Canadian Hunter et al Nazko

d-96-E / 93-B-11

Metres | Core and Box | Grain Size: cobble, pebble, granule, sand (v c m f v), silt, clay | Photo | Remarks

Core 16: 7.4 m recovery



cgl, very broken core, clast-sup peb cgl poss changes to cL mod sorted sst in top 5cm; cgl not obv stratified,abund mud ripup and wood frags at base, cgl mod sorted w clasts subrd - rd, variably shaped, most clasts chert (gy, grn blk), + volc, dolost, qtz

sharp, erosive

top 40 cm red-stained silty shale, more roots and ped struc - incip palesol?

silty shale: dk gy to grn mottled, blocky fracs, some ped struc near top, and some prob root traces, primary structures uncertain (altered)

silty sst: mottled gy to grn-gy, root traces, carb detrgus, appears altered - prob weathered, incipient paleosol

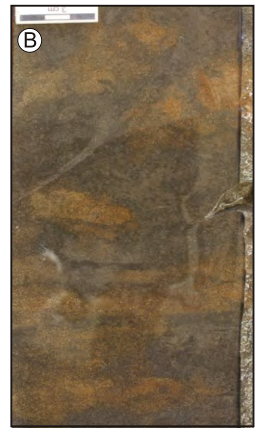
gradational

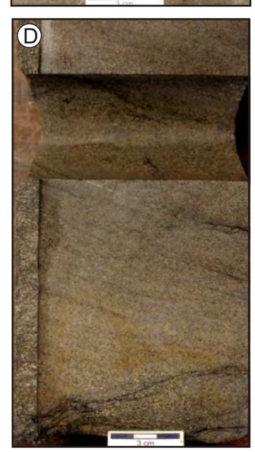
sst / silty mudst: most vf sst in 3cm thin beds w mudst lams between,all biogenically homogenized, poss remnant osc ripples with fugichnia, some mud ripups, BI = 3 *Planolites, Chondrites*, poss *Phycosiphon?*

sharp, basal sst may be on TSE or MFS ?

sst" mL-mU lithic to ligh arenite, mod sorted w. Minor hematite to siderite stained grains, common small mudst ripups, and oxid carb detritus; sst in stacked cycles of beds erosionally amalgamated x-stratified (planar and trough) in bedsets 10-125cm thick;

more soft sed def'm up and more carb detritus, minor current ripple lams, more to top, poss vert burrows and ADM towards top



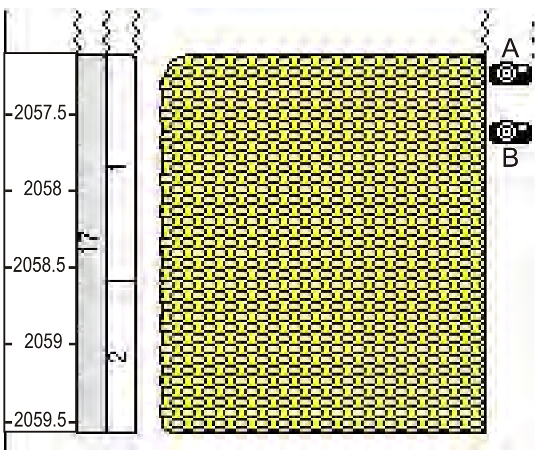


Canadian Hunter et al Nazko

d-96-E / 93-B-11

Metres | Core and Box | Grain Size: cobble, pebble, granule, sand (v c m f v), silt, clay | Photo | Remarks

Core 17: ~1.7 m recovery



cgl, peb-cob, clast sup in cse - granule sst matrix, mod sorted with some matrix rich zones, clasts rd to subrd, subspher w. 10-15% discoid shapes, appears non-stratified, non-graded, matrix remarkably clean; clasts are dolost (orange-altered) and chert (blk, grn, gy) some radiolarian chert? minor volc clasts

Canadian Hunter Redstone 1981. Location: b-82-C / 92-0-14 (E in figure 2)

Core 1: 1293-1302m

Mostly moderate- to well-sorted, very fine-, fine- and rarely medium-grained sandstone with a few intercalated silty mudstone units up to 0.3m thick. The lowest sandstones are > 1.5m thick with combined-flow and oscillation ripples, and some heterolithic intervals of flaser bedding with mud drapes. This interval contains sparse numbers of *Skolithos*, *Chondrites*, *Thalassinoides*, *Asterosoma*, *Taenidium*/*Scolicia*, *Palaeophycus*, *Planolites*, *Diplocraterion*, and fugichnia. Such suites are characteristic of proximal expressions of the *Cruziana* Ichnfacies, but diversities are generally low. This, with the association of syneresis cracks and soft-sediment deformation is consistent with shallow, subaqueous deposition under rapid sedimentation and salinity fluctuations. The facies is interpreted to represent a shallow, brackish-water environment, probably within a sandy bay margin complex.

This interval is overlain at 1300.6m by 0.6m of silty mudstone, which is slightly carbonaceous and contains root traces. This unit is weakly bioturbated with sand-filled biogenic structures of probable insect origin (adhesive meniscate burrows of probable beetle origin) and some possible oligochaete-generated burrows (in this case, attributable to Planolites). This probably represents subaerial exposure of either terrestrial mudstones, or of originally brackish-water bay mudstones. The immediately overlying 0.6m interval of very fine-grained sandstone is hematite-stained and shows variable mottling, possibly also containing insect-generated burrowing (Skolithos and Planolites). This interval lacks original sedimentary structures, and appears to be a weathered, subaerially exposed layer.

At 1299m is the base of a 1m heterolithic sandstone/mudstone interval, which contains oscillation and combined-flow ripples, as well as moderately abundant trace fossils, including Skolithos, Thalassinoides, Chondrites, Palaeophycus, and Planolites. This suite is consistent with a low diversity expression of the Cruziana Ichnofacies, recording largely subaqueous deposition under lowered salinity conditions. This interval likely represents deposition in a shallow, low-energy brackish-water shoreline area (e.g., bays).

The uppermost 5m of core comprises stacked, 0.6 to 2m thick bedsets of fine- to medium-grained sandstone and minor silty mudstone. The sandstone is generally well-sorted and contains very rare oscillation ripples and some current ripples, as well as undulatory parallel lamination, low-angle parallel lamination, and rarer trough cross-stratification. Rare root traces occur in some layers and carbonaceous detritus occurs in several beds. At the top of the interval, a thin layer of heterolithic sandstone-mudstone similar to the unit occurring at 1299-1298m, occurs. Trace fossils are sparse and generally simple vertical burrows (Skolithos), although Paleophycus and fugichnia occur in one bed, and there are several mottled areas that likely reflect intense insect-generated burrowing. Rare adhesive meniscate burrows of likely beetle origin are also locally present. Much of the sandstone is slightly mottled and pink-stained. This thick sandstone interval probably was deposited originally in moderate-energy subaqueous environments subjected to wave reworking. Such settings are consistent with brackish-water estuaries or sheltered marginal-marine (bay margin) shoreline environments. Periodic exposure and weathering are indicated by the presence of root traces, hematite staining, and overall mottling, and possible palimpsest insect-generated burrowing.

Canadian Hunter Redstone 1981

Location: b-82-C / 93-O-14

Date Logged: June, 2006

Logged by: J. MacEachern, P. Mustard

Remarks: core is stratigraphically upside down in boxes! Box 1 is bottom of core, Box 7 is top; core here is shown in stratigraphic upright order (thus box 1 here is box 7 in core archive)

Legend

Sandstone	Shaly Siltstone	Mudstone
Silty Sandstone	Silty Shale	Lost Core
Siltstone	Sandy Shale	

CONTACTS

Sharp

PHYSICAL STRUCTURES

Current-Ripple Lam.	Trough Cross-strat.	Symmetrical Ripple
Gently Inclined Lam.	Wavy Parallel Lam	Mud Drapes (Dbl.)
UFR Horizontal Parallel Lam.	Slump/SSD	Combined Flow Ripple

LITHOLOGIC ACCESSORIES

Silt Lamina	Coal Fragments	Sid Siderite
Py Pyrite	Fe Ferruginous	Rip Up Clasts
Carbonaceous Debris	Cht Chert	Mottled

ICHNOFOSSILS

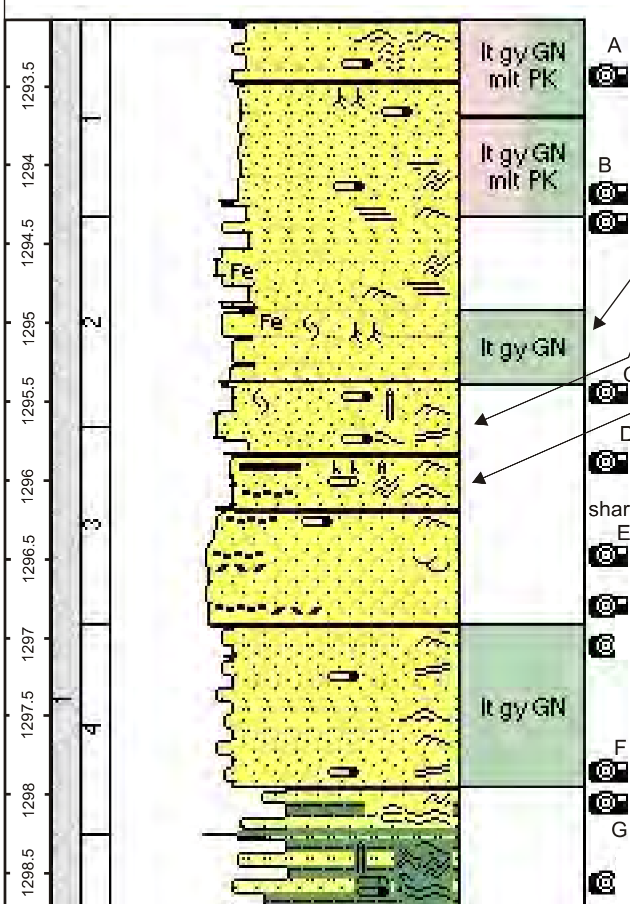
Rootlets	Skolithos	Planolites
Palaeophycus	Diplocraterion	Escape Trace
Asterosoma	Thalassinoides	Chondrites

Metres	Core and Box	Grain Size: cobble, pebble, granule, sand (v c m f v), silt, clay	Colour	Remarks

Canadian Hunter Redstone 1981

Location: b-82-C / 93-O-14

Metres	Core and Box	Grain Size (cobble, pebble, granule, sand v c m f v, silt, clay)	Colour	Remarks



vfg sst + silty sst, lams to thin beds but soft sed deformed (convolute); upper part hetrolithic wavy // lams to osc ripples, rare combined flow ripples; crosscut by 1cm dia dark gy silt-filled burrows, some *Planolites* + isolated escape structures

well sort vfg sst w rem lams, overprinted w crackled alter'n, hematitie stains, mottling; minor 1cm dia sandy burrows near base; some gray root traces with hematite halos

sst as above but less mottled, some vf silty sst interlams; ~ 60% mL pink sst w current ripples, // lams, some soft sed def'm

grn gy vf-fL sst, minor siltst; well sorted massive (bioturb?) w rare rem lams; diagentic alter'n - hematite stains, some root traces, some poss insect burrow mottling

vfg sst, mottled hematite stained, w <5% mL pinkish sst; crackle fract + diagen alted, some sand-filled buurrows, Ca cemented (week); in mL sst are curr + osc ripples, undul // lams, BI 3 - *Palaeophycus*, roots?, poss *Skolithos* near top;

heterolithic vfg - mL sst >> silty mudst, fines/thins up; small osc + curr ripples (3-5mm) so*me* soft sed defm near base; coalified wood as partings; BI=3 - poss roots, *Skolithos* near top, beetle-generated ADM (sandy fill) to 1 cm dia

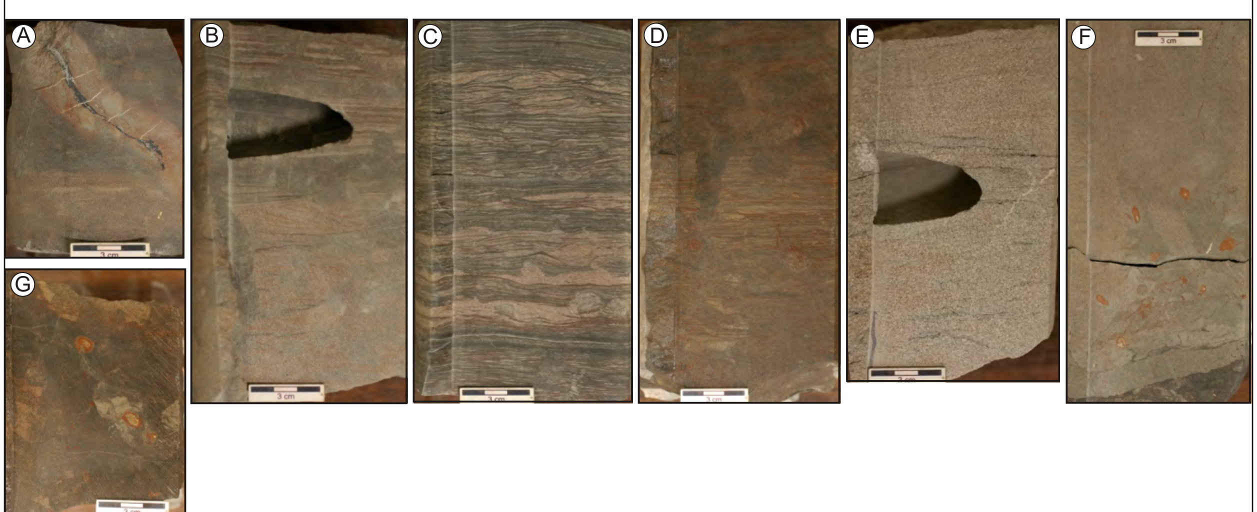
mL-Mu sst: trough x-strat + fining up, some clay and carb detrius along xbeds, minor current ripple lams; mostly 10-15cm xsets, some wood frags, BI=1, rare ADM, 1 *Planolites* in mudst

sharp, erosive

fU sst with interbeds mL pink-orange sst. prob orig interbedded but strongly disrupted by bioturb except upper 1 ft well bedded and strongly heterolithic; some preserved osc ripples, low angle // lams, current ripples; all mod well sorted; BI=3-4 near based but declines up; *Planolites*, some poss beetle generated burrows to 1.5cm dia; poss branching ant burrows

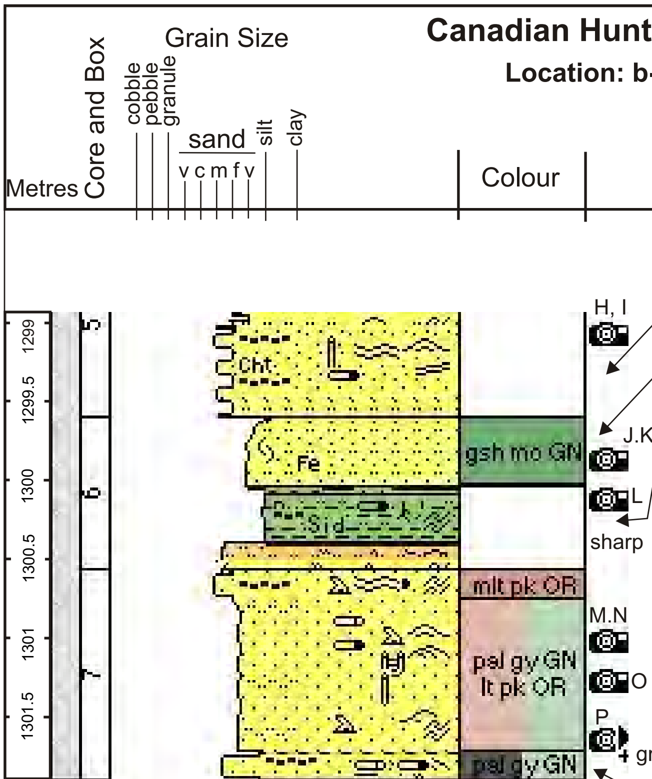
sharp

hetrolithic, well-bedded mudst/sst; more sst near base but mudst more soft sed defomed at top; sst thin beds, vf to mL (pinkish), silst interlasm , some norm graded, some osc and cfr ripples, some wavy // lams; BI 3, strongest near base with *Planolites, Skolitithos, Thalassinoides, Chondrites, Palaeophycus*



Canadian Hunter Redstone 1981

Location: b-82-C / 93-O-14



interbed vfg silty sst and mL pink-stained sst; sl csen up except silty in top .05 ft; mL sst in 1.5-3cm beds w remnant low angle undulatory // lams (osc ripples?) minor carb detritus, some chert chips + soft sed def'm; unit overprinted by silty sst filled 1- 1.5 cm dia burrows + 0.5 cm horiz burrows (ADM?), very rare *Skolithos* and *Planolites*

silty vfg sst - subhoriz crackled w hematite stains, reddish overprint on gy-grn colour, variegated mottling - poss insect burrows?

silty mudst, carb w root traces, some siderite, some carb frags pyritic, oxid halos, soft sed def'm / bioturb w poss non-marine elements (oligochaete?), *Planolites*? sand-filled insect *Planolities*? or ADM burrows

mL sst and silty sst, fining up to muddy siltst; mottling, soft sed def'm, osc ripples to /// lams; *Thalassinoides, Asteroma*? *Planolites*, *Scolicia*?, poss *Skolithos,* some carb detritus

sst; vf - mL, bedded to thick lams, well sorted, some soft sed def;m, combined flow and osc ripples, some wave ripples, BI 3 of *Skolithos, Diplocraterion, Palaeophycus*, fugichina

hetrolithic mU to mL sst / siltst/ mudst; 0.5-2cm sst lams/beds with osc and comb flow ripples; 25% siltst w. curr ripples + mud draped; BI 1-2 of *Planolites*, *Chondrites*, prob *Thalassinoide*s; poss syneresis cracks; rare *Palaeophycus* tubularis, poss *Lockeia* - prob brackish water?

Canadian Hunter Chilcotin 1982. Location: b-22-K / 93-C-9 (F in figure 2)

Core 1: 3119-3124.5m

All mottled red-green feldspar porphyry volcanic (basalt?) and volcanic breccia; deposited by active subaerial volcanism.

Northern Lights Kersley 1981. Location: d-2-E / 93-B-16 (G in figure 2)

Core 1: 713.6-725.8m (no core log is presented for this well)

Nearly no recovery, with only 5 small bags of rubble preserved, containing mixes of dried drilling mud and fragments of what appears to be altered volcanic rock. It appears as if this cored interval was from a volcanic unit.

Canadian Hunter Chilcotin 1982

Location: b-22-K / 93-C-9

Date Logged: June, 2006

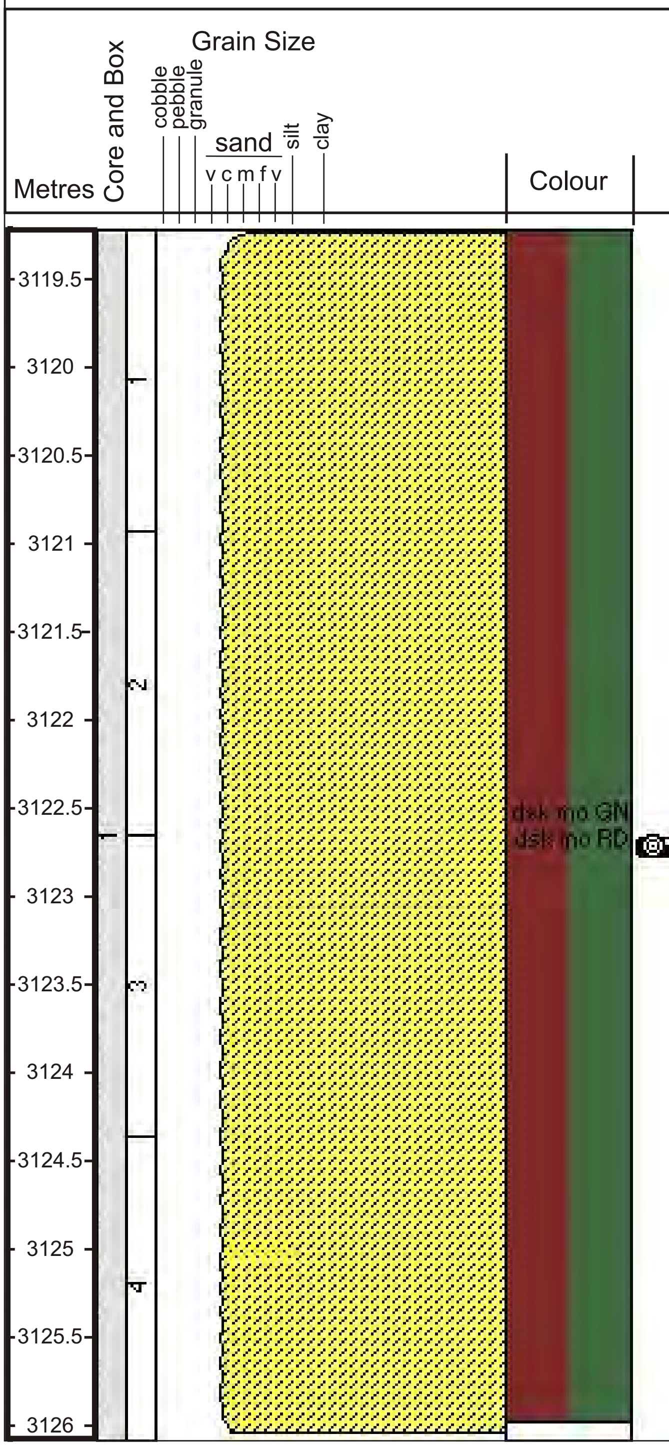
Logged by: J. MacEachern, P. Mustard

Remarks: 4 boxes only, near 100% core recovery

Legend

Basalt

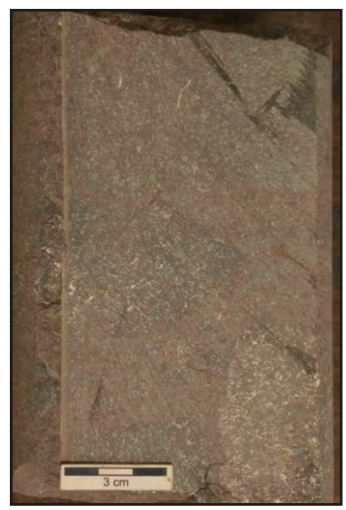
Lost Core



Remarks

Core is all mottled to variagated red-green feldspar porphyry volcanic (basalt?) and volcanic breccia

Environment is subaerial volcanic



New Geoscience Data from the Nechako Basin Project

By Janet Riddell[1], Filippo Ferri[1], Arthur Sweet[2] and Paul O'Sullivan[3]

INTRODUCTION

The Nechako Basin Project is in its second full year of a multi-year research program designed to generate new geoscience data and interpretations to facilitate oil and gas exploration in central British Columbia (Figure 1). The program includes geological field reconnaissance, Rock-Eval, thermal maturity, and reservoir quality analyses, apatite fission track thermochronometry, biostratigraphy, and radiometric dating. The prime goal of the project is to determine whether the essential components of a petroleum system exist in the Nechako region.

Work completed in the first full year of the project in 2005 included reconnaissance and sampling of Jura-Cretaceous strata in the southern and central parts of the Nechako Basin, new sampling and analysis of drill core and cuttings from old oil and gas exploration wells, and new interpretations of well stratigraphy and regional geophysical data (Ferri and Riddell, 2006).

This report includes description of 2006 fieldwork, presentation and interpretation of new data derived from samples collected during the 2005 season, and a synopsis of ongoing research.

2006 FIELD SEASON

In 2006 the project expanded to the northwest the area of geological reconnaissance to include the Fawnie and Nechako Ranges southwest of Vanderhoof and scattered exposures of Jura-Cretaceous strata around Batnuni Lake, south of Francois Lake, and on the north side of Ootsa Lake (Figure 1). We also conducted follow-up in some of the 2005 reconnaissance areas with detailed work, including

- 1:50 000 scale geological mapping of the Nazko River valley,
- collection of 114 new samples of coarse clastic rocks for a regional reservoir quality assessment,
- collection of 115 new samples of shale units for Rock-Eval analysis to assess source-rock potential,
- collection of 47 new samples for vitrinite reflectance analysis of thermal maturity, and
- collection of magnetic susceptibility data and new samples for apatite fission track thermochronometry and pollen biostratigraphy.

RECONNAISSANCE IN THE NECHAKO AND FAWNIE RANGES

Mesozoic rocks that include strata that broadly correlate with the Bowser Lake and Hazelton Groups (Diakow et al., 1997) are exposed in a horst that is bounded on the north and south by the northeast-trending Natalkuz and Blackwater extensional faults (Friedman et al., 2001) (Figure 2). The horst block is directly south of the east end of Natalkuz Lake, about 200 km southwest of Vanderhoof. It includes the Fawnie and Nechako Ranges, which strike north-northwest and are 40 to 50 km long. They are separated by the broad Chedakuz River valley, which is about 15 km wide. Cenozoic volcanic rocks and thick Pleistocene till and glaciofluvial deposits cover much of the low-relief plateau areas surrounding the two ranges.

Our goals during 2006 reconnaissance of the Nechako and Fawnie Ranges were twofold: to examine Mesozoic strata and compare their stratigraphy to age-equivalent rocks in the Bowser Basin, the Nazko River valley, and the southern rim of the Nechako area (i.e., the Chilcotin Mountains) and to sample for analysis of source-rock and reservoir potential.

The Mesozoic stratigraphy in the Nechako and Fawnie Ranges (Table 1) correlates broadly with age-equivalent rocks that occur to the northwest in the Hazelton, Smithers and Bowser Basin regions (Tipper and Richards, 1976; Ferri et al., 2005). However, the Nechako-Fawnie strata are distinct in that they record significantly greater volcanic activity in Middle to Late Jurassic time.

The oldest rocks in the Nechako-Fawnie horst are poorly exposed Upper Triassic fossiliferous marine sandstones presumed to correlate with the Stuhini Group (Diakow 1997).

The Lower to Middle Jurassic Hazelton Group island arc succession of north-central BC (Tipper and Richards, 1976) is represented in the Nechako-Fawnie area by the Entiako and Naglico formations (Diakow et al., 1997). The Entiako formation is Toarcian to early(?) Bajocian in age and includes marine volcanic-derived sedimentary facies and a felsic volcanic facies. The Bajocian Naglico forma-

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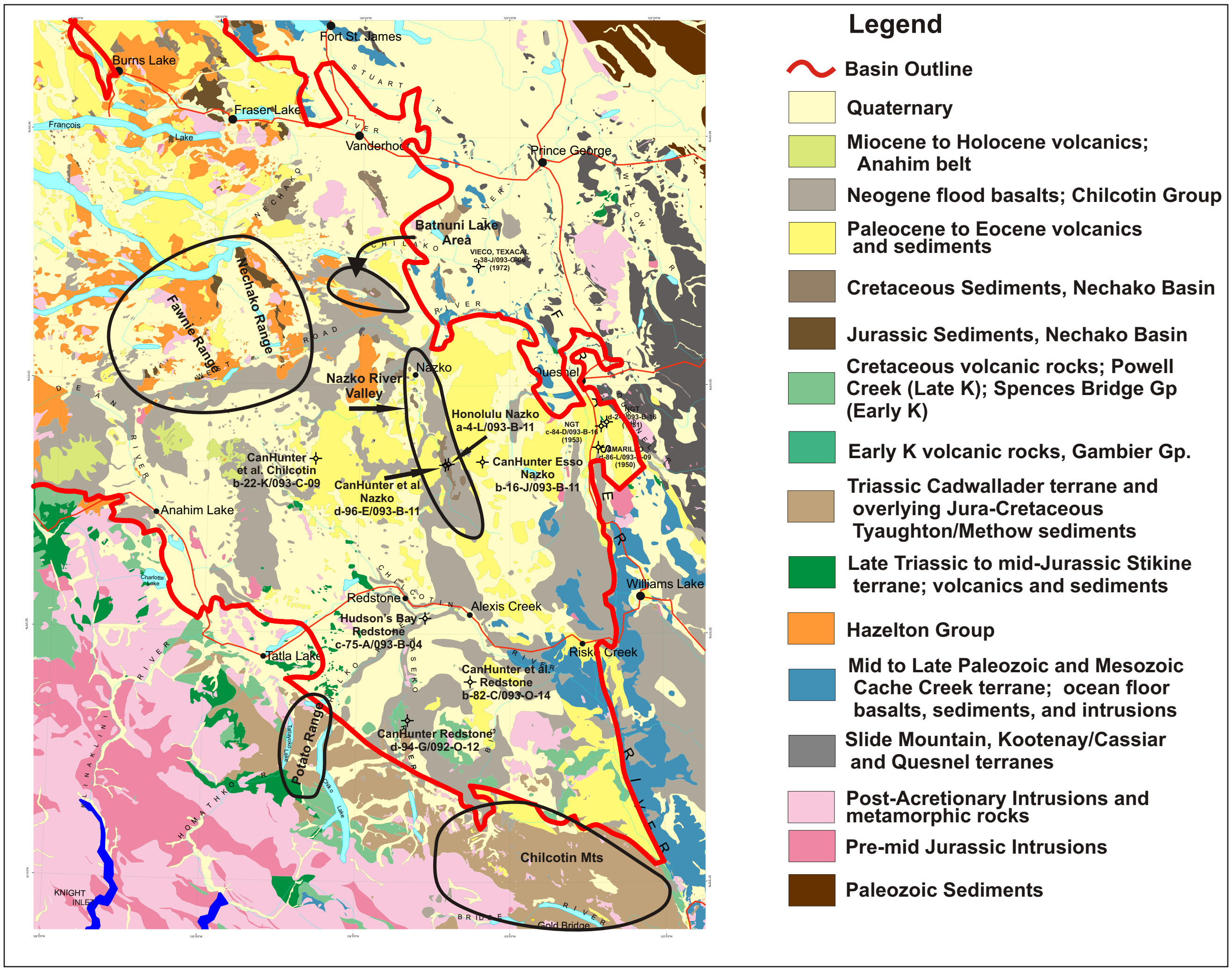


Figure 1. Nechako project area—geology and fieldwork areas.

tion is dominated by augite-phyric flows, with some tuffs and minor marine sedimentary rocks.

Black to dark grey carbonaceous siltstone, locally with bedded or authigenic pyrite horizons up to 0.5 cm thick, occur within the Entiako formation and, to a lesser extent, within the Naglico formation. These horizons are part of a widespread Lower to Middle Jurassic "black clastic" sequence within the Cordillera (Ferri et al., 2004; Ferri and Boddy, 2005) and were sampled and analyzed for source-bed potential (see **Rock-eval results** under **RESULTS AND DISCUSSION** below).

The Naglico formation is overlain by Bowser Lake Group equivalents—the Ashman Formation and the informally named Nechako volcanics. The type section of the Ashman Formation is Ashman Ridge, 40 km west of Smithers, where it comprises late Bajocian to early Oxfordian dark grey to black shale, feldspathic to quartzose sandstone, greywacke, and chert-pebble conglomerate (Tipper and Richards, 1976). In the Fawnie and Nechako Ranges, the Ashman includes two interfingering clastic successions that span late(?) Bathonian through Callovian to early(?) Oxfordian time. A deeper-water succession, consisting mainly of mudstone and siltstone, is best exposed in the Fawnie Range. A coarser, shallower facies is present as rare lenses of conglomerate in the Fawnie Range, and it thickens eastward to over 1500 m of conglomerate, sandstone, and siltstone that is exposed along the axis of the northern Nechako Range (Diakow et al., 1997).

Exposures of dark grey to black siltstone and beige sandstone within a road quarry on the northwest side of the Nechako Ranges display lithological and sedimentological characteristics that are consistent with the Ritchie-Alger assemblage of the Bowser Lake Group (Evenchick and Thorkelson, 2005). Although the exposure is poor, turbiditic deposition is suggested by the dominant dark grey to black siltstone interbedded with sandstone beds that display graded bedding and siltstone rip-up clasts at the base.

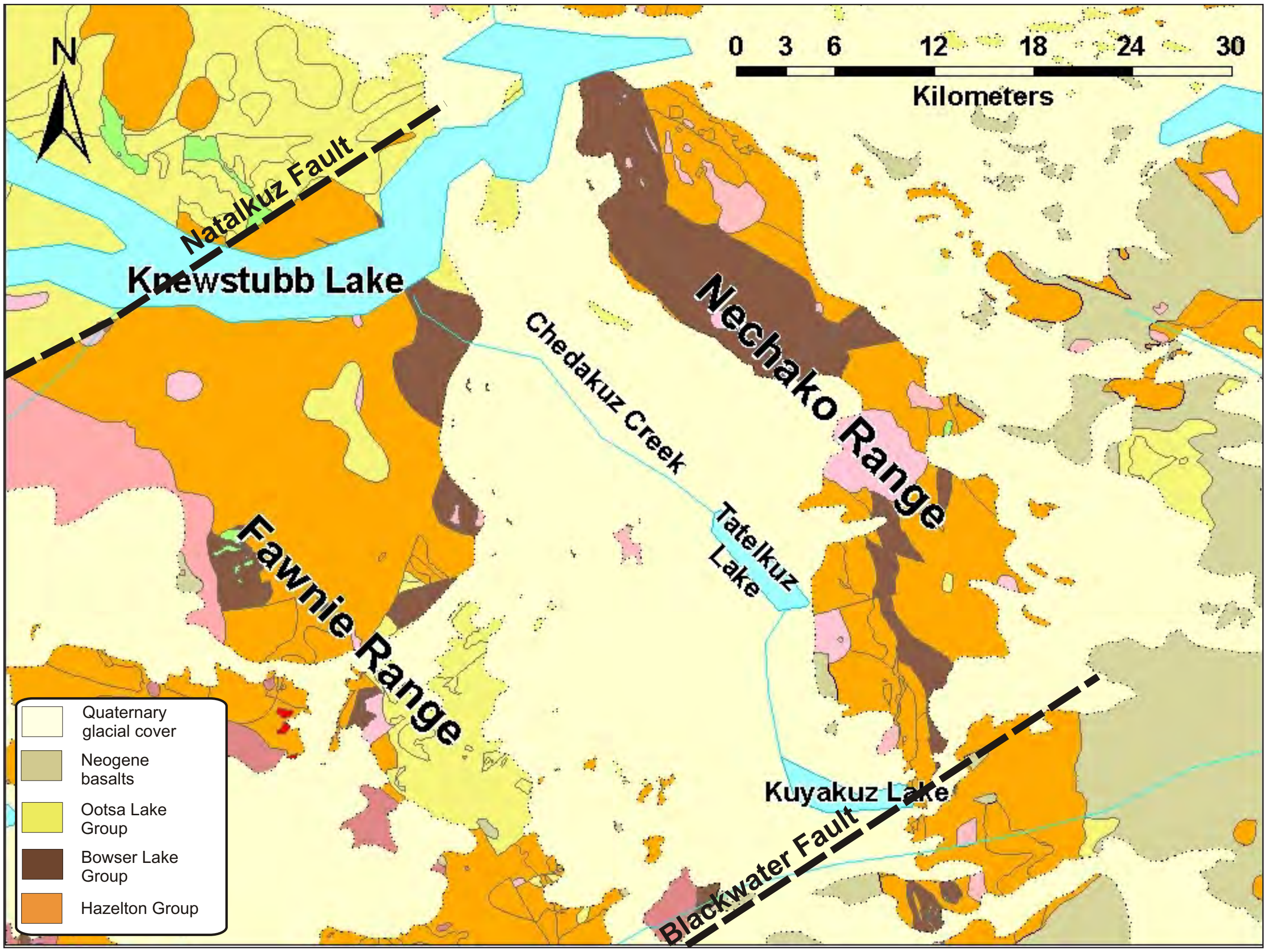


Figure 2. The Fawnie and Nechako Ranges. Geology after Diakow and Levson (1997).

Massive to thick-bedded chert-pebble conglomerate and sandstone occur on the western flank of the north end of theNechako Range. Although upward-coarsening sequences and a local coal occurrence suggest fluvial-deltaic deposition, correlation with specific deltaic or fluvial assemblages in the Bowser Basin (i.e., Groundhog-Gunanoot, Eaglesnest, Skelhorne assemblages) is speculative at this level of definition.

Even though outcrop is poor in the Nechako Ranges, fluvial-deltaic chert-pebble conglomerate appears to sit above turbiditic rocks of the Ritchie-Alger assemblage with no intervening shelf sandstone and siltstone deposits (i.e., Muskaboo Creek assemblage). This, together with the deformed nature of the conglomerate, suggests a structural juxtaposition.

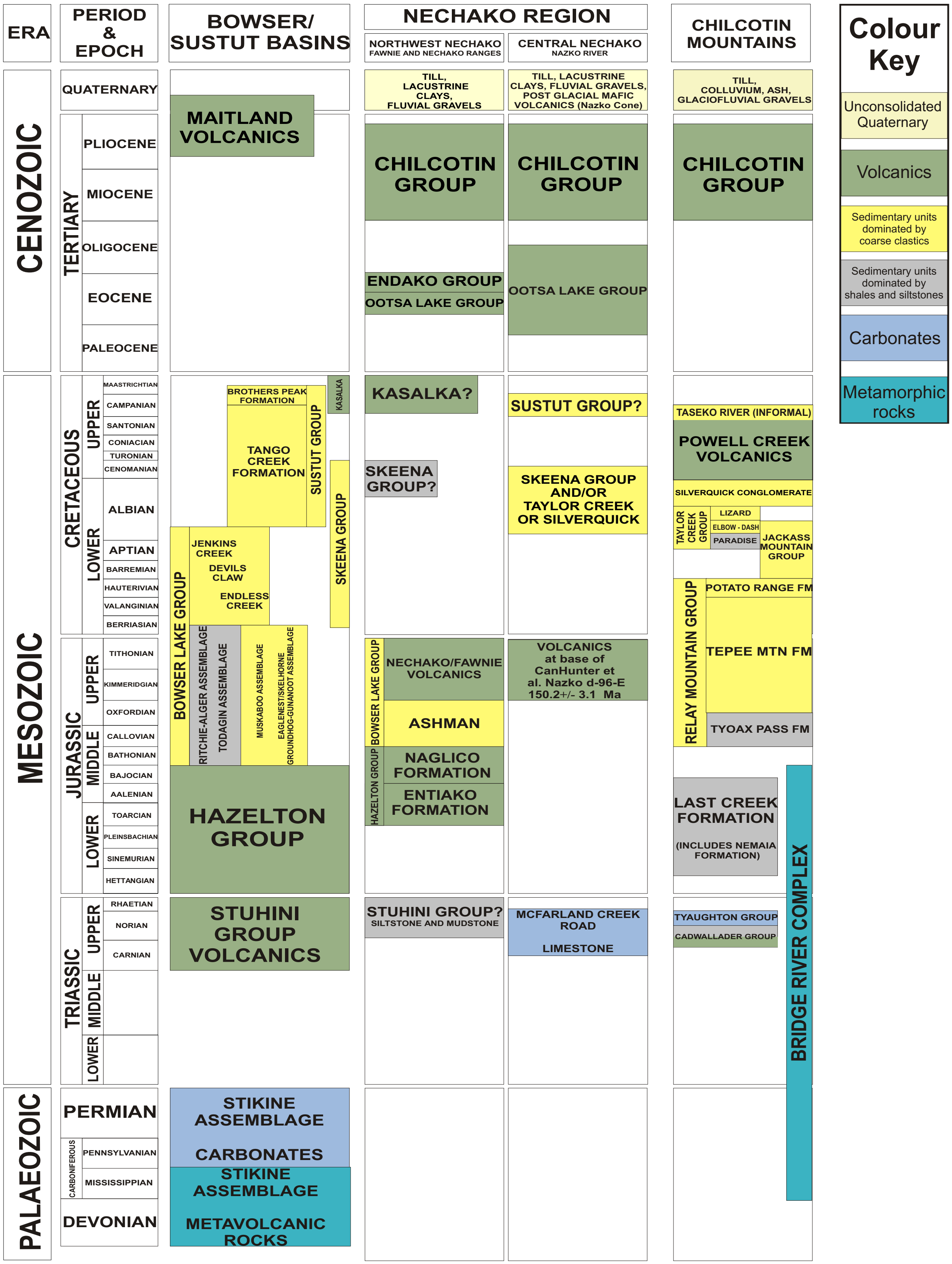
The Nechako volcanics overlie the Ashman Formation in the Nechako Range and comprise mafic flows within distinctive coarse vitreous pyroxene phenocrysts and associated ash and lapilli tuffs. In the Fawnie Range, some white rhyolite ash-flow tuff and andesite porphyry flow are tentatively assigned to the Nechako volcanics, based on their relationship with underlying Ashman Formation strata (Diakow et al., 1997). An 40Ar/39Ar date of 152 ± 2 Ma was obtained from the base of the Nechako volcanics (Diakow et al., 1997) in the northern Nechako Range.

Cretaceous strata are scarce in the Nechako and Fawnie Ranges. Diakow et al. (1997) describe a single site where the Entiako River flows into Natalkuz Lake; there, Albian to Cenomanian black mudstones and dark green siltstones are exposed. These rocks are probably correlative with the Skeena Group.

RECONNAISSANCE NEAR OOTSA AND FRANCOIS LAKES

The field crew spent two days investigating scattered outcrops of sedimentary rocks between Francois Lake and Ootsa Lake. Colourful polymict conglomerates were sampled for the reservoir quality on Nithi Ridge (between Binta and Francois Lakes), but the silicified and well-indurated

Table 1. Nechako region stratigraphic correlation chart.



rocks appear to have low reservoir potential. Samples of carbonaceous siltstones (probably belonging to the Hazelton Group) were taken from outcrops on the north side of Ootsa Lake, near Marilla, for Rock-Eval analysis of source-rock potential. At this locality, some 10 to 15 m of dark grey to black carbonaceous siltstone with plant fragments occur. Boundaries with the fine volcaniclastics above and below are gradational.

The crew visited the Francois Lake Asphaltum occurrence (MINFILE 093K 056) and sampled the asphaltum bitumen there for analysis of potential light hydrocarbon fraction by the Geological Survey of Canada (Calgary). The discovery of the bitumen was first reported by Galloway (1923). At this locality, bitumen occurs as 1–2 cm black shiny blobs within open spaces in botryoidal collinsite, a phosphate mineral. The bitumen and phosphate are hosted by Neogene vesicular basalt, probably of the Endako Group. Unfortunately, no light hydrocarbons suitable for typing the occurrence were recovered during analysis (M. Li, personal communication, 2007).

RECONNAISSANCE IN THE BATNUNI LAKE AREA

Our work in the Batnuni Lake area in 2006 was focussed on examining the chert-rich sedimentary rocks mapped by Tipper (1960) and attempting to locate bitumen occurrences reported by Tipper (1963) on Batnuni Cone and in Swede Creek.

Rocks south of Batnuni Lake were originally assigned a Jurassic(?) age by Tipper (1960) and are currently shown as part of the Upper Cretaceous Powell Creek or Kasalka volcanics on the Nechako compilation map (Riddell, 2006). The presence of Powell Creek-Kasalka–equivalent rocks would have implied that Cretaceous sediments (Silverquick conglomerate and Taylor Creek Group or Skeena Group) could be expected to underlie them at depth. We examined these outcrops to check the Powell Creek-Kasalka correlation; our observations of felsic to intermediate volcanics and associated interbedded dark grey to black siltstone, which better resemble the Hazelton Group, did not support correlation with Powell Creek-Kasalka.

Chert-pebble conglomerates and associated sandstones occur on the low hills north of the east end of Batnuni Lake. Tipper (1960) mapped these as Lower(?) Jurassic strata associated with Triassic Nicola-Takla volcanic rocks (Tipper's unit 6B). Our impression, from the sparse outcrop we observed, is that these rocks more closely resemble middle Cretaceous chert-rich sandstones and conglomerates of the Nazko River valley—they are similar in that they are relatively undeformed and are characterized by anomalously low magnetic susceptibility readings.

GEOLOGY OF THE NAZKO RIVER AREA

The Nazko River area, south of the Nazko Highway, is the centre of historical oil and gas exploration in the Nechako region and has to date provided the most promising results in the region; it is also the site of the only significant exposures of rocks with hydrocarbon potential in the Nechako region. The exposures at surface are coarse clastic Albian sedimentary rocks, which have hydrocarbon reservoir potential. The 2 drill holes in the Nazko River valley—Honolulu Nazko (a-4-L/93-B-11) and CanHunter Nazko (d-96-E/93-B-11)—intersected 2000 to 2500 m thicknesses of these coarse clastic rocks. The Albian ages were determined with palynoforms collected at surface and from drill cuttings by Hunt (1992) and from drill core and cuttings by this project (Ferri and Riddell, 2006).

In 2006 we conducted 1:50 000 scale geological mapping (compiled at 1:120 000 scale, Figure 3) of the area of these Cretaceous exposures along the Nazko River near Tzazati Lake, from just north of Wentworth Creek to Lasointonioco Creek, and on the hills near Cantillon Creek and Lasointonioco Creek, about 3 km southeast of their confluences with Nazko River. The Nazko River Cretaceous window has an elongate shape about 3 km wide and 14 km long, where the Cretaceous rocks are exposed on the lower valley slopes above the river (Figure 4). The same rocks form islands above about 1220 to 1250 m elevation at the top of the hill southwest of Cantillon Creek; there they poke up above the Chilcotin basalt blanket, which laps up on the flanks of the hill to an elevation of about 1220 m. In general the Cretaceous rocks are exposed in small to medium-sized isolated outcrops on lower forested slopes; however, two good large exposures exist. A gently dipping 80 to 90 m thick section of interbedded sandstone and conglomerate is exposed in a creek directly east of Tzazati Lake, and a cliff outcrop 15 m high and about 75 m long is exposed on the hill southwest of Cantillon Creek. This latter conglomerate outcrop dips steeply to the north and is exposed along its strike length, so it represents only a few metres of section.

The Cretaceous rocks are chert-rich sandstones and associated chert-pebble conglomerates. The outcrops are tan- to beige-weathering with common black shiny pyrolusite fracture coatings and locally abundant orange limonitic staining. Conglomerate clasts range from granule size to about 8 cm. The most common clast types are pale to dark grey and black chert, with lesser cream, maroon to pink, and green chert, and quartz. Rare clast types are volcanic rocks, siltstone, and coaly fragments. Sandstones are medium- to coarse-grained with similar clast content to the conglomerates but for slightly higher amounts of quartz grains and varying amounts of muscovite flakes. Isolated 1–2 cm pebble clasts are common. The amount of consolidation in the sandstones is variable; some are quite well-indurated with silica cement while others are very friable and may prove to have good reservoir quality. Bitumen has been identified in

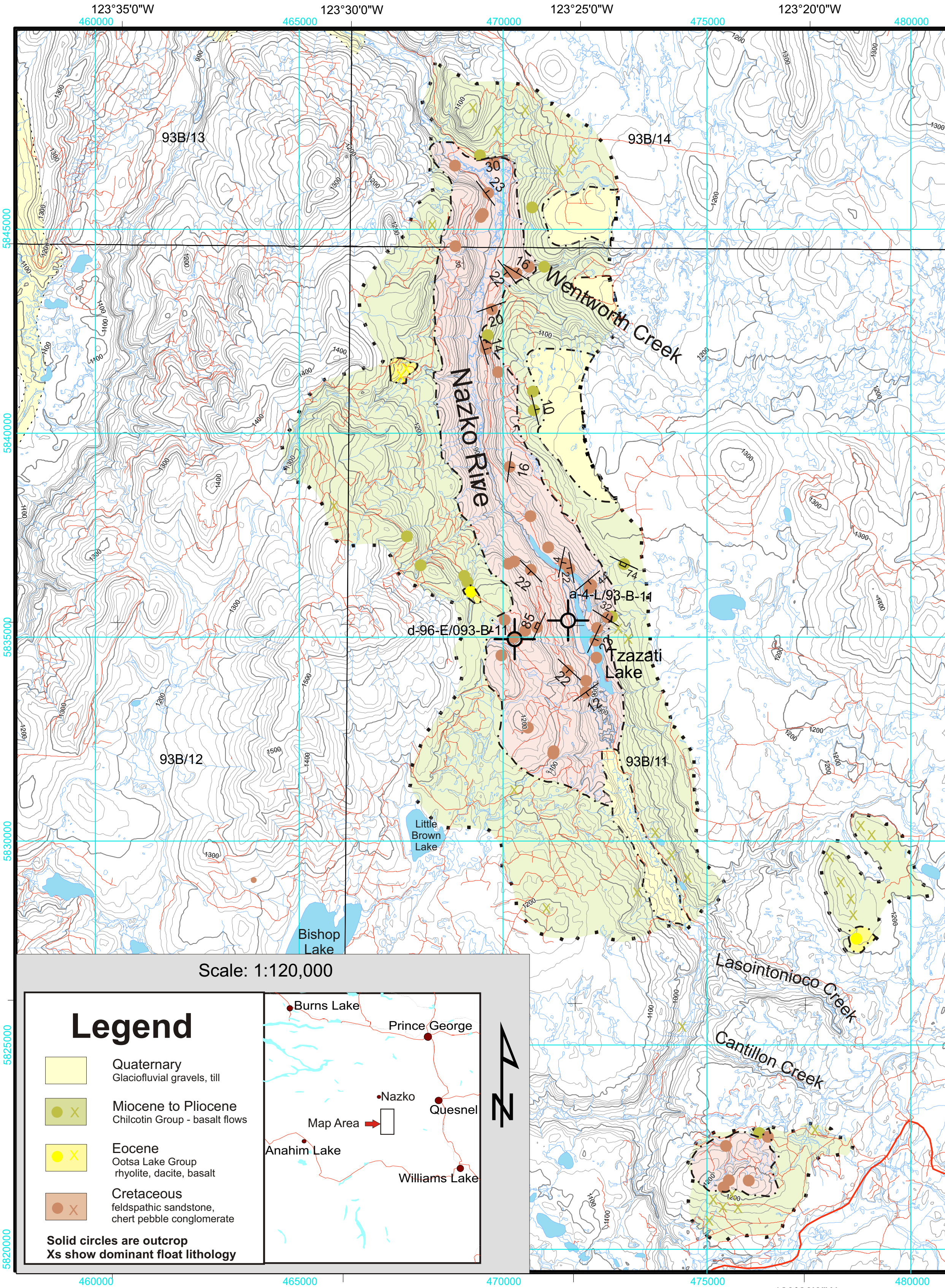


Figure 3. Geology of the Nazko River valley.

Figure 4. Cretaceous chert-rich conglomerates and sandstones are exposed in isolated outcrops on the lower slopes of the Nazko River valley. Crude layering is apparent in many outcrops. Cross-bedding is not uncommon.

thin section as a common pore lining in a sandstone sample from the Honolulu Road along Nazko River, about 3 km north of Wentworth Creek. The magnetic susceptibility signature of these Cretaceous sandstones and conglomerates is very consistent, and values are very low.

Crude layering is apparent in many exposures. Cross-bedding is not uncommon, and fining-upward sequences can be observed in the exposed section west of Tzazati Lake, so we infer a fluvial depositional environment for these rocks. Bedding dips in the Nazko River outcrops are shallow to the east or west; the axial plane derived from the stereonet plots strikes at about 170° and is located sub-parallel to the river on its west side, with a fold axis plunging very shallowly (between 5° and 7°) to the south. This is consistent with the interpretation of the seismic data, which identified the north-south striking anticline that was the target of the two exploration holes drilled west of the river in 1960 and 1980.

The Cretaceous clastic strata in the Nazko River window have been correlated with the Skeena Group (Hannigan et al., 1994; Massey et al., 2005) and the Jackass Mountain Group (Cosgrove, 1981). We tentatively correlated the surface outcrops with the Taylor Creek Group (Dash and Lizard formations) and/or the Silverquick conglomerate of the Chilcotin Mountains (Ferri and Riddell, 2006); however, our observations in the Nazko River valley do not preclude the correlation with the Skeena Group (Table1). The rocks at surface in the Nazko River do not resemble Jackass Mountain Group strata; however, chip samples from several intervals between 2500 and 2600 m in CanHunter Nazko d-96-E are from dense green sandstones and granite-bearing conglomerates, which are more like Jackass Mountain Group than either Skeena or Taylor Creek-Silverquick. A new U-Pb date for cuttings from the volcanic package at the base of CanHunter Nazko d-96-E yields a Late Jurassic age (see New Radiometric Ages, below), which correlates best with the Nechako volcanics (Diakow et al., 1997) and implies a better fit with the stratigraphy to the Nechako-Fawnie area to the northwest than with the Chilcotin Mountains. Similarly, new palynological data from Honolulu Nazko a-4-L identify a Campanian sedimentary package at a depth of about 2000 m, presumably beneath a thrust fault. This section is time-equivalent and lithologically compatible with a correlation with the Sustut Group (Tango Creek or Brother's Peak Formations) to the northwest in the Bowser Basin. Similar-aged sedimentary rocks are not known in the Chilcotin Mountains.

Rare, small exposures of felsic volcanic rocks (rhyolite and dacite flows) of the Eocene Clisbako volcanics of Metcalfe et al. (1997) occur on the west side of the Nazko River valley at and above about 1150 m elevation and on the hill northeast of Lasointonioco Creek. These rocks are time-equivalent with Ootsa Lake volcanics and are included with them on some maps (for example Massey et al., 2005).

Neogene flood basalts of the Chilcotin Group form conspicuous cap rocks that rim both the east and west sides of the Nazko River valley and form the local "Indian Head" landmark cliff at the north end of our mapping area (Figure 5). The cap rock blanket sits at about 1150 m elevation at the north end of the map area and slopes gently down to about 1040 m elevation to the south end of Tzazati Lake.

BASEMENT EXPOSURE WEST OF THE NAZKO RIVER AREA

Grey limestone is relatively well exposed over an area of just over 1 km^2 on a low northeast-striking ridge just north of McFarland Creek, about 20 km due west of the north end of the Cretaceous exposures along the Nazko River. The limestone is uniformly grey on weathered and fresh surfaces and locally contains fossil hash.

The rocks were correlated with the Cache Creek Group by Tipper (Unit 1 of Tipper, 1959), and a Triassic age based on a fossil call was quoted by Metcalfe et al. (1997) from a personal communication with Tipper. We are attempting to confirm this age determination with conodonts; results are pending. In any case, this occurrence of basement rock requires the existence of a major north-northwest striking structure between itself and the Cretaceous strata exposed in the Nazko River valley. This structure delimits the western edge of the Nazko River oil and gas prospective zone. It is unknown whether the structure pre- or post-dates deposition of the Cretaceous clastic sequence.

POTATO RANGE

Sections of the Relay Mountain Group and Nemaia Formation were sampled for reservoir quality and source-bed potential in the Potato Range. The Nemaia Formation as defined by Umhoefer and Tipper (1998) includes Lower Jurassic black siltstone and shale overlain by Middle Jurassic sandstones, siltstones, and conglomerates. Samples were collected along Umhoefer and Tipper's measured section on Huckleberry Mountain at the southern Potato Range (Figure 1). A suite of samples were collected for reservoir quality analysis along the measured section through the Upper Jurassic to Lower Cretaceous Teepee Mountain and Potato Range Formations (Umhoefer et al., 2002) of the Relay Mountain Group on the west facing slope above Tatlayoko Lake.

CHILCOTIN MOUNTAINS

We returned to the Chilcotin Mountains to supplement 2005 sampling and to conduct new sampling in the Camelsfoot Range east of the Yalakom fault. We sampled the following for source-bed potential: shaly units of the Paradise and Lizard formations of the Cretaceous Taylor Creek Group, black fossiliferous Jurassic shales underlying the Jackass Mountain Group in the Camelsfoot Range, and black shale of the Lower to Middle Jurassic Junction Creek formation (Schiarizza et al., 1997) in the sliver between the Camelsfoot and Yalakom faults along the Yalakom River. Reservoir quality samples were collected from the Dash, Paradise (of the Taylor Creek Group), and Silverquick conglomerates and from Jackass Mountain Group sandstones from the Camelsfoot Range, east of the Yalakom fault.

RESULTS AND DISCUSSION

Figures 6, 8, and 9 show the distribution of surface sample locations in the various areas of the Nechako region over the 2005 and 2006 field seasons. In addition, drill cuttings from the old exploration wells were sampled for pollen biostratigraphy, U-Pb radiometric dating, and apatite fission track analysis. Some new data that have become available since the release of our preliminary report last year (Ferri and Riddell, 2006) are presented herein. The remainder will follow in subsequent publications.

ROCK-EVAL RESULTS

Samples of dark carbonaceous shale and siltstone were collected from various parts of the basin for analysis of source-bed potential (Figure 6; Appendix I). The majority of the samples were taken from Lower to Middle Jurassic rocks of the Hazelton, Junction Creek, and Nemaia Groups and Middle Jurassic to Lower Cretaceous strata of the Bowser Lake Group. In addition, we increased the density of sampling in marine clastics of the middle Cretaceous rocks of the lower parts of the Jackass Mountain Group and the Paradise and Lizard formations of the Taylor Creek Group to better quantify their organic content. These middle Cretaceous horizons may occur below strata penetrated by drilling in the Redstone area wells (d-94-G, c-75-A, and b-82-C) and possibly the Nazko River wells (d-96-E and a-4-L). Dark grey to black carbonaceous rocks of Early to Middle Jurassic age are widespread within the Cordillera

Figure 5. Neogene flood basalts of the Chilcotin Group form cap rocks that rim the east and west sides of the Nazko River valley and form the local "Indian Head" landmark cliff, seen here from the Honolulu Road near Wentworth Creek.

(Ferri et al., 2004; Ferri and Boddy, 2005). These rocks were encountered within the Fawnie and Nechako Ranges where they are part of the Entiako formation of the Hazelton Group (Diakow et al., 1997). Further south, within the Tyaughton-Methow Basin, rocks of similar age and composition are part of the Nemaia Formation in the Potato Range, the Junction Creek Formation along the Yalakom River, and the Last Creek Formation in the Tyaughton Creek area.

In the Nechako and Fawnie Ranges, current total organic carbon (TOC) values are fair to poor. Tmax and vitrinite reflectance values for these samples show that they are mature to overmature, so much of the original hydrocarbons have been driven off, suggesting the original TOC values were originally several times higher. Basal Bowser Lake Group sediments of the Ashman Formation also were analyzed and gave similar values (Appendix I). The thickness of these sequences is difficult to determine in the area due to poor exposure, but a conservative estimate would be a minimum of 100 m.

To the south, rocks of the Nemaia and Junction Creek formations exhibit the best TOC values of all rocks sampled during the 2006 field season. These units are dominated in their lower parts by dark grey to black siltstone, shale, and fine sandstone with lesser calcareous siltstone and limestone. Thicknesses of sequences observed during sampling were in the order of 50 m or more, and structural sections indicate that these units are several hundred metres thick (Umhoefer and Tipper, 1998; Schiarizza et al., 1997). TOC values are up to 2.5% and generally higher than 0.5%. A plot of S2 versus TOC (**Figure 7**a) shows current hydrocarbon contents of approximately 40 mg/g rock and that this kerogen is clearly Type III in nature. These concentrations are low, but given that the thermal maturity of these rocks is high (as indicated by vitrinite reflectance maturation levels of 1.57% to 1.93%), original hydrocarbon concentrations would have been much higher. One hand sample from this sequence contained oil inclusions within vein material; this material has been extracted and is being analyzed.

These Lower to Middle Jurassic rocks are widespread within the Nechako and Tyaughton-Methow basins; they

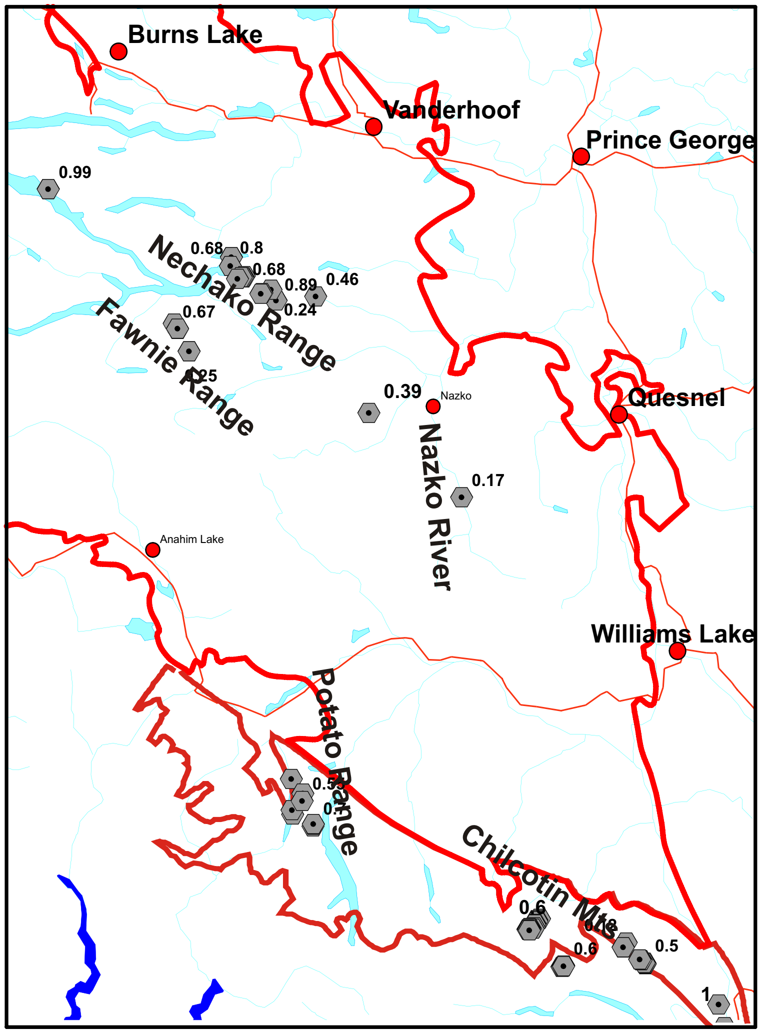


Figure 6. Rock-Eval surface sample locations, 2005 and 2006. Numbers beside symbols are total organic carbon in per cent (TOC%). Data for 2006 samples from Appendix I. Data from 2005 samples from Ferri and Riddell (2006).

may be preserved in parts of the Nechako Basin to the north and could have functioned as source rocks.

The Paradise and Lizard formations contain dark grey to black siltstone and shale sequences up to a few hundred metres thick in the Tyaughton Trough of the Chilcotin Mountains. These were sampled approximately every 20 m through exposed sections. Based solely on TOC contents, Cretaceous rocks show poor to fair source-bed potential. This is accompanied by low HI values, although these have been lowered by maturation.

THERMAL MATURATION FROM VITRINITE REFLECTANCE RESULTS

Thermal maturation based on vitrinite data from surface samples are shown in Table 2 and Figure 8. Generally, thermal maturation increases with age of the sequence, probably reflecting a greater burial depth. Rocks of the Lower Cretaceous Taylor Creek Group along the Nazko River have reflectance values between 0.53% and 1.63%. Bowser Lake Group sediments show higher values—up to 4.8% along the Nechako Ranges. In general, Hazelton Group strata and parts of the Bowser Lake Group show lower reflectance values (from 1.68% to 1.96%). Higher values for the Bowser Lake Group along the Brewster Road section may reflect proximity to intrusive rocks.

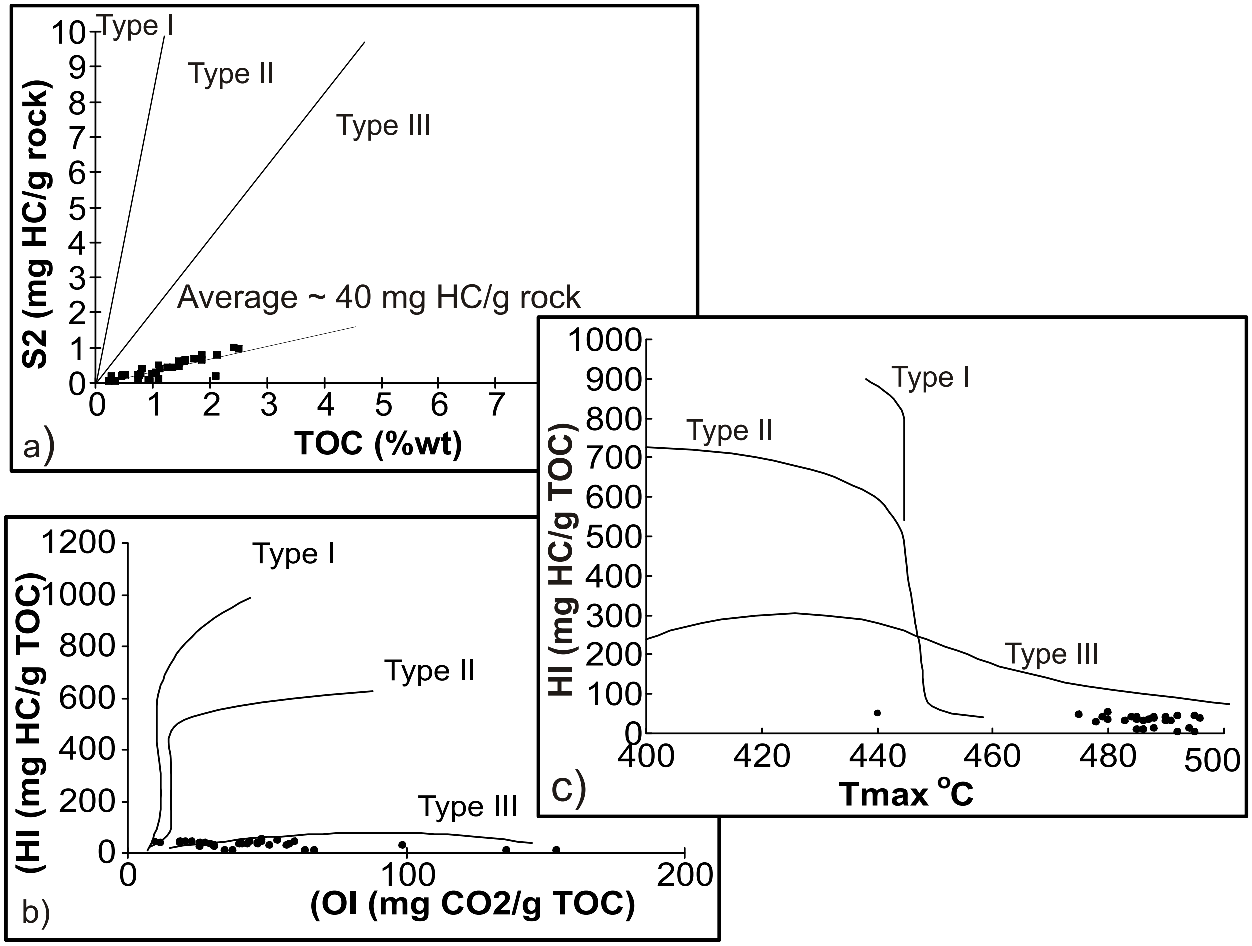


Figure 7. Graphs of Rock-Eval data for kerogen from surface samples of Lower-Middle Jurassic strata from the Yalakom River and Potato Range areas. Data points are presented in Appendix I. a) HI (hydrogen index) versus OI (oxygen index) diagram; b) S2 versus TOC (total organic carbon) diagram; c) HI vs Tmax diagram.

Several of the samples within the Junction Creek formation and Bowser Lake and Jackass Mountain Groups contain migrabitumen; the presence of migrabitumen in these thermal maturity analyses is a positive indication for the generation and migration of liquid petroleum in these sediments.

NEW PALYNOLOGY RESULTS

Analyses of palynomorphs from nearly 70 new drillhole cuttings and core samples are presented in Appendix III. New constraints on the ages of the stratigraphy were obtained in 5 of the drillholes.

- Honolulu Nazko a-4-L: A Middle to Late Albian sequence (at depths of 403 to 1619 m) overlies a Campanian unit at 2245 m, requiring structural repetition of stratigraphy. Both sequences contain dominantly terrestrial palynoforms, and the presence of a marine algae species indicates intermittent proximity to a marine influence.
- CanHunter et al. Nazko d-96-E: Middle to Late Albian to Cenomanian ages and dominantly terrestrial conditions were determined for depths from 300 to 1890 m.
- CanHunter et al. Redstone b-82-C: A Late Albian to Cenomanian age and an inferred terrestrial depositional environment is indicated for the stratigraphy between 1210 and 1610 m.
- Hudson's Bay Redstone c-75-A: A potential source-bed unit of Late Albian marine shale was identified in the top of this well (115 to 152 m). It is underlain by marginal marine to terrestrial sequences of Middle to Late Albian ages.
- CanHunter Redstone d-94-G: A late Middle Albian to Cenomanian age and a dominantly terrestrial depositional environment is indicated for depths between 30 and 1980 m.

Anomalously barren zones were encountered in 3 of the holes: b-22-K from 317 to 3700 m, b-82-C from 410 to 1120 m, and b-16-J from 310 to 2395 m. Given the lithology of these units (sediments within felsic volcanic sequences),

Table 2. Vitrinite reflectance data for surface samples collected in 2006.

Station	Formation	Easting (Zone 10)	Northing (Zone 10)	Ro%
FF06-12a	Bowser Lake Group	379434	5932897	2.10
FF06-12b	Bowser Lake Group	379434	5932897	2.21
FF06-22	Bowser Lake Group	376804	5929737	1.69
FF06-34	Bowser Lake Group	381860	5924166	2.49
FF06-63	Bowser Lake Group	435864	5912238	1.06
FF06-64	Bowser Lake Group	419484	5916619	1.63
JR06-02	Bowser Lake Group	398575	5893292	3.88
JR06-11	Bowser Lake Group	390415	5915147	5.44
JR06-13	Bowser Lake Group	391433	5917830	3.37
JR06-15	Bowser Lake Group	394236	5918421	4.35
JR06-16	Bowser Lake Group	394086	5918377	4.14
JR06-17	Bowser Lake Group	393936	5918302	4.65
JR06-18	Bowser Lake Group	394874	5918578	3.28
JR06-19	Bowser Lake Group	394206	5919331	3.36
JR06-20	Bowser Lake Group	394003	5919332	3.41
FF06-50	Hazelton?	305662	5960299	3.06
FF06-02	Hazelton-Entiako	362308	5894980	1.68
FF06-07	Hazelton-Entiako	357703	5904020	3.36
FF06-30	Hazelton-Entiako	384166	5924793	1.96
JR06-03	Hazelton-Entiako	375233	5886155	4.80
JR06-117	Jackass Mtn. Group	542292	5651976	1.37
FF06-151	Junction Creek	545734	5648643	1.57
FF06-152	Junction Creek fm	544401	5649735	1.27
FF06-156	Junction Creek fm	537260	5654700	1.61
JR06-113	Junction Creek fm	546141	5648042	1.93
JR06-131	Junction Creek fm	549503	5647499	1.87
JR06-135	Junction Creek fm?	552295	5644711	1.97
FF06-125	Lizard	513059	5647157	2.69
FF06-92	Nemaia Fm	412281	5703686	0.86
FF06-96	Nemaia Fm	403770	5710180	2.77
FF06-55	Ootsa Lake Grp.	427462	5910515	2.06
JR06-33	Ootsa Lake Grp.	420723	5916847	0.89
JR06-121	Paradise fm	500446	5663203	1.65
JR06-101	Relay Mountain Gp	407688	5717624	2.36
JR06-93a	Relay Mountain Gp	480324	5716807	1.93
JR06-93b	Relay Mountain Gp	480324	5716807	1.93
JR06-97	Relay Mountain Gp	408441	5716335	1.96
FF06-100	Relay Mtn. Grp	408028	5716806	1.74
FF06-105	Relay Mtn. Grp	407922	5713095	2.02
FF06-107	Relay Mtn. Grp	408047	5713778	2.09
FF06-108	Relay Mtn. Grp	407583	5713705	2.01
FF06-69	Taylor Ck Group	470109	5843963	0.53
FF06-78	Taylor Ck Group	471114	5837205	1.06
JR06-49	Taylor Creek or Skeena	468821	5846566	1.27

*Samples in red text contain migrabitumen

we suspect that they are correlative with the Eocene Ootsa Lake Group. The barren character of this unit may be due to silicification caused by hydrothermal activity associated with felsic volcanism.

Analyses for surface palynology samples (Figure 9d) are not yet available.

APATITE FISSION TRACK THERMOCHRONOMETRY RESULTS

Apatite fission track (AFT) analysis was recently completed for 50 samples by Paul O'Sullivan at the Apatite to Zircon Lab in Viola, Idaho. The sample set includes 22 surface samples from across the Nechako region and 28 drill cuttings taken from 6 of the exploration wells. The samples fall into 8 regional suites (**Figure 9a**). A report of these new data with interpretations is in preparation for publication. The information from AFT analysis is especially useful in the Nechako region, where so much of the pre-Neogene geology, including major structural elements, is covered by young volcanic flows and glacial material and so is not mappable at surface. Individual structural domains can be identified by their peculiar burial and cooling (uplift) histories, and structural relationships can be inferred between different domains. Also, the AFT data indicate timing for the period when samples last cooled through the annealing temperature of apatite (110°C to 160°C), providing important constraints on the timing of hydrocarbon generation.

The data are new, and further work will be done to integrate other data with them. In some suites, more than one possibility exists to explain the data, so in order to eliminate rival hypotheses we will try to obtain new vitrinite reflectance data and in some cases new radiometric dates. However, new insights are apparent for some of the suites sampled.

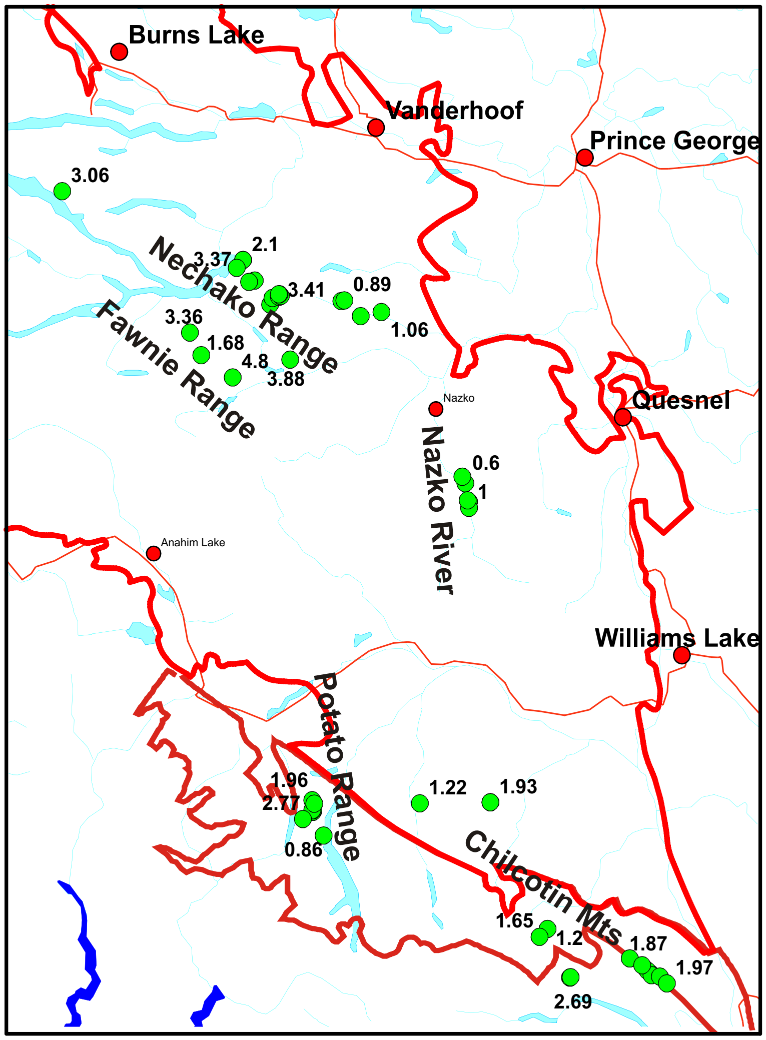


Figure 8. Vitrinite reflectance surface sample locations 2005 and 2006. Numbers beside symbols are reflectance values (Ro) in per cent. 2005 data from Ferri and Riddell (2006). 2006 data from Table 2.

With some notable exceptions, the samples show that much of the southern Nechako region experienced a rapid cooling event (or events) in the Early Eocene (approximately 50 to 55 Ma). Some areas experienced a Late Eocene to Early Oligocene cooling event, but these events are more localized. Some interesting facts are emerging from the AFT data.

- Taseko River suite: This suite consists of 6 samples from drill cuttings from the CanHunter Redstone well d-94-G and one surface sample of the unit we informally called the Taseko River strata (Ferri and Riddell, 2006), 8 km south-southwest of the well site. The AFT data show that the surface sample moved upward (cooled significantly) relative to the samples in the well and that this upward movement must have occurred during the Eocene. The AFT ages of the 6 samples in the well (see the AFT column, figure 16) are consistent with one another, which suggests that the samples cooled as a composite block since at least the time of cooling from resetting temperatures at approximately 40 to 45 Ma (Middle Eocene). This does not discount the possibility for the thrust faulting required to reconcile the radiometric date at 2050 m with the older palyonology dates higher in the well but it does constrain its timing to prior to or simultaneous with the rapid cooling around 40 to 45 Ma.
- Big Creek suite: There are 16 samples in this suite—12 surface samples from several rock types across the Big Creek gravity low and 4 samples in the CanHunter et al. Redstone b-82-C well cuttings.

  The surface samples fall into 3 distinct domains based on the cooling time recorded by each sample. The first group, from two plutons assumed to be Cretaceous, record significant cooling in the Late Cretaceous (70 to 80 Ma) to near surface conditions and no obvious rapid events since. The second group consists of 6 samples, including Eocene sedimentary rocks and volcanic

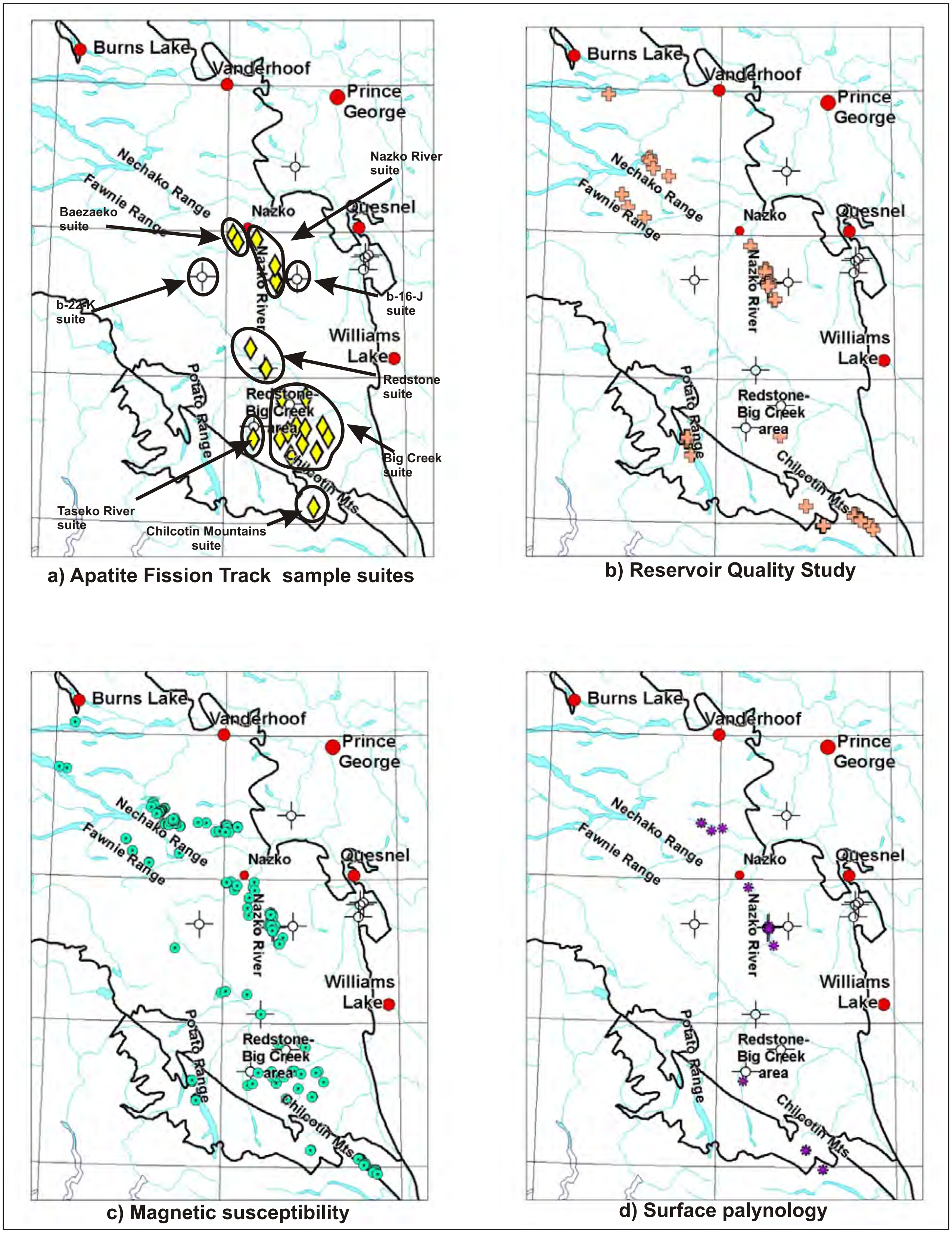


Figure 9. Surface sample locations: a) apatite fission track; b) reservoir quality; c) magnetic susceptibility (data are tabled in Appendix 2); d) palynology.

rocks, middle(?) Cretaceous andesitic breccia, and plutons of Cretaceous(?) ages. AFT data in this group indicate varying degrees of rapid Early Eocene cooling, most commonly at 50 to 55 Ma. The third group contains 4 samples, mainly from east of Big Creek, that show a significant cooling event between 40 and 30 Ma that is absent in the other samples.

Data from the well samples indicate that the structural block in which the b-82-C well was drilled experienced a very different history from the second group of surface samples, which lie only 10 to 20 kilometres to the south. No Early Eocene cooling event is recorded. The granite at the base of the well experienced rapid cooling soon after intrusion and was then reburied and reheated in middle to Late Cretaceous time. A minor amount of Paleocene cooling occurred, suggesting minimal unroofing before the Eocene followed by stability until the present time. The samples in the sedimentary packages above the granite provide provenance information about their source terranes. The basin fill material in the lower parts of the well was sourced from material with an identical thermal history as that indicated for the granite; the sediments at the top of the well were provided from a source terrane that had experienced rapid cooling during the Eocene to Oligocene.

- Redstone suite: This set comprises 5 samples—2 from surface outcrops near Redstone and 3 from cuttings from Hudson's Bay Redstone c-75-A. All 5 record middle Cretaceous deposition, followed by burial to apatite reset conditions anytime from the middle Cretaceous to Eocene and rapid cooling and uplift around 40 to 50 Ma.
- b-16-J suite: The 5 samples in this suite are from drill cuttings from CanHunter Esso Nazko b-16-J. New radiometric ages (see section below) from detrital zircons in the sedimentary section between about 550 to 1700 m show that the source of the material that fills this basin was rapidly exhumed in the Paleocene, so it predates the Ootsa Lake Group volcanic event of approximately 50 to 54 Ma. The Eocene history in this suite is still unclear; we will attempt to obtain more vitrinite reflectance data to help resolve the uncertainties.
- Nazko suite: This suite includes 4 surface samples of chert-rich sandstone from the Nazko River valley and 6 drill cuttings samples from CanHunter et al. Nazko d-96-E. The surface rocks are assumed to be Albian based on a single palynology call reported by Hunt (1989). This is consistent with the AFT data, which show that the dominant grain age in these clastic rocks are 90 to 110 Ma, implying that the source terrane for this material was rapidly exhumed and cooled at that time and was shed directly into the basin. Since then the unit exposed at surface has remained at relatively shallow depths, resulting in little if any AFT grain-age reduction.

  The well samples show a thermal history dominated by increased heating due to burial throughout the Late Cretaceous and early Tertiary, followed by a significant amount of rapid cooling during the Eocene. There is also a hint of some repetition (suggesting thrust faulting) in the data between samples below 1500 m and those above.

NEW RADIOMETRIC AGES

Twelve new U-Pb zircon ages were determined from drill cuttings and core from 5 of the Nechako oil and gas exploration wells by Paul O'Sullivan at the Apatite to Zircon Lab in Viola, Idaho. A report with these new data and interpretations is in preparation for publication in the near future. All ages cited below are from O'Sullivan (written communication, 2007), with the exception of the andesite at 3121 m in CanHunter et al. Chilcotin b-22-K, which is O'Sullivan (verbal communication, 2007).

The U/Pb ages presented here, particularly for the sedimentary sequences, are based on the youngest fraction of the zircons analyzed. It has been demonstrated by Evenchick et al. (2006) that in the Jurassic and Cretaceous sedimentary rocks of the Bowser Lake Group, the U/Pb data for the youngest detrital zircon population is the same age as fossil data in equivalent sections. This implies that it may be reasonable to infer that age of the youngest zircons in a sedimentary rock, at least in the volcanically active terranes, is the same (within the error of the analysis) as its depositional age. This assumption should be used with caution and with consideration of lithology, as the possibility exists that the age of a youngest zircon population is only a minimum age of deposition if a significant period of volcanic quiescence preceded it's deposition.

Some of the new ages were unexpected; consequently some of the interpretations published last year (Ferri and Riddell, 2006) of the stratigraphy in the drill holes have been revised.

- CanHunter et al. Nazko d-96-E: A sample of the mafic volcanic rocks near the base of this well at depths of 3180 to 3320 m yielded a date of 150.2 ± 3.1 Ma. The best regional correlative fit for Upper Jurassic rocks of this lithology is the Nechako volcanics (Diakow et al., 1997), which implies a tie with the stratigraphy to the northwest in the Nechako and Fawnie Ranges. This strengthens the correlation of the Cretaceous clastic rocks above the volcanics in this hole and in Honolulu Nazko a-4-L with the Skeena and Sustut Groups to the northeast and weakens the correlation with the Taylor Creek Group and Silverquick conglomerate of the Chilcotin Mountains.

- CanHunter et al. Chilcotin b-22-K: Four new ages were obtained from this well, and all are Eocene. Three detrital ages from tuffs and reworked volcanics are 52.4 ± 1.6 Ma (from 2020 to 2095 m depths), 54.0 ± 2.1 Ma (from 2570 to 2670 m depths), and 50.6 ±1.6 Ma (from 3625 to 3745 m depths). The fourth sample yields an Early to Middle Eocene age obtained from a plagioclase porphyry andesite flow or dike from the lone core sample for this hole at 3121 m.

  In Ferri and Riddell (2006) we suggested correlation of the volcanics at the bottom of the b-22-K well with the Upper Cretaceous Powell Creek volcanics; this correlation is clearly not valid as these results show that these rocks are far younger.

  We are not able to reconcile these ages with the palynological data presented by Hunt (1989), which indicated Maastrichtian to Albian-Campanian ages for the rocks at depths from about 700 m to the bottom of the drillhole. We were unable to reproduce those results with new palynology (Appendix III).

- CanHunter Esso Nazko b-16-J: Three new dates were obtained for this drillhole. Two are detrital dates from conglomerates in middle sections of the well that contain mixed conglomerates, sandstones, and tuffaceous material—the ages are both Paleocene. The conglomerate from 1060 to 1120 m contains clasts of chert, along with hornblende and quartz crystals, and yielded an age of 57 ± 2.5 Ma. The conglomerate from 1640 to 1720 m is rich in quartz and hornblende crystals and biotite flakes and yields a detrital date of 61.4 ± 4.2 Ma. We had assumed that felsic volcanic rocks of the Ootsa Lake Group were the main source rocks for these quartz-rich clastics, so Early Eocene ages (50 to 54 Ma) typical of those volcanics were expected. Instead, a Paleocene volcanic or intrusive source, which is not exposed or not recognized in the region (Breitsprecher and Mortensen, 2003) provided much of the material.

  The 140.6 ± 1.6 Ma age from the volcanic rocks at the bottom of the well was also intriguing. This sample was collected in the tuffaceous material from 2300 to 2385 m, just above the basalt flows in the well bottom. This Early Cretaceous age indicates that the volcanics are too young to fit the Cache Creek and/or Hazelton Group correlations that we suggested last year (Ferri and Riddell, 2006); nor are they old enough to correlate with Triassic Takla-Nicola volcanics of the Quesnel Terrane.

  The results confirm both that the stratigraphy in b-16-J is completely unlike that found in the Nazko Valley wells (CanHunter et al. Nazko d-96-E and Honolulu Nazko a-4-L) 15 km to the west and that a major structure exists between them.

- CanHunter et al. Redstone b-82-C: The granite pluton at the base of this well at 1730 m is dated at 101.4 ± 1.9 Ma. The detrital age from the coarse clastic sequence above it at 635-730m is 101.7 ± 2.2 Ma. AFT data (see Apatite fission track thermochronometry results above) indicate that the pluton was uplifted and unroofed soon after intrusion and shed material into an Albian basin. We had previously interpreted the age of the middle sedimentary section of this well as Tertiary based on lithology and the absence of palynomorphs.

- CanHunter Redstone d-94-G: The zircon date for the volcanic rocks at the base of this well is 91.2 ± 6.1 Ma. These volcanics may correlate with the Spences Bridge Group or the Powell Creek volcanics. New pollen dates from the overlying shale and siltstone sequence indicate that they may be older than the volcanics, and so the contact between the two units is a thrust fault.

RESERVOIR QUALITY ASSESSMENT

Sandstones and conglomerates were collected from surface outcrops throughout the Nechako region and from all available drill cores. A new reservoir quality study (consisting of a petrographic study of rock type, diagenesis, visible porosity, and pore system characteristics) of 68 of the samples is underway.

Reservoir quality, insofar as it is observable in outcrop, is variable across the Nechako region. Some promising units are exposed in the Nazko River valley, and in the Taylor Creek and Jackass Mountain groups in the Chilcotin Mountains. The coarse clastics we observed in the Fawnie and Nechako ranges do not show much promise; they are strongly silicified, and most show evidence of deformation. There are thick coarse clastic sequences in the Nemaia Formation and in the Relay Mountain Group of the Potato Range, but porosity appears to be very poor.

Work on the first suite of 45 samples of surface and core from the Nazko River area is complete. Porosity and reservoir characteristics are highly variable in the Nazko River suite, but units with moderate to good reservoir quality were identified at surface and in the upper half of one of the wells. Visible porosity is dominantly solutional in type. Total porosity includes a micropore component, which would not constitute effective porosity in a liquid hydrocarbon system but may be useful in a gas-prone system, such as that indicated by Rock-Eval results in the Nechako wells (Ferri and Riddell, 2006; Hunt, 1992).

The work on the remaining 23 samples from Potato Range and Chilcotin Mountains (surface only) and Redstone (core and surface) areas is near completion. It will be compiled with existing work from Hayes et al. (2002) and published in the coming months.

MAGNETIC SUSCEPTIBILITY RESULTS

Field crews collected 151 magnetic susceptibility readings from 18 formations across the Nechako region (**Figure 9c**). These data (Appendix II) will be included in the rock properties database compiled by the Geological Survey of Canada, which is used to calibrate geophysical models.

EXPLORATION DRILLHOLE DATA COMPILATIONS

Figures 10 to 16 compile and summarize the sources of the available data (old, new, and imminent) for 7 of the oil and gas exploration wells drilled in the southern Nechako region in the 1960s and 1980s. Historical well files for all Nechako region exploration wells are in the public domain and are available online (see Table 3 for individual well file sources).

New petrophysical analyses of the existing digital log data for 8 of the Nechako wells have recently been completed, and the results are published in this volume (Smith, 2007). Calculated gas-pay zones from this report are summarized in **Figures 10 to 16** in a column for each drillhole.

FUTURE WORK

2007 FIELD SEASON PLANS

Reconnaissance of Jurassic and Cretaceous sedimentary exposures in the north westernmost part of the Nechako region, between the Fawnie Ranges and the Smithers area, will be the main activity of the 2007 field season. A substantial amount of work on source-bed geochemistry was completed in that area by Hunt (1992); our work will follow up on some of those results. We will also sample coarse clastics for reservoir quality and expand our apatite fission track thermochronometry study into that area.

Work in the southern areas (south of Highway 20) will include follow-up sampling of positive source-bed results and targeted collection of new samples for vitrinite reflectance analysis to improve calibration of our apatite fission track thermochronometry.

DATA INTEGRATION

Results from analyses of the drill cuttings will be followed up by further targeted sampling and analyses of lithology, palynology, vitrinite reflectance and radiometric dating.

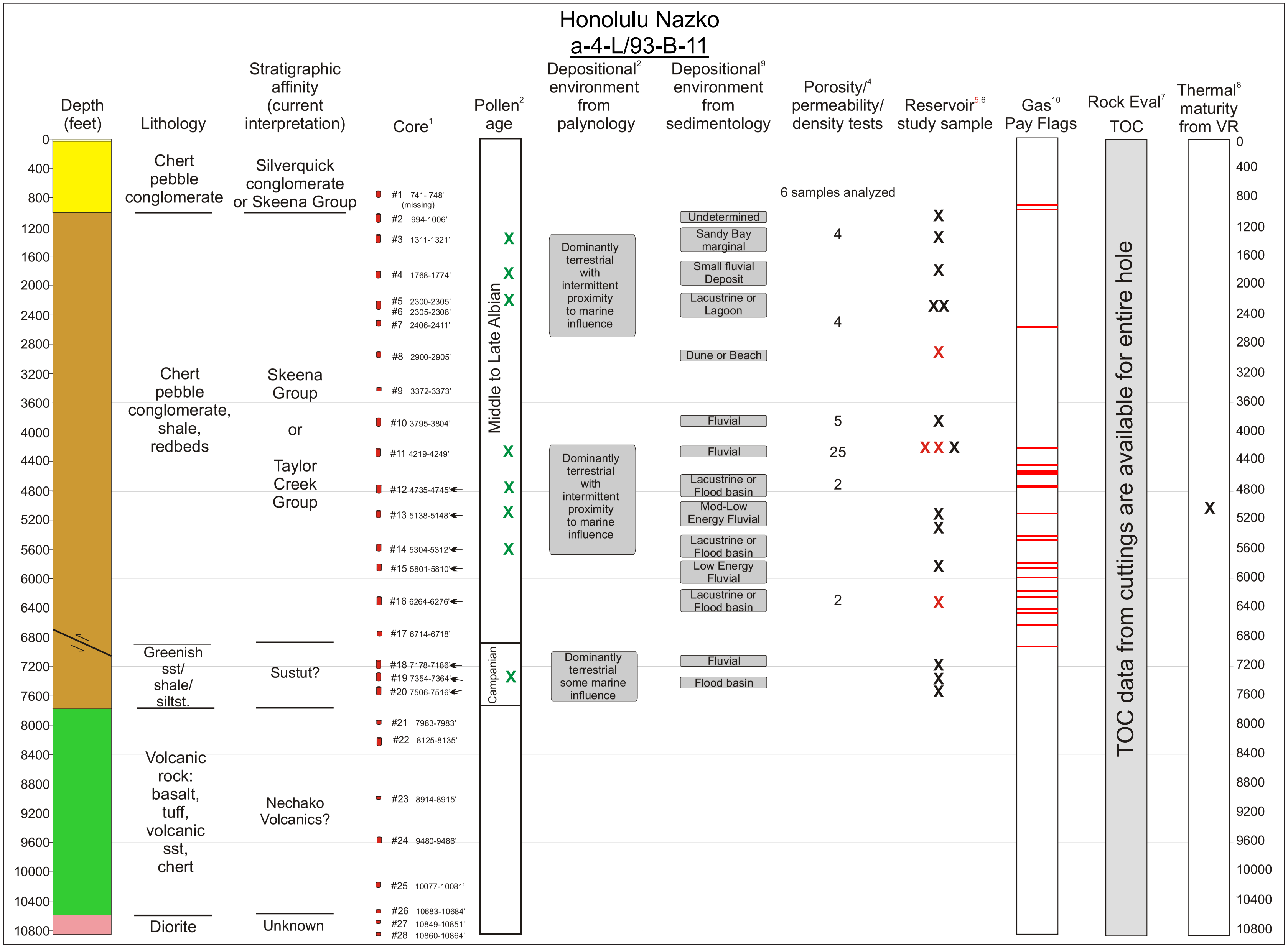


Figure 10. Drillhole a-4-L data compilation. See Table 3 for data sources.

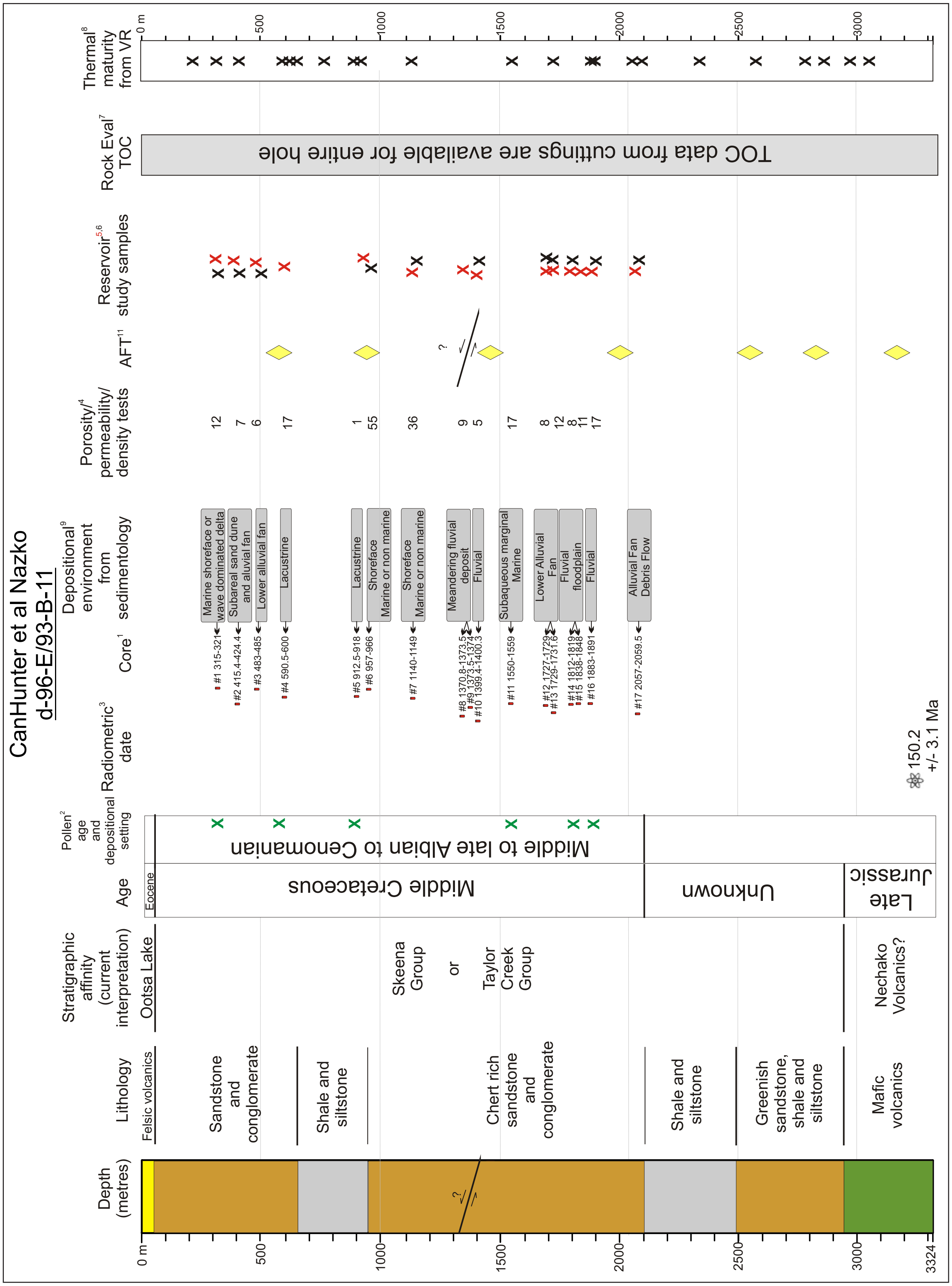


Figure 11. Drillhole d-96-E data compilation. See Table 3 for data sources.

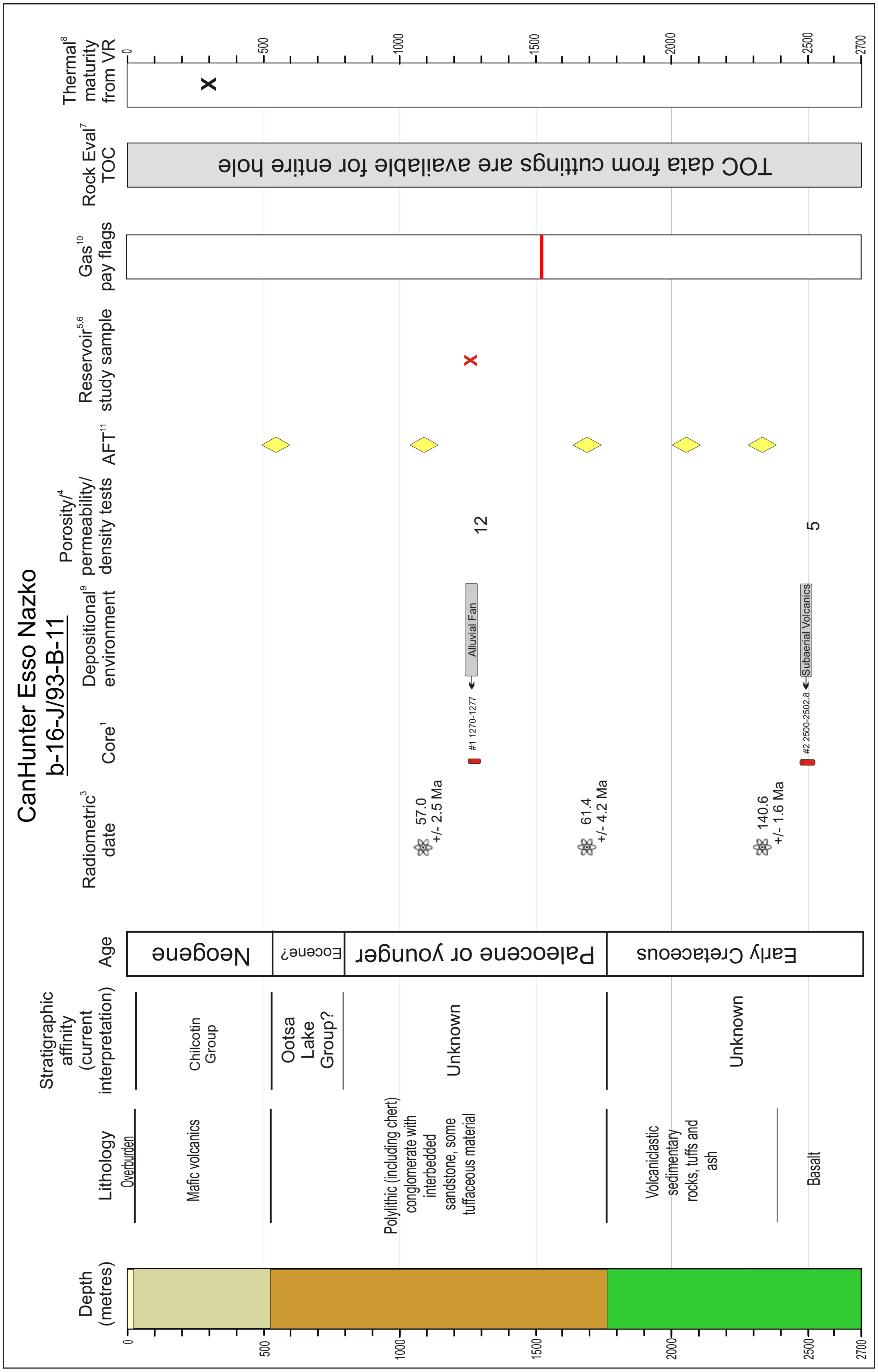


Figure 12. Drillhole b-16-J data compilation. See Table 3 for data sources.

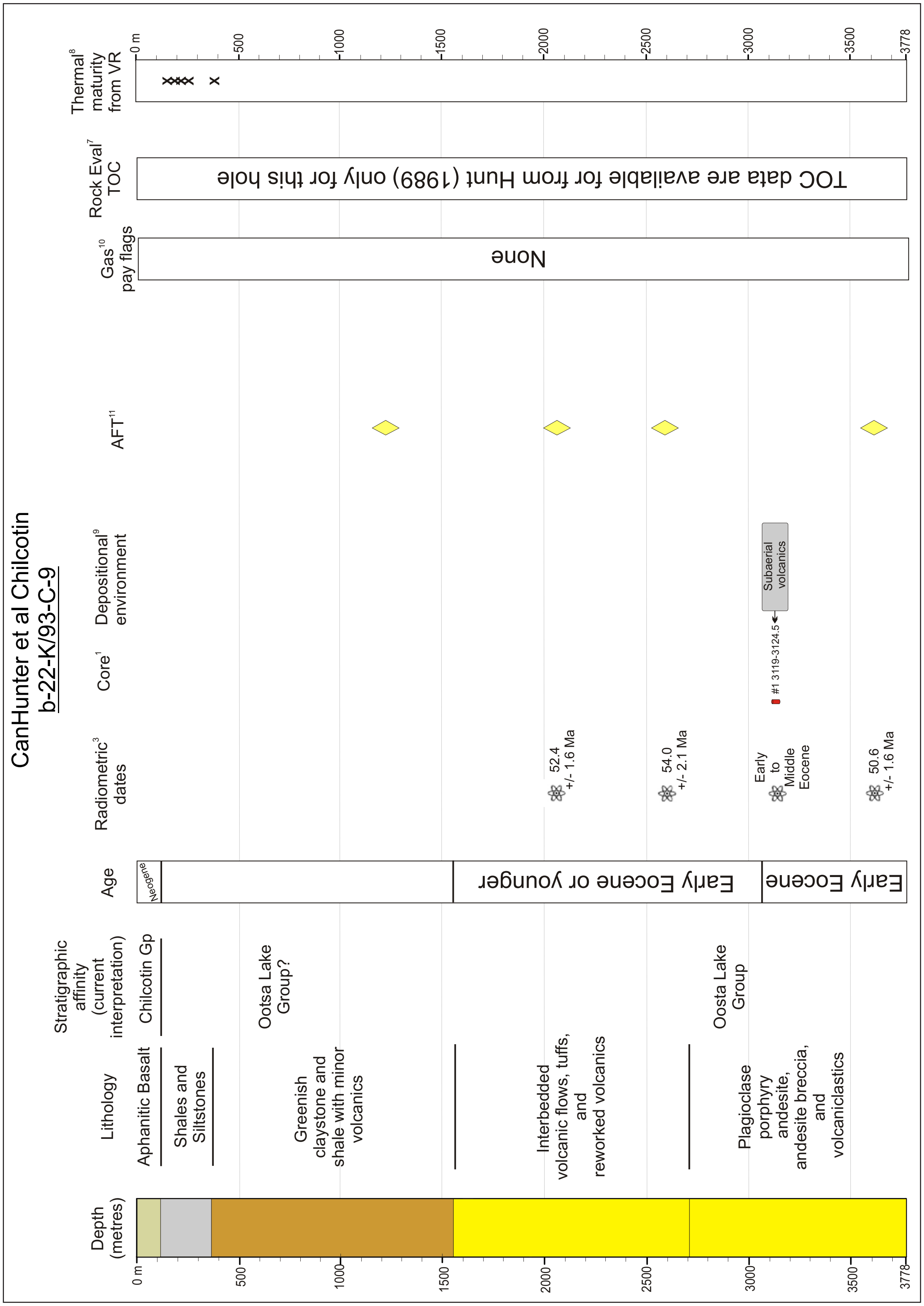


Figure 13. Drillhole b-22-K data compilation. See Table 3 for data sources.

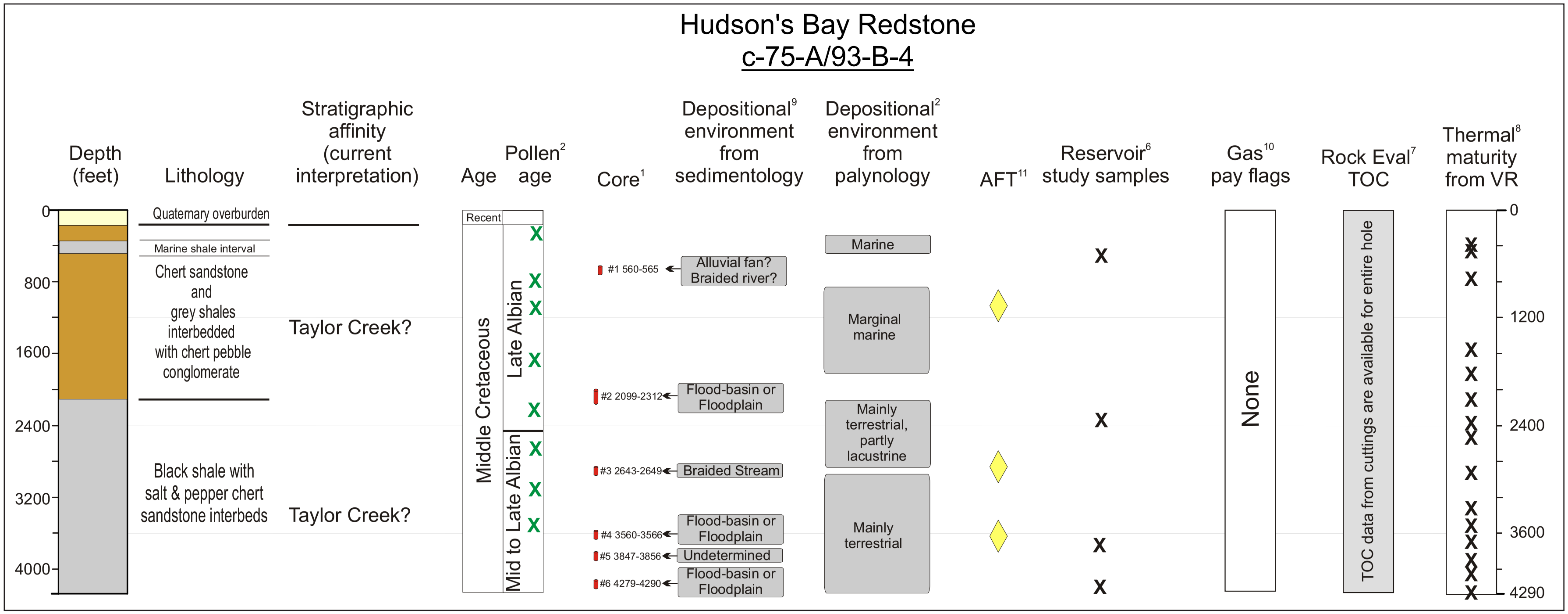


Figure 14. Drillhole c-75-A data compilation See Table 3 for data sources.

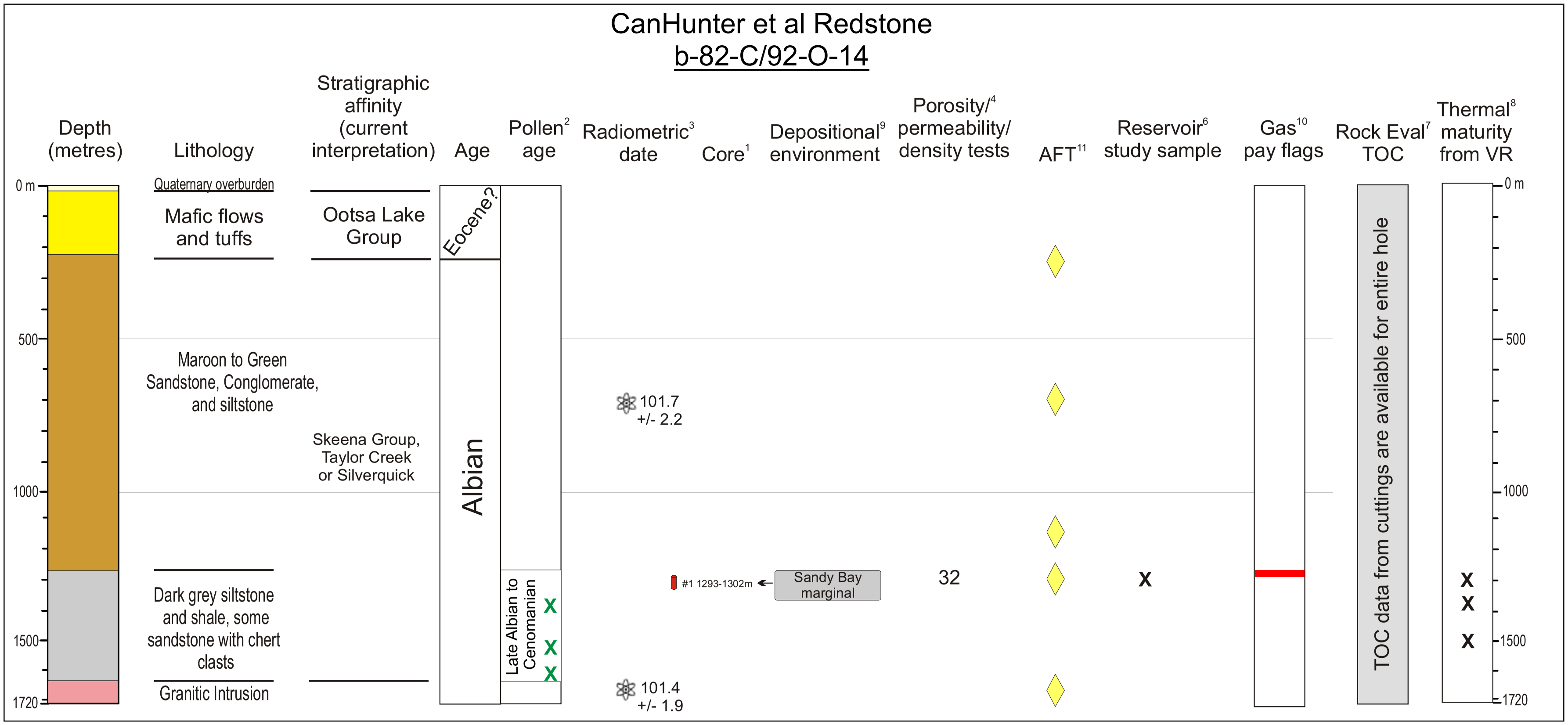


Figure 15. Drillhole b-82-C data compilation. See Table 3 for data sources.

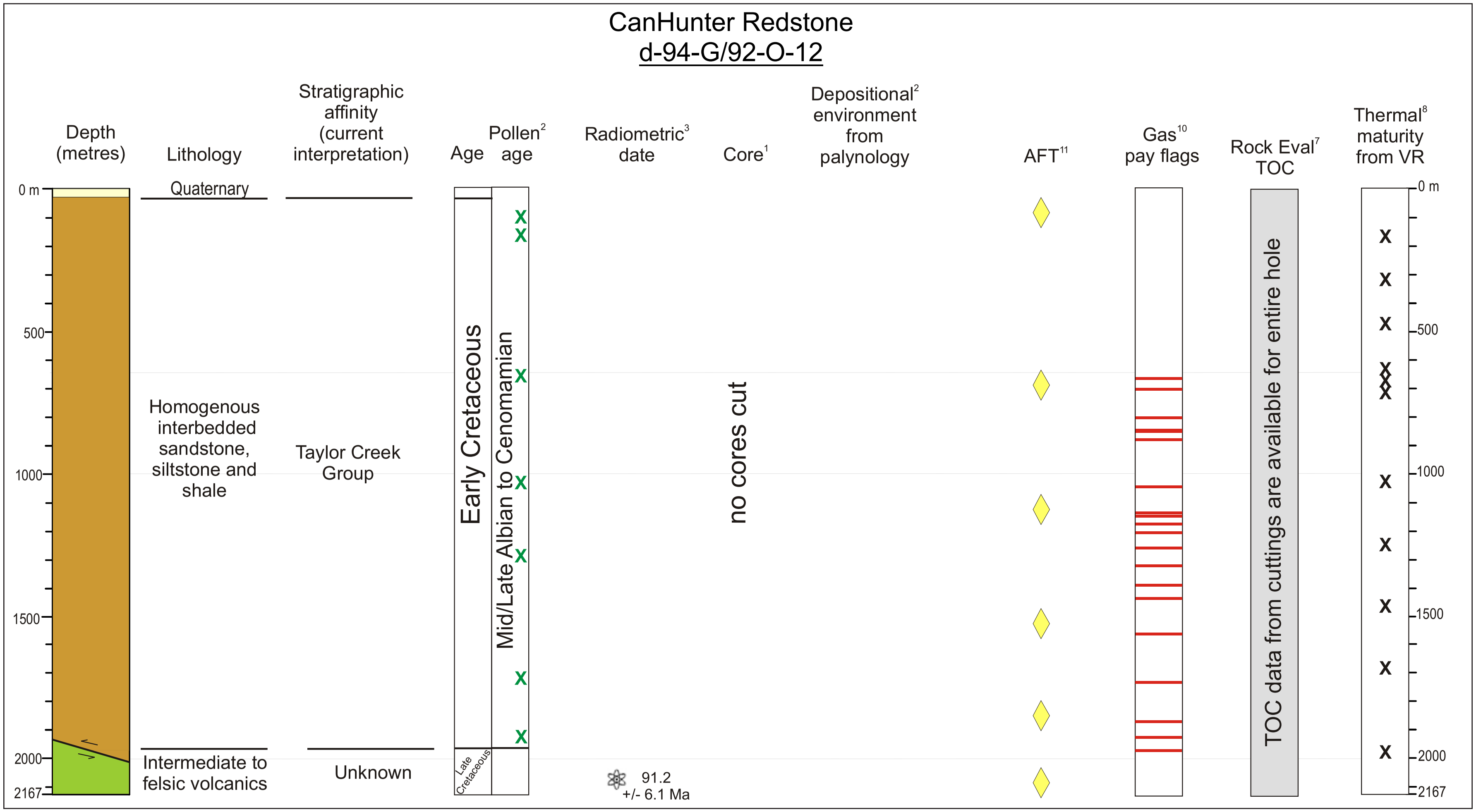


Figure 16. Drillhole d-94-G data compilation. See Table 3 for data sources.

Table 3. Data sources for Figures 10 to 16.

Data	Data Source
1. Core intervals (available from individual well files)	Cosgrove, D.T. (1981a): Well history report on Canadian Hunter *et al.* Nazko d-96-E/93-B-11; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Well File 5439. Cosgrove, D.T. (1981b): Well history report on Canadian Hunter *et al.* Redstone b-82-C/92-O-14; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Well File 5680. Cosgrove, D.T. (1982): Well history report on Canadian Hunter *et al.* Chilcotin b-22-K/93-C-9; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Well File 5702. Cosgrove, D.T. (1986a): Well hist ory report on Canadian Hunter Esso Nazko b-16-J/93-B-11; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Well File 5544. Cosgrove, D.T. (1986b): Well history report on Canadian Hunter Redstone d-94-G/92-O-12; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Well File 6438. Landreth, T.C. (1961): Well history report on Honolulu Nazko a-4-L/93-B-11; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Well File 634. Ramsay, T.B. (1972): Sample descriptions for Vieco Texacal Punchaw c-38-J/93-G-6; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Well File 3149.
2. Palynology	Appendix III, this report: Sweet, Arthur; Summary of Palynological Results, Nechako Basin Wells
3. Radiometric ages	O'Sullivan, P.B., written communication (A report on New U/Pb dates from Nechako area oil and gas exploration well cuttings, is in preparation.)
4. Porosity, permeability and density tests (available from individual well files)	Landreth, T.C. (1961): Well history report on Honolulu Nazko a-4-L/93-B-11; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Well File 634. Cosgrove, D.T. (1986a): Well history report on Canadian Hunter Esso Nazko b-16-J/93-B-11; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Well File 5544. Cosgrove, D.T. (1981b): Well history report on Canadian Hunter *et al.* Redstone b-82-C/92-O-14; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Well File 5680. Cosgrove, D.T. (1981a): Well history report on Canadian Hunter *et al.* Nazko d-96-E/93-B-11; *B.C. Ministry of Energy, Mines and Petroleum Resources,* Well File 5439.
5. Reservoir quality	Hayes, B. (2002): Petroleum exploration potential of the Nechako Basin, British Columbia; *B.C. Ministry of Energy and Mines,* Petroleum Geology Special Paper 2002-3, 52 pages.
6. Reservoir quality	Brown, David; Simpson,James and Riddell,Janet: A report on the petrographic analysis of Nechako basin coarse clastic rocks is in preparation, to be released late 2007 by the BC Ministry of EMPR, Oil and Gas Division.
7. Rock Eval data	Osadetz, K.G, Snowdon, L.R. and & Obermajer, M. (2003): Rock-Eval/TOC data for eleven northern British Columbia boreholes, *British Columbia Ministry of Energy, Mines and Petroleum Resources*, New Ventures Branch, Petroleum Geology Open File 2003-1 and Hunt, Julie A. (1989): Stratigraphy, maturation and source rock potential of Cretaceous strata in the Chilcotin-Nechako region of British Columbia;unpublished MSc thesis, *University of British Columbia,* Vancouver, 448 pages.
8. Thermal Maturity	Ferri, Filippo, and Riddell, Janet (2006): The Nechako Basin Project: New Insights from the southern Nechako Basin; *in* Summary of Activities 2006, *B.C. Ministry of Energy, Mines and Petroleum Resources*, pages 89-124
9. Depositional Environment	Mustard, P.S. and. MacEachern, J.A. (2007) A Detailed Facies (Sedimentological and Ichnological) Evaluation of Archived Hydrocarbon Exploration Drill Core from the Nechako Basin, B.C.; *in* Nechako Initiative Geoscience Update, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Petroleum Geology Open File 2007-1 (this volume), pages 7-57.

Table 3. (continued)

Data	Data Source
10. Petrophysical analysis	Smith, Ian F. (2007): Petrophysical Analysis, Nechako Basin, British Columbia Canada; *in* Nechako Initiative Geoscience Update, *B.C. Ministry of Energy, Mines and Petroleum Resources*, Petroleum Geology Open File 2007- 1 (this volume), pages 99-108.
11. Apatite fission track thermochronometry	O'Sullivan, P.B., written communication. (A report on apatite fission track results from the Nechako basin is in preparation.)

Note: Nechako well files are in the public domain and are available at:

http://www.em.gov.bc.ca/subwebs/oilandgas/petroleum_geology/wellreports/wellreports.htm

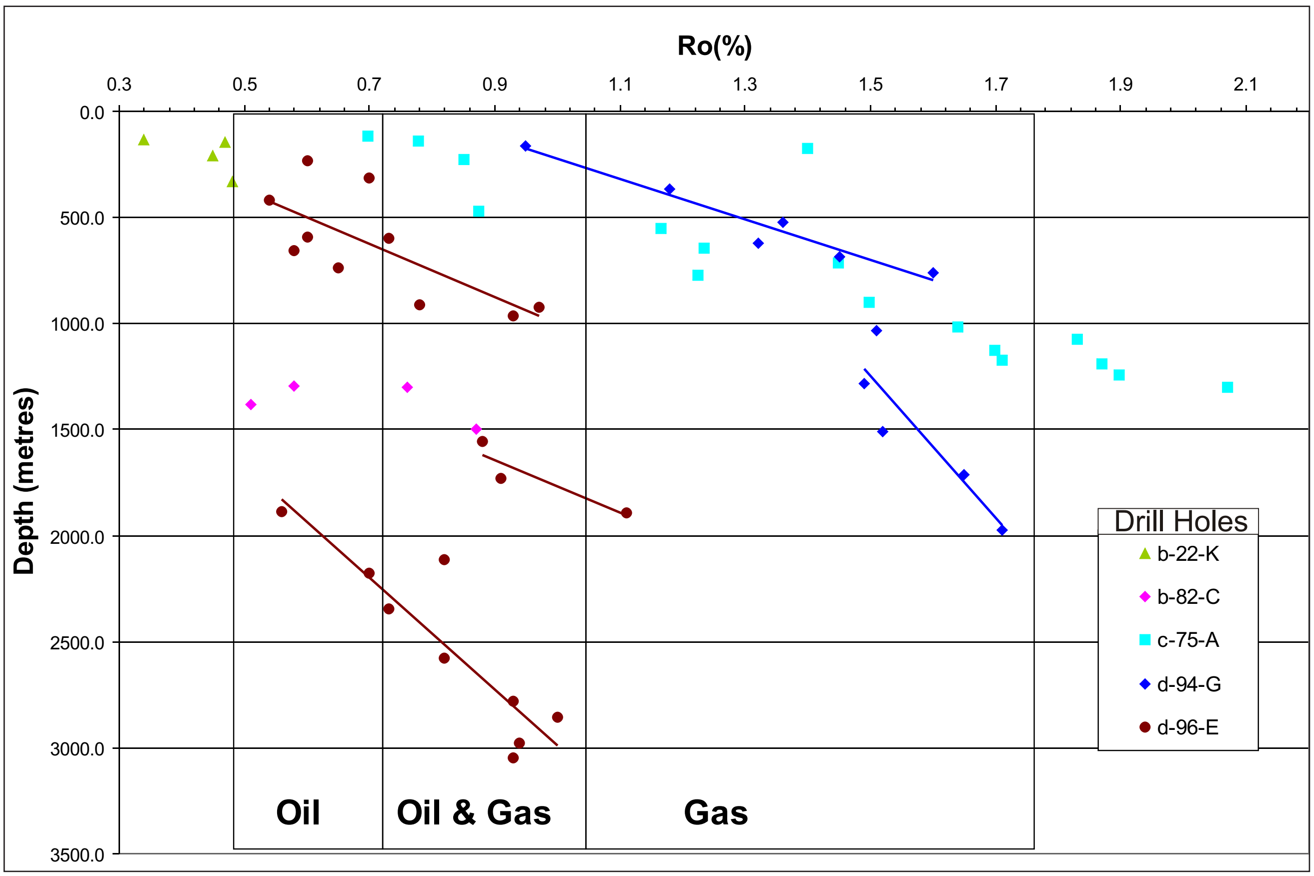


Figure 17. Plot of subsurface vitrinite reflectance values against depth. Data from Ferri and Riddell (2006). The data for d-96-E (deep red dots) and d-94-G (dark blue diamonds) show back-stepping of thermal maturity with depth, which can be explained by repetition of section by thrust faulting.

CONCLUSIONS

- The Mesozoic stratigraphy in the Nechako and Fawnie ranges correlates broadly with age-equivalent rocks that occur to the northwest in the Hazelton-Smithers and Bowser Basin regions. Total organic carbon (TOC) values from this area are fair to poor. Reservoir quality of the coarse clastic rocks in the Fawnie and Nechako ranges appears to be very poor.
- The subsurface of the Nazko River valley contains 2000 to 3000 m of Cretaceous clastic rocks. The remnant of this basin has an elongate, north-northwest–trending shape, about 27 km wide and as much as 150 km long. It is bound to the east by an unknown structure that separates it from very different stratigraphy in CanHunter Esso Nazko b-16-J. The nature of its western boundary is unknown, but it lies east of the exposure of Triassic(?) basement rock at McFarland Creek 18 km to the west of CanHunter et al. Nazko d-96-E. Similar Cretaceous clastic rocks can be traced north as far as Batnuni Lake. Cretaceous rocks are not anywhere exposed between the Cantillon Creek outcrops (Figure 3) and Highway 20 to the south, but a similar gravity signature to the Nazko River area exists around White Pelican Lake, so there may be similar rocks in the subsurface there.
- There are independent indications of thrust faulting in the Nazko River subsurface from the apatite fission track (AFT), palynology, and vitrinite reflectance data sets (subsurface vitrinite reflectance data were presented in Ferri and Riddell [2006] and are plotted against depth in Figure 17).
- Similarly, thrust faulting is indicated in CanHunter Redstone d-94-G by the radiometric and pollen dates. Apatite fission track (AFT) data constrain thrust faulting in the well section to 40 to 45 Ma or before.
- The plot of vitrinite reflectance against depth (Figure 17) demonstrates that geothermal gradients are consistent across the southern Nechako region to a depth of about 1500 m. The plots for both CanHunter Redstone and d-94-G and CanHunter et al. Nazko show a marked decrease in the gradient at greater depths.
- Radiometric dates and palynology from cuttings from CanHunter et al. Nazko d-96-E and Honolulu Nazko a-4-L provide data that strengthen correlation of the Cretaceous clastic sequences of the Nazko River valley with the Skeena and Sustut Groups rather than with the Taylor Creek Group-Silverquick conglomerate. The volcanic rocks at the base of CanHunter et al. Nazko d-96-E, and presumably also Honolulu Nazko a-4-L, probably correlate with the Nechako volcanics of the Fawnie Range.
- The stratigraphy in CanHunter et al. Chilcotin b-22-K is no older than Early Eocene to a depth of at 3700 m or more, and most of it correlates best with the Ootsa Lake Group. It is much younger than we previously believed (Ferri and Riddell, 2006), and the possibility that the large gravity low in that area represents a Jura-Cretaceous clastic basin with good oil and gas potential now seems remote.
- Rock-Eval data were obtained from shales in the Lower to Middle Jurassic rocks of the Hazelton, Junction Creek, and Nemaia Groups and Middle Jurassic to Lower Cretaceous strata of the Bowser Lake Group. Rocks of the Nemaia and Junction Creek formations returned the best results of all rocks sampled for Rock-Eval analysis during the 2006 field season, with TOC values generally between 0.5% and 2.5%. TOC values are fair to poor in samples from the Nechako and Fawnie ranges.

  A plot of S2 versus TOC **(Figure 7a)** for samples of lower Middle Jurassic strata from the Yalakom River and Potato Range areas shows that current hydrocarbon contents are approximately 40 mg/g rock and that kerogen is clearly Type III. The indication of a gas-prone system is consistent with previous data from the Nechako region (Hunt and Bustin, 1997: Osadetz et al., 2003; Ferri and Riddell, 2006).

  Rock-Eval results from Middle Cretaceous shales of the Jackass Mountain Group and the Paradise and Lizard formations of the Taylor Creek Group were disappointing. TOC values from shales of that age have consistent but low values in the range of 0.30% to 0.60% (Appendix I).
- With AFT analysis, individual structural domains can be identified by their peculiar burial and cooling (uplift) histories, and important constraints on the timing of hydrocarbon generation can be established. Analyses of 50 AFT samples from surface and well cuttings have provided new data that will be integrated with radiometric, biostratigraphic, and geophysical data to help us identify and locate regional structural elements that are hidden beneath the extensive Neogene volcanic flows and glacial material. The majority of our samples record a rapid cooling event (or events) in the early Eocene (approximately 50 to 55 Ma) that coincides with the eruption of the Ootsa Lake Group volcanics.
- New radiometric dates in the CanHunter Esso Nazko b-16-J well and AFT data in the b-82-C well indicate that an igneous event and a possibly related minor cooling (uplift and unroofing) occurred in some parts of the southern Nechako region in Paleocene time. There are no similar radiometric dates documented in

the BC Age database (Breitsprecher and Mortensen, 2004), although there are a number of similar dates in the Anahim Lake area. This may be because related rocks are not exposed at surface; alternatively, it may be that the Paleocene rocks are similar to Ootsa Lake volcanics and have not been recognized nor dated.

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APPENDIX I: ROCK-EVAL DATA FOR SURFACE SAMPLES COLLECTED IN 2006.

Sample	Formation	Area	Easting	Northing	TOC	S1	S2	PI	S3	Tmax	Tpeak	S3CO	PC(%)	RC%	HI	OICO	OI	MINC%
FF06-12a	Bowser Lk Gp	Fawnie-Nch	379434	5932897	1.17	0.01	0.07	0.14	0.19	598	638	0.13	0.02	1.15	6	11	16	0.7
FF06-12b	Bowser Lk Gp	Fawnie-Nch	379434	5932897	0.92	0.01	0.06	0.15	0.28	595	635	0.02	0.02	0.90	7	2	30	0.6
FF06-12c	Bowser Lk Gp	Fawnie-Nch	379434	5932897	0.69	0.01	0.06	0.16	0.24	593	633	0.14	0.02	0.67	9	20	35	0.5
FF06-16	Bowser Lk Gp	Fawnie-Nch	379059	5929379	0.39	0.01	0.02	0.27	0.41	310	350	0.00	0.01	0.38	5	0	105	0.7
FF06-34	Bowser Lk Gp	Fawnie-Nch	381860	5924166	0.32	0.01	0.03	0.22	0.21	497	537	0.03	0.01	0.31	9	9	66	0.2
FF06-47	Bowser Lk Gp	Fawnie-Nch	391624	5918456	0.89	0.01	0.06	0.14	0.71	500	540	0.20	0.04	0.85	7	22	80	0.1
FF06-48	Bowser Lk Gp	Fawnie-Nch	391222	5918185	0.24	0.01	0.03	0.24	0.26	434	474	0.03	0.01	0.23	12	12	108	0.5
JR06-02	Bowser Lk Gp	Fawnie-Nch	398575	5893292	0.89	0.01	0.02	0.20	0.34	496	536	0.02	0.01	0.88	2	2	38	0.1
JR06-11	Bowser Lk Gp	Fawnie-Nch	390415	5915147	0.07	0.00	0.01	0.31	0.13	321	361	0.09	0.01	0.06	14	129	186	0.1
JR06-12	Bowser Lk Gp	Fawnie-Nch	390673	5915168	0.12	0.01	0.02	0.19	0.18	427	467	0.09	0.01	0.11	17	75	150	0.2
JR06-13	Bowser Lk Gp	Fawnie-Nch	391433	5917830	0.64	0.00	0.01	0.32	0.77	516	556	0.07	0.03	0.61	2	11	120	0.1
JR06-15	Bowser Lk Gp	Fawnie-Nch	394236	5918421	0.94	0.01	0.01	0.37	0.29	427	467	0.02	0.01	0.93	1	2	31	0.9
JR06-17	Bowser Lk Gp	Fawnie-Nch	393936	5918302	1.01	0.01	0.03	0.18	0.58	497	537	0.04	0.03	0.98	3	4	57	0.2
JR06-18	Bowser Lk Gp	Fawnie-Nch	394874	5918578	0.77	0.01	0.02	0.36	0.28	278	318	0.00	0.01	0.76	3	0	36	0.5
JR06-19	Bowser Lk Gp	Fawnie-Nch	394206	5919331	0.77	0.02	0.04	0.39	0.17	609	649	0.03	0.01	0.76	5	4	22	0.5
JR06-21	Bowser Lk Gp	Fawnie-Nch	395311	5819790	0.59	0.01	0.03	0.30	0.24	607	647	0.12	0.02	0.57	5	20	41	0.8
FF06-118	Dash congl	Chilcotin Mts	512546	5646987	0.48	0.01	0.01	0.28	0.44	514	554	0.11	0.02	0.46	2	23	92	0.4
FF06-119	Dash congl	Chilcotin Mts	512634	5647006	0.47	0.00	0.01	0.33	0.50	610	650	0.03	0.02	0.45	2	6	106	0.2
FF06-02a	Hazelton	Fawnie-Nch	362308	5894980	0.05	0.00	0.01	0.27	0.24	425	465	0.00	0.01	0.04	20	0	480	0.6
FF06-02b	Hazelton	Fawnie-Nch	362308	5894980	0.25	0.02	0.03	0.36	0.21	430	470	0.01	0.01	0.24	12	4	84	10.0
FF06-04a	Hazelton	Fawnie-Nch	397341	5915460	0.68	0.01	0.01	0.35	0.32	303	343	0.04	0.01	0.67	1	6	47	0.9
FF06-04b	Hazelton	Fawnie-Nch	397341	5915460	0.68	0.01	0.02	0.46	0.47	308	348	0.01	0.02	0.66	3	1	69	1.7
FF06-05	Hazelton	Fawnie-Nch	395308	5919791	0.98	0.01	0.03	0.20	0.28	605	645	0.05	0.02	0.96	3	5	29	0.8
FF06-06	Hazelton	Fawnie-Nch	356321	5906147	0.13	0.01	0.02	0.33	0.17	492	532	0.01	0.01	0.12	15	8	131	0.2
FF06-07	Hazelton	Fawnie-Nch	357703	5904020	0.55	0.01	0.02	0.30	0.39	316	356	0.04	0.02	0.53	4	7	71	0.3
FF06-08	Hazelton	Fawnie-Nch	357688	5904067	0.58	0.01	0.03	0.27	0.77	332	372	0.07	0.03	0.55	5	12	133	0.3
FF06-09	Hazelton	Fawnie-Nch	357681	5904136	0.67	0.02	0.03	0.39	0.55	516	556	0.10	0.03	0.64	4	15	82	0.2
FF06-29	Hazelton	Fawnie-Nch	384642	5925304	0.61	0.00	0.01	0.31	0.33	365	405	0.04	0.01	0.60	2	7	54	0.2
FF06-30a	Hazelton	Fawnie-Nch	384166	5924793	0.80	0.01	0.02	0.21	0.54	487	527	0.01	0.02	0.78	2	1	68	0.1
FF06-30b	Hazelton	Fawnie-Nch	384166	5924793	0.84	0.00	0.01	0.32	0.49	523	563	0.14	0.02	0.82	1	17	58	0.4
FF06-31	Hazelton	Fawnie-Nch	383870	5924916	0.94	0.01	0.02	0.21	0.32	368	408	0.01	0.01	0.93	2	1	34	0.1
FF06-32	Hazelton	Fawnie-Nch	383327	5924918	0.55	0.01	0.01	0.58	0.54	277	317	0.01	0.02	0.53	2	2	98	1.0
FF06-50a	Hazelton	Ootsa Lake	305662	5960299	0.82	0.02	0.03	0.43	0.24	298	338	0.06	0.02	0.80	4	7	29	2.0
FF06-50b	Hazelton	Ootsa Lake	305662	5960299	0.78	0.00	0.01	0.25	0.40	485	525	0.04	0.02	0.76	1	5	51	0.1

APPENDIX I (CONTINUED)

Sample	Formation	Area	Easting	Northing	TOC	S1	S2	PI	S3	Tmax	Tpeak	S3CO	PC(%)	RC%	HI	OICO	OI	MINC%
FF06-50c	Hazelton	Ootsa Lake	305662	5960299	0.99	0.03	0.06	0.31	0.25	387	427	0.09	0.02	0.97	6	9	25	0.6
FF06-66	Hazelton	Batnuni Lk	413345	5917087	0.46	0.03	0.15	0.15	0.41	499	539	0.03	0.03	0.43	33	7	89	1.3
JR06-03	Hazelton	Fawnie-Nch	375233	5886155	0.04	0.00	0.01	0.26	0.14	420	460	0.09	0.01	0.03	25	225	350	0.1
JR06-04	Hazelton	Fawnie-Nch	375177	5886146	0.23	0.01	0.02	0.38	0.14	441	481	0.03	0.01	0.22	9	13	61	0.3
JR06-05	Hazelton	Fawnie-Nch	375137	5885965	0.03	0.01	0.03	0.24	0.13	517	557	0.08	0.01	0.02	100	267	433	0.1
JR06-133	Hurley Fm?	Yalakom R	548870	5645872	0.29	0.03	0.16	0.15	0.14	482	522	0.04	0.02	0.27	55	14	48	0.0
FF06-113	Jackass Mt Gp	Yalakom R	538412	5656790	0.12	0.00	0.04	0.11	0.22	502	542	0.01	0.01	0.11	33	8	183	0.0
JR06-117	Jackass Mt Gp	Yalakom R	542292	5651976	0.20	0.02	0.05	0.22	0.38	496	536	0.16	0.03	0.17	25	80	190	0.1
JR06-129	Jackass Mt Gp	Yalakom R	550574	5647928	0.24	0.01	0.03	0.25	0.37	566	606	0.05	0.02	0.22	12	21	154	0.0
FF06-140	Junction Ck	Yalakom R	546115	5648061	1.12	0.03	0.48	0.06	0.11	480	520	0.21	0.06	1.06	43	19	10	0.1
FF06-141	Junction Ck	Yalakom R	546043	5648323	1.14	0.04	0.39	0.09	0.66	495	535	0.05	0.06	1.08	34	4	58	0.2
FF06-142	Junction Ck	Yalakom R	545871	5648610	0.50	0.03	0.22	0.13	0.24	488	528	0.03	0.03	0.47	44	6	48	0.6
FF06-143	Junction Ck	Yalakom R	545871	5648610	2.13	0.16	0.78	0.17	0.26	484	524	0.11	0.10	2.03	37	5	12	0.1
FF06-144	Junction Ck	Yalakom R	545871	5648610	0.54	0.03	0.22	0.13	0.24	487	527	0.10	0.03	0.51	41	19	44	0.0
FF06-145	Junction Ck	Yalakom R	545871	5648610	1.28	0.05	0.44	0.10	0.38	490	530	0.06	0.06	1.22	34	5	30	0.1
FF06-146	Junction Ck	Yalakom R	545808	5648639	1.86	0.05	0.62	0.08	0.77	488	528	0.15	0.09	1.77	33	8	41	0.1
FF06-147	Junction Ck	Yalakom R	545808	5648639	2.43	0.07	0.99	0.06	0.55	479	519	0.13	0.11	2.32	41	5	23	0.1
FF06-148	Junction Ck	Yalakom R	545808	5648639	0.48	0.03	0.20	0.11	0.29	485	525	0.01	0.03	0.45	42	2	60	0.0
FF06-149	Junction Ck	Yalakom R	545808	5648639	1.48	0.09	0.60	0.13	0.31	485	525	0.17	0.08	1.40	41	11	21	0.1
FF06-150	Junction Ck	Yalakom R	545808	5648639	1.58	0.10	0.62	0.14	0.45	485	525	0.20	0.09	1.49	39	13	28	0.1
FF06-151	Junction Ck	Yalakom R	545734	5648643	1.48	0.09	0.53	0.15	0.63	486	526	0.14	0.08	1.40	36	9	43	0.1
FF06-152a	Junction Ck	Yalakom R	544401	5649735	2.11	0.01	0.17	0.05	2.87	513	553	0.19	0.12	1.99	8	9	136	2.3
FF06-152b	Junction Ck	Yalakom R	544401	5649735	1.56	0.04	0.60	0.07	0.74	475	515	0.22	0.09	1.47	38	14	47	0.1
FF06-152c	Junction Ck	Yalakom R	544401	5649735	0.83	0.06	0.40	0.13	0.45	478	518	0.14	0.06	0.77	48	17	54	10.8
FF06-153	Junction Ck	Yalakom R	543856	5650054	0.79	0.03	0.21	0.14	0.78	491	531	0.04	0.05	0.74	27	5	99	0.1
FF06-154	Junction Ck	Yalakom R	543856	5650054	1.36	0.03	0.42	0.06	0.77	485	525	0.00	0.06	1.30	31	0	57	0.1
FF06-155	Junction Ck	Yalakom R			0.75	0.01	0.06	0.08	0.50	594	634	0.13	0.03	0.72	8	17	67	0.1
FF06-157	Junction Ck	Yalakom R	537204	5654864	1.01	0.03	0.26	0.10	0.31	510	550	0.24	0.05	0.96	26	24	31	0.1
FF06-158a	Junction Ck	Yalakom R	537213	5654887	0.47	0.02	0.16	0.13	0.19	501	541	0.06	0.02	0.45	34	13	40	0.0
FF06-158b	Junction Ck	Yalakom R	537213	5654887	1.08	0.03	0.30	0.09	0.33	505	545	0.20	0.05	1.03	28	19	31	0.1
JR06-113	Junction Ck	Yalakom R	546141	5648042	0.76	0.03	0.20	0.11	0.20	496	536	0.08	0.03	0.73	26	11	26	0.0
JR06-114a	Junction Ck	Yalakom R	545838	5648626	1.74	0.09	0.68	0.12	0.33	490	530	0.07	0.08	1.66	39	4	19	0.1
JR06-114b	Junction Ck	Yalakom R	545838	5648626	1.88	0.12	0.77	0.14	0.36	483	523	0.22	0.10	1.78	41	12	19	0.1
JR06-119	Junction Ck	Yalakom R	537150	5655007	0.40	0.04	0.14	0.21	0.20	497	537	0.00	0.02	0.38	35	0	50	0.5

APPENDIX I (CONTINUED)

Sample	Formation	Area	Easting	Northing	TOC	S1	S2	PI	S3	Tmax	Tpeak	S3CO	PC(%)	RC%	HI	OICO	OI	MINC%
JR06-127a	Junction Ck	Yalakom R	548625	5648085	1.47	0.06	0.47	0.11	0.69	486	526	0.17	0.08	1.39	32	12	47	0.1
JR06-127b	Junction Ck	Yalakom R	548625	5648085	0.81	0.04	0.25	0.14	0.41	488	528	0.05	0.04	0.77	31	6	51	0.1
JR06-130	Junction Ck	Yalakom R	550241	5640879	0.93	0.01	0.07	0.10	0.33	573	613	0.07	0.02	0.91	8	8	35	0.0
JR06-131a	Junction Ck	Yalakom R	549503	5647499	0.36	0.02	0.04	0.26	0.23	486	526	0.01	0.01	0.35	11	3	64	0.1
JR06-131b	Junction Ck	Yalakom R	549503	5647499	1.11	0.03	0.09	0.26	0.42	575	615	0.01	0.03	1.08	8	1	38	0.1
JR06-132	Junction Ck	Yalakom R	549187	5646641	2.51	0.13	0.94	0.12	0.66	480	520	0.38	0.13	2.38	37	15	26	0.1
FF06-81	K clastics	Nazko R	472117	5836208	0.17	0.00	0.06	0.08	0.72	446	486	0.00	0.02	0.15	35	0	424	0.1
FF06-122	Lizard	Chilcotin Mts	512786	5647086	0.44	0.01	0.02	0.23	0.28	529	569	0.17	0.02	0.42	5	39	64	0.3
FF06-123	Lizard	Chilcotin Mts	512863	5647094	0.45	0.00	0.02	0.21	0.24	608	648	0.00	0.01	0.44	4	0	53	0.0
FF06-124	Lizard	Chilcotin Mts	512985	5647118	0.44	0.01	0.02	0.19	0.25	605	645	0.01	0.01	0.43	5	2	57	0.0
FF06-125	Lizard	Chilcotin Mts	513059	5647157	0.31	0.00	0.01	0.16	0.24	601	641	0.05	0.01	0.30	3	16	77	0.0
FF06-126	Lizard	Chilcotin Mts	513195	5647335	0.53	0.00	0.01	0.23	0.31	609	649	0.02	0.01	0.52	2	4	58	0.0
FF06-127	Lizard	Chilcotin Mts	513201	5647352	0.62	0.01	0.03	0.17	0.17	606	646	0.11	0.02	0.60	5	18	27	0.1
FF06-128	Lizard	Chilcotin Mts	513204	5647380	0.60	0.01	0.02	0.17	0.25	607	647	0.08	0.02	0.58	3	13	42	0.1
FF06-129	Lizard	Chilcotin Mts	513209	5647404	0.39	0.00	0.02	0.17	0.22	605	645	0.05	0.01	0.38	5	13	56	0.0
FF06-130	Lizard	Chilcotin Mts	513226	5647433	0.34	0.01	0.02	0.20	0.29	607	647	0.00	0.01	0.33	6	0	85	0.2
FF06-131	Lizard	Chilcotin Mts	513240	5647457	0.35	0.01	0.02	0.26	0.20	594	634	0.14	0.02	0.33	6	40	57	0.1
FF06-132	Lizard	Chilcotin Mts	513260	5647492	0.46	0.00	0.02	0.17	0.29	607	647	0.11	0.02	0.44	4	24	63	0.0
FF06-133	Lizard	Chilcotin Mts	513275	5647521	0.45	0.00	0.02	0.17	0.41	609	649	0.00	0.01	0.44	4	0	91	0.0
FF06-135	Lizard	Chilcotin Mts	513263	5647613	0.38	0.00	0.01	0.20	0.31	608	648	0.08	0.01	0.37	3	21	82	0.0
FF06-92	Nemaia Fm	Potato Rnge	412281	5703686	0.70	0.01	0.06	0.14	0.38	605	645	0.23	0.03	0.67	9	33	54	0.0
FF06-93	Nemaia Fm	Potato Rnge	412464	5704373	0.02	0.00	0.01	0.18	0.22	440	480	0.12	0.01	0.01	50	600	1100	0.4
FF06-94	Nemaia Fm	Potato Rnge	412449	5704584	0.46	0.01	0.01	0.37	0.32	492	532	0.06	0.02	0.44	2	13	70	0.3
FF06-95	Nemaia Fm	Potato Rnge	404087	5708465	0.87	0.00	0.02	0.20	0.35	495	535	0.06	0.02	0.85	2	7	40	0.1
FF06-96	Nemaia Fm	Potato Rnge	403770	5710180	0.67	0.01	0.03	0.16	0.21	607	647	0.18	0.02	0.65	4	27	31	0.1
FF06-97	Nemaia Fm	Potato Rnge	403610	5722786	0.21	0.01	0.03	0.20	0.14	494	534	0.08	0.01	0.20	14	38	67	0.2
JR06-80	Nemaia Fm	Potato Rnge	411969	5703016	0.44	0.00	0.01	0.30	0.25	609	649	0.05	0.01	0.43	2	11	57	0.0
JR06-83	Nemaia Fm	Potato Rnge	411385	5702608	0.06	0.00	0.01	0.25	0.14	493	533	0.12	0.01	0.05	17	200	233	0.0
JR06-84	Nemaia Fm	Potato Rnge	411415	5702339	0.89	0.01	0.01	0.35	0.64	348	388	0.23	0.03	0.86	1	26	72	0.3
JR06-85	Nemaia Fm	Potato Rnge	411417	5702270	1.03	0.01	0.01	0.34	0.50	492	532	0.06	0.02	1.01	1	6	49	0.1
JR06-86	Nemaia Fm	Potato Rnge	411389	5702139	0.37	0.00	0.01	0.32	0.49	493	533	0.10	0.02	0.35	3	27	132	0.2
JR06-87	Nemaia Fm	Potato Rnge	411342	5701973	0.45	0.01	0.02	0.27	0.83	388	428	0.08	0.03	0.42	4	18	184	0.1
JR06-89	Nemaia Fm	Potato Rnge	411121	5701767	1.48	0.00	0.02	0.22	0.47	506	546	0.21	0.03	1.45	1	14	32	0.1
JR06-90	Nemaia Fm	Potato Rnge	410250	5701875	0.79	0.01	0.05	0.16	0.73	357	397	0.31	0.04	0.75	6	39	92	0.3

Sample	Formation	Area	Easting	Northing	TOC	S1	S2	PI	S3	Tmax	Tpeak	S3CO	PC(%)	RC%	HI	OICO	OI	MINC%
JR06-120	Paradise fm	Chilcotin Mts	500441	5663295	0.51	0.02	0.09	0.16	0.36	504	544	0.04	0.02	0.49	18	8	71	0.0
JR06-121	Paradise fm	Chilcotin Mts	500446	5663203	0.60	0.02	0.12	0.14	0.42	508	548	0.10	0.03	0.57	20	17	70	0.1
JR06-122	Paradise fm	Chilcotin Mts	500466	5663119	0.49	0.02	0.09	0.18	0.35	509	549	0.01	0.02	0.47	18	2	71	0.0
JR06-123	Paradise fm	Chilcotin Mts	500406	5663068	0.46	0.02	0.10	0.16	0.33	512	552	0.05	0.03	0.43	22	11	72	0.2
JR06-124	Paradise fm	Chilcotin Mts	500349	5663022	0.50	0.02	0.09	0.16	0.26	512	552	0.15	0.02	0.48	18	30	52	0.0
JR06-126	Paradise fm	Chilcotin Mts	500260	5662870	0.33	0.01	0.05	0.15	0.41	514	554	0.09	0.02	0.31	15	27	124	0.0
FF06-109	Relay Mt Gp	Potato Rnge	407868	5713897	0.55	0.00	0.06	0.06	0.21	548	588	0.07	0.02	0.53	11	13	38	0.4
FF06-99	Relay Mt Gp	Potato Rnge	408244	5716848	0.05	0.00	0.02	0.16	0.31	492	532	0.02	0.01	0.04	40	40	620	0.1
JR06-101	Relay Mt Gp	Potato Rnge	407688	5717624	0.21	0.00	0.01	0.23	0.29	593	633	0.07	0.01	0.20	5	33	138	0.0
JR06-104	Relay Mt Gp	Potato Rnge	407957	5717492	0.20	0.00	0.02	0.17	0.23	559	599	0.05	0.01	0.19	10	25	115	0.0
JR06-95	Relay Mt Gp	Potato Rnge	408427	5716554	0.03	0.00	0.01	0.29	0.25	492	532	0.07	0.01	0.02	33	233	833	0.1
JR06-96	Relay Mt Gp	Potato Rnge	408445	5716438	0.30	0.01	0.04	0.17	0.46	521	561	0.05	0.02	0.28	13	17	153	0.1

Quality of source rock with reference to organic carbon content

Tmax: Temperature (^{o}C) at the top of the S2 peak; S1: Hydrocarbons evolved during heating at 25 ^{o}C intervalsbetween 300^{o}C and 600oC (mg hydrocarbons/g rock);

S3: Organic carbon dioxide evolved at 300^{o}C and up to 390^{o}C (mgCO_2/g rock); PI: Production Index = S1/(S1+S2); PC(%): Pyrolysable Carbon

HI: Hydrogen Index = (100xS2)/TOC; OI: Oxygen Index = (100xS3)/TOC

APPENDIX II: MAGNETIC SUSCEPTIBILITY DATA COLLECTED IN 2006

Station_ID	Formation	Rock type	EASTING	NORTHING	MS (X10^{-3} SI)
FF06-001	Hazelton	sandstone	362474	5894444	0.83
FF06-002	Hazelton	siltstone	362308	5894980	3.16
FF06-004	Hazelton	siltstone	397341	5915460	0.66
FF06-005	Hazelton	siltstone	395308	5919791	0.25
FF06-007	Hazelton	siltstone	357703	5904020	0.20
FF06-009	Hazelton	siltstone	357681	5904136	0.48
FF06-011	Nechako volcs	breccia	357465	5904371	62.70
FF06-013	Bowser Lake	conglomerate	378897	5932616	0.12
FF06-014	Bowser Lake	conglomerate	378193	5931558	0.11
FF06-015	Intrusion	diorite	378960	5929454	6.32
FF06-016	Bowser Lake	conglomerate	379059	5929379	0.11
FF06-017	Intrusion	fsp porphyry	379488	5929526	0.26
FF06-018	Bowser Lake	conglomerate	379646	5929469	0.25
FF06-019	Bowser Lake	conglomerate	379960	5929510	0.14
FF06-020	Bowser Lake	conglomerate	379989	5929792	0.09
FF06-021	Bowser Lake	siltstone	376902	5929059	0.14
FF06-023	Nechako volcs?	andesite	387774	5927848	16.40
FF06-024	Nechako volcs?	porphyry	387012	5927781	0.22
FF06-025	Hazelton	siltstone	385641	5926832	0.28
FF06-026	Hazelton	sandstone	385211	5926694	0.03
FF06-027	Intrusion	diorite	384937	5925723	0.49
FF06-029	Hazelton	siltstone	384642	5925304	0.15
FF06-030	Hazelton	siltstone	384166	5924793	0.19
FF06-031	Hazelton	siltstone	383870	5924916	0.23
FF06-032	Hazelton	siltstone	383327	5924918	0.15
FF06-033	Bowser Lake	sandstone	381994	5924306	0.26
FF06-034	Bowser Lake	siltstone	381860	5924166	0.31
FF06-035	Intrusion	diorite	381605	5924079	0.54
FF06-036	Intrusion	diorite	382244	5923576	0.40
FF06-037	Nechako volcs	breccia	381413	5923664	0.28
FF06-039	Nechako volcs	porphyry	399638	5913849	37.60
FF06-040	Nechako volcs	breccia	399254	5913804	8.32
FF06-041	Hazelton	breccia	386335	5916162	0.52
FF06-042	Chilcotin Group	basalt	396116	5916217	0.50
FF06-043	Nechako volcs?	breccia	395085	5916370	0.62
FF06-044	Nechako volcs?	breccia	394424	5916211	0.46
FF06-046	Bowser Lake	conglomerate	391075	5916085	0.08
FF06-049	Tertiary	siltstone	311723	5958915	0.14
FF06-051	Endako Gp	basalt	318096	5995122	6.01
FF06-052	Chilcotin Group	basalt	443966	5913481	1.61
FF06-053	Chilcotin Group	basalt	443815	5913051	3.86
FF06-054	Ootsa Lake?	basalt	426930	5909803	0.37
FF06-057	Ootsa Lake?	basalt	429731	5910124	1.67
FF06-058	Ootsa Lake?	basalt	434586	5914930	3.80
FF06-059	Ootsa Lake?	basalt	434967	5914833	6.62
FF06-061	Ootsa Lake?	basalt	435974	5914898	7.29
FF06-062	Taylor Ck Gp	conglomerate	435332	5914068	0.03
FF06-063	Taylor Ck Gp	sandstone	435864	5912238	0.13
FF06-064	Bowser Lake	sandstone	419484	5916619	0.13
FF06-066	Hazelton	siltstone	413345	5917087	0.10
FF06-067	Chilcotin Group	basalt	469438	5846820	22.40
FF06-068	Chilcotin Group	basalt	470711	5845542	8.44
FF06-069	Taylor Ck Gp	conglomerate	470109	5843963	0.06
FF06-072	Chilcotin Group	basalt	471013	5844088	10.00
FF06-077	Chilcotin Group	basalt	470754	5840568	3.57
FF06-078	Taylor Ck Gp	conglomerate	471114	5837205	0.02

APPENDIX II (CONTINUED)

Station_ID	Formation	Rock type	EASTING	NORTHING	MS (X10^{-3} SI)
FF06-081	Taylor Ck Gp	sandstone	472117	5836208	0.07
FF06-082	Taylor Ck Gp	sandstone	472167	5836283	0.13
FF06-083	Chilcotin Group	basalt	472671	5835507	2.34
FF06-084	Taylor Ck Gp	sandstone	472559	5835489	0.70
FF06-086	Taylor Ck Gp	conglomerate	472266	5834917	0.05
FF06-088	Chilcotin Group	basalt	472969	5836798	5.24
FF06-090	Ootsa Lake	rhyolite	478671	5827618	3.34
FF06-111	Jackass Mt Gp	sandstone	539828	5656131	3.80
FF06-112	Jackass Mt Gp	conglomerate	538709	5656831	8.79
FF06-113	Jackass Mt Gp	sandstone	538412	5656790	0.31
FF06-114	Jackass Mt Gp	sandstone	538056	5656766	3.72
FF06-115	Jackass Mt Gp	sandstone	537512	5656704	8.99
FF06-116	Jackass Mt Gp	sandstone	537465	5656405	5.29
FF06-117	Jackass Mt Gp	sandstone	537407	5656099	3.90
JR06-002	Bowser Lake	siltstone	398595	5893292	0.24
JR06-003	Hazelton	siltstone	375233	5886155	1.20
JR06-004	Hazelton	siltstone	375177	5886146	0.98
JR06-005	Hazelton	siltstone	375137	5885965	0.30
JR06-006	Nechako volcs	dacite	387292	5915703	0.26
JR06-007	Nechako volcs	andesite	387376	5915650	0.59
JR06-008	Nechako volcs	breccia	387915	5915571	0.43
JR06-009	Nechako volcs	andesite	388115	5915580	0.47
JR06-011	Bowser-Ashman	shale	390415	5915147	0.43
JR06-012	Bowser-Ashman	conglomerate	390673	5915168	0.19
JR06-013	Bowser-Ashman	siltstone	391433	5917830	0.17
JR06-014	Bowser-Ashman	chert conglom	392951	5918910	0.05
JR06-015	Bowser-Ashman	shale	394236	5918421	0.17
JR06-016	Bowser-Ashman	chert conglom	394086	5918377	0.18
JR06-017	Bowser-Ashman	shale	393936	5918302	0.21
JR06-018	Bowser-Ashman	shale	394874	5918578	0.22
JR06-019	Bowser-Ashman	siltstone	394206	5919331	0.22
JR06-020	Bowser-Ashman	chert conglom	394003	5919330	0.06
JR06-021	Bowser-Ashman	shale	395311	5819790	0.17
JR06-038	Chilcotin/Endako	basalt	437071	5909108	17.40
JR06-039	Ootsa Lake?	basalt	434376	5909433	19.90
JR06-040	Ootsa Lake?	andesite	398748	5893230	26.60
JR06-041	Ootsa Lake?	dacite	452675	5857782	0.22
JR06-042	Ootsa Lake?	dacite	452736	5857772	0.42
JR06-043	Stuhini Gp?	limestone	452620	5845019	0.17
JR06-045	Ootsa Lake?	dacite	451523	5850600	2.87
JR06-046	Quaternary	basalt	452674	5858729	12.30
JR06-047	Taylor Ck Gp	conglomerate	457156	5864185	0.15
JR06-049	Taylor Ck Gp	sandstone	468821	5846566	0.17
JR06-050	Taylor Ck Gp	conglomerate	469639	5845892	0.02
JR06-053	Taylor Ck Gp	conglomerate	469506	5845389	0.09
JR06-054	Chilcotin	basalt	467642	5837485	2.39
JR06-055	Chilcotin	basalt	467979	5836771	2.06
JR06-056	Chilcotin	basalt breccia	469052	5836505	0.02
JR06-059	Taylor Ck Gp	chert conglom	470133	5836807	0.02
JR06-067	Taylor Ck/Lizard?	sandstone	472031	5833659	0.79
JR06-068	Taylor Ck Gp	conglomerate	472037	5833939	0.06
JR06-069	Taylor Ck/Lizard?	sandstone	471233	5832155	0.06
JR06-070	Taylor Ck	sandstone	470607	5832783	0.03
JR06-071	Chilcotin	basalt	476283	5822851	7.14
JR06-072	Taylor Ck Gp	chert conglom	475467	5822534	0.03
JR06-077	Taylor Ck Gp	chert sandst	476496	5822759	0.04
JR06-078	Nemaia Fm	sandstone	412125	5703325	0.29

Station_ID	Formation	Rock type	EASTING	NORTHING	MS ($X10^{-3}$ SI)
JR06-079	Nemaia Fm	sandstone	412074	5703045	0.28
JR06-081	Sill	hb porphyry	411821	5702970	6.60
JR06-082	Nemaia Fm	sandstone	411465	5702914	0.42
JR06-084	Nemaia Fm	siltst/tuff	411415	5702339	0.17
JR06-085	Nemaia Fm	shale	411417	5702270	0.08
JR06-086	Nemaia Fm	conglomerate	411389	5702139	0.15
JR06-087	Nemaia Fm	siltstone	411342	5701973	0.11
JR06-088	Nemaia Fm	siltstone	411331	5701867	0.42
JR06-094	Potato Range Fm	sandstone	408342	5716789	0.19
JR06-095	Potato Range Fm	sandstone	408427	5716554	0.34
JR06-096	Potato Range Fm	siltstone	408445	5716438	0.32
JR06-097	Potato Range Fm	sandstone	408441	5716335	0.22
JR06-098	Potato Range Fm	sandstone	408471	5716283	10.20
JR06-099	Potato Range Fm	sandstone	408358	5716143	0.82
JR06-101	Tepee Mt Fm	siltstone	407688	5717624	0.27
JR06-102	Tepee Mt Fm	sandstone	407768	5717632	0.17
JR06-103	Tepee Mt Fm	conglomerate	407827	5717584	0.32
JR06-104	Tepee Mt Fm	cobble cong	407957	5717492	0.19
JR06-105	Tepee Mt Fm	sandstone	408014	5717460	0.19
JR06-106	Tepee Mt Fm	magnetic sst	408034	5171412	4.77
JR06-107	Tepee Mt Fm	white sst	408090	5717422	0.11
JR06-108	Tepee Mt Fm	brown sst	408122	5717397	0.41
JR06-109	Tepee Mt Fm	sandstone	408239	5717336	0.24
JR06-110	Tepee Mt Fm	magnetic sst	408333	5717283	79.10
JR06-111	Tepee Mt Fm	sandstone	408368	5717240	0.26
JR06-115	Jackass Mt Gp	sandstone	542592	5652983	0.33
JR06-116	Jackass Mt Gp	sandstone	542633	5652481	0.39
JR06-117	Jackass Mt Gp	sandstone	542292	5651976	0.17
JR06-118	Dike	felsic dike	541327	5651298	0.08
JR06-120	Taylor Ck/Paradi	shale	500441	5663295	0.27
JR06-124	Taylor Ck/Paradi	shale	500349	5663022	0.36
JR06-126	Taylor Ck/Paradi	shale	500260	5662870	0.25
JR06-127	Junction Creek	shale	548625	5648085	0.26
JR06-128	Jackass Mt Gp	conglomerate	550733	5647893	0.50
JR06-129	Jackass Mt Gp	sandstone	550574	5647928	4.42
JR06-131	Junction Creek	sandstone	549503	5647499	0.29
JR06-132	Hurley Fm	siltstone	549187	5646641	0.20
JR06-133	Hurley Fm	shale	548870	5645872	0.20
JR06-135	Jackass Mt Gp?	sandstone	552295	5644711	0.43

APPENDIX III - SUMMARY OF PALYNOLOGICAL RESULTS, NECHAKO BASIN WELLS

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CANHUNTER REDSTONE, D-94-G, NTS 92O/12, UTM 10U 453711m E, 5723900m N; 23 cutting samples; P4924; C-455811 to 455819, C- 467074 to 467087.

Intervals:
30–1980 m: Late Middle Albian or Cenomanian

The age is based on the presence of *Clavatipollenites hughseii* Couper 1958 and simple tricolpate angiosperm pollen in combination with the spores *Cicatricosisporites augustus* Singh 1971, *C. hughsei* Dettmann 1963, *C. venustus* Deák 1963, *Costatoperforosporites* sp., *Distaltriangulisporites perplexus* (Singh) Singh 1971, *Foraminisporis asymmetricus* (Cookson and Dettmann) Dettmann 1963, *F. wonthaggiensis* (Cookson and Dettmann) Dettmann 1963, *Klukisporites pseudoreticulatus* Couper 1958, *Microreticulatisporites uniformis* Singh 1971 and *Polycingulatisporites radiatus* Singh 1971, and the gymnosperm pollen *Balmeiopsis limbatus* (Balme) Archangelsky 1977 and *Classopollis parvus* Xu and Zhang 1980.

2085 m: Indeterminate

General Comments:

The presence of tricolpate angisosperm pollen places a lower age limit of late Middle Albian down to a depth of 1980 m. Very rare dinoflagellates may indicate a sporadic marine influence, but otherwise the depositional environment was overwhelmingly terrrestrial. The thermal alteration index (TAI) ranges from -3 to 4.

REDSTONE, B-82-C, NTS 92O/14, UTM 10U 480980m E 5740701m N; 10 cutting samples; P 4950; C-455729, C-455802 to 455810, C-467098.

Intervals:
410–1120 m: indeterminate (6 samples)

Samples effectively barren of palynomorphs.

1210–1610 m: Late Albian or Cenomanian (4 samples)

The age is based on a diverse suite of angiosperm pollen that includes *Clavatipollenites hughseii* Couper 1958, *Liliacidites inaequalis* Singh 1971, *Liliacidites tricotomosulcatus* Singh 1971, *Retitricolpites crassus* Samoilovitch 1965, *Rousea* sp., *Tricolpites* spp. and tricolporate pollen, and the spores *Balmeisporites glenelgensis* Cookson & Dettmann 1958, *Concavissimisporites punctatus* (Delcourt & Sprumont) Brenner 1963, *Crybelosporites striatus* (Cookson & Dettmann) Dettmann 1963, *Foraminisporis asymmetricus* (Cookson & Dettmann) Dettmann 1963, *Microfoveolatosporis pseudoreticulatus* (Hedlund) Singh 1983 and *Microreticulatisporites uniformis* Singh 1971.

General Comments:

There appears little likelihood that palynomorphs will be recovered from the interval above 1120 m, especially if only a small amount of sample is available for analysis. The presence of a diverse suite of angisosperm pollen, which includes tricolporate taxa, places a lower age limit of latest Albian on the 1210—1610 m interval. With the exception of one questionable dinoflagellate, there is no indication of anything other than a terrestrial deposition environment. The TAI ranges from +1 to 3.

APPENDIX III (CONTINUED)

ESSO NAZKO, B-16-J, NTS 93B/11, UTM 10U 486398m E 5836290m N; 12 cutting samples; P4951; C-455730, C-455792 to 455801, C-467073.

Interval:
310–2395 m: indeterminate
Samples mostly barren of palynomorphs; the rare specimens observed are not age-diagnostic.

General Comments:
The lack of recovery from these samples provides little encouragement for running more samples from this well. It is difficult to envision 2395 m of effectively barren sediments.

HB REDSTONE, C-75-A, NTS 93B/04, UTM 10U 461398m E, 5768336m N; 28 cutting and 5 core samples; P4952; C-455731 to 455735, C-467053 to 467070, C-467088 to 467097.

Intervals:
85.4 m: indeterminate (1 sample)
Effectively barren of palynomorphs.
115.9–152.4 m: Late Albian (4 samples)
The age is based on the diverse suite of dinoflagellates which includes *Apteodinium granulatum* Eisenack 1958, *Catastomocystis spinosa* Singh 1983, *Chichouadinium vestitum* (Brideaux) Bujak & Davis 1983, *Cribroperidinium edwardsii* Cookson & Eisenack 1958, *Florentina cooksoniae* (Singh) Duxbury 1980, *Ginginodinium* sp., *Pseudoceratium eisenackii* (Davey) Bint 1986, and *Pseudoceratium* spp.
231.7–637.2 m: probable age Late Albian (9 samples)
Samples dominated by degraded fusinitic debris. The rare palynomorphs include dinoflagellates, indicating a marginal marine depositional environment, but provide little independent age information.
641–805.6m: probable age Late Albian (7 samples)
The age is based in part on the stratigraphic context and in part on the presence of tricolpate angiosperm pollen and the spores *Cicatricosisporites venustus* Deák 1963, *Foraminisporis wonthaggiensis* (Cookson & Dettmann) Dettmann 1963, *Pilosisporites* sp., *Trilobosporites* sp., and the gymnosperm pollen *Balmeiopsis limbatus* (Balme) Archangelsky 1977 and *Classopollis parvus* Xu and Zhang 1980. Sporadic *Pediastrum* indicates an in part lacustrine depositional environment within an otherwise terrestrial sucession.
888.2–1304 m: probable age Middle or Late Albian (12 samples)
The continued presence of tricolpate pollen to the base of the sampled section (the 1304 m sample is from core) infers a lower limit of Middle Albian.

General Comments:

Of the wells analyzed in this palynological study, the 115.9 to 152.4 m interval in Redstone C-75-A is unique in containing a diverse suite of dinoflagellates, which argue for a Late Albian age. The remainder of the sampled interval sees several variations in the style of recovery but overall adds little to the dinoflagellate-based age determination for the sampled top of the well. The depositional environments range from fully marine near the top, to marginal marine, to terrestrial in the lower part. The TAI ranges from -2 (at top) – 4.

HONOLULU NAZKO, A-04-L, NTS 93B/11, UTM 10U 471599m E, 5835406m N; 8 core samples; P4953; C-455736 to 455743.

Intervals:
403–1619 m: Late Albian or Cenomanian (7 samples)
The age is based on the presence of tricolpate pollen in combination with the gymnosperm pollen *Balemeiopsis limbatus* (Balme) Archanselsky 1977, *Callialasporites damperieri* (Balme) Dev 1961 and *Rugubivesiculites* sp.; the spores *Aequitriradiates spinulosus* (Cookson & Dettmann) Cookson & Dettmann 1961, *Foraminisporis wonthaggiensis*

(Cookson & Dettmann) Dettmann 1963 and *Polycingulatisporites* sp.; and the algae *Januasporites spiniferous* Singh 1964. The assemblages support a terrestrial depositional environment with the proviso that the presence of *Januasporites* usually indicates a proximity to a marine influence. The TAI is 2 - +2.

2245 m: Campanian (1 sample)

This age is based on the presence of the angiosperm pollen taxa *Aquilapollenites quadrilobus* Rouse 1957, *A. trialatus* Rouse 1957, porate? pollen, *Tricolpites* spp., tricolporate pollen and *Ulmipollenites tricostatus* Anderson 1960. The assemblage is dominantly terrestrial in character; however one dinoflagellate was observed, which may indicate a marine influence. The TAI is +3 - -4.

General Comments:

The surprise in this well is that Campanian age strata appear to underlie middle Cretaceous strata. This is notwithstanding that the lowest sample in the well has the highest TAI in combination with the youngest age. Certainly, structure has to be invoked to explain these relationships.

CANHUNTER NAZKO, D-96-E, NTS 93B/11, UTM 10U 470283m E, 583495 m N; 7 core samples; P4954; C-455744 to 455750.

Interval:

318–1886 m: probably late Middle or Late Albian but possibly Cenomanian

The age is based on the combined presence of tricolpate angiosperm pollen in combination with the spores *Aequitriradites* sp., *Cicatricosisporites venustus* Deák 1963, *Costatoperforosporites* sp., *Plicatella* sp. and *Trilobosporites* sp.; and the gymnosperm pollen *Callialasporites damperieri* (Balme) Dev 1961 and *Classopollis* sp.

General Comments:

The average recovery from samples from Nazko D-96-E was good and was generally terrestrial in character. The presence of *Januasporites spiniferous* Singh 1964 in the 598 and 912.5 m samples and the abundance of thin-walled circular bodies in the 598 and 1555 m samples, which are probably algal cysts, suggest intervals of lacustrine deposition proximal to marine conditions. The TAI ranges from 2 to +3.

Rouse (1992) reported on 35 samples from the from D-96-E. He concluded a Tertiary age for the 17.5–48 m interval, a Cenomanian age for the 50–270.5 m interval, a Middle Albian to Cenomanian age for the 290—2817 m interval, and an Aptian age for the 2980-3120 m interval. The present age results for the 318–1886 m interval are in agreement with those of Rouse for the same interval. However, Rouse reported dinoflagellates from throughout this interval, while none were seen in this study.

CHILCOTIN, B-22-K, NTS 93C/09, UTM 10U 413936m E, 5837969m N; 37 cutting samples; P4983; C- 467099 to 467135.

Intervals:

72.5–230 m : Eocene or younger (7 samples)

The recovered palynoflora included the angiosperm pollen *Alnipollenites* sp., *Caryapollenites* sp., *Nyssapollenites* sp., *Pterocarya stellatus* Martin and Rouse 1966, *Ulmipollenites undulosus*, and the gymnosperm pollen *Piceapollenites* sp., *Scadiopytes* sp., *Tsugapollenites* sp.. Although these species support an Eocene or younger age, it is difficult to conclude a more precise age within the Tertiary.

317.5–3700 m: Indeterminate (30 samples)

Although rare palynomorphs were observed, no age-diagnostic specimens have been recorded. Most residues are completely barren of palynomorphs.

APPENDIX III (CONTINUED)

General Comments:

The recovery from samples from this well was disappointing. However, as other wells also had extensive intervals of effectively barren samples (Redstone B-82-C, 410–1120 m; Esso Nazko B-16-5, 310–2395 m), this may be characteristic of a particular rock succession.

Rouse (1992) presented results from 24 samples from the B-22-K well. He concluded the 72.5–230 m interval to be Miocene, the 317.5–720 m to be mostly Eocene, the 740–1355 m interval to be Campanian to Maastrichtian, the 1395–2970 m to be indeterminate, and the 3490–3557 m interval to be Albian to Campanian. The present study was not able to duplicate these results.

Reference

Rouse, G. E. 1992. Appendix D, Palynology Results *in* Hunt, J.A. Stratigraphy, maturation and source rock potential of Cretaceous strata in the Chilcotin-Nechako region of British Columbia. M.Sc. thesis, *University of British Columbia*, Vancouver, B.C. Canada, 1992, pp. 448.

Petrophysical Analysis – Nechako Basin

by Ian Smith[1]

Summary

- This report summarizes the petrophysical interpretation completed on eight (8) tests drilled in the Nechako Basin in Bristish Columbia, Canada.
- Very limited gas potential was identified, this was a result of the low porosity (generally less then 5%).
- Calculation of formation water saturation is questionable due to the limited laboratory analysis available in the area.
- The correlation of core porosity to log porosity was graded as "fair to good" validating the petrophysical models applied.
- The overall quality of the borehole at the time of logging was "poor to fair" over much of the shalier intervals which tended to collapse and enlarge the hole, over these intervals the interpretation was compromised.
- Difficulties in discerning sandstones from volcanic strata was assisted by the inclusion of geologic striplog descriptions.
- The arithmetic mean of the core porosity was 5.0%.
- 80% of core Kmax permeability was less than 1.5 mD.
- 80% of the Kv permeability was less than 1.0 mD.
- Electrofacies analysis using Multi-Resolution Graph-Based Clustering (MRGC) algorithms was applied in order to define natural data groups free from operator bias, the overall results were satisfactory enabling recognition of similar rock types.
- Table 5 (Tables Section) provides the pay sensitivity results based on a well by well basis, reservoir cutoffs applied: shale volume <= 30%, porosity >= 3.0% to 6.0%, and water saturation <=60%.

INTRODUCTION

This report summarizes the petrophysical interpretation completed on eight (8) tests drilled in the Nechako Basin, British Columbia. The wells were drilled between 1960 and 1985 and varied from 1278 to 3786 meters in depth intersecting both classic and volcanic sequences, no formation tops were provided. The wells analyzed are shown in Table 1.

The primary objectives of the study were to review all downhole petrophysical data (core, tests, and logs) analyzing each of the wells from surface casing to total depth, to calculate reservoir petrophysical results (net pay, average porosity, water saturation), and to identify fluid contact(s) where possible. Final computed log curves such as effective porosity, water saturation and shale volume were a required output for inclusion into future geologic mapping. Data output was provided both digitally and in hard copy format.

The study was initiated in mid January 2007 with results presented to the *Resource Development and Geoscience Branch of the B.C. Ministry of Energy, Mines and Petroleum Resources* on March 12 2007.

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Table 1. Well List Summary.

a-004-L/093-B-11*	b-016-J/093-B-11*	b-022-K/093-C-09*
b-082-C/092-O-14*	c-038-J/093-B-06	c-075-A/093-B-04*
c-095-E/093-B-11*	d-094-G/092-O-12	

** denotes cored wells (6 wells)*

The entire *REPORT NO BCM-2007-03-1* is provided in SI units consistent with the majority of original open hole log and core data. This report was initiated by, and completed solely for use by *B.C. Ministry of Energy, Mines and Petroleum Resources.* No public disclosure of the data and/or results, both verbal or written will be provided, this report has been treated as CONFIDENTIAL.

REPORT FORMAT

This report is divided into three (3) sections of text, illustrations and data tables, and is accompanied with data appendices and log display Enclosures (1:500 scale). Enclosures are housed separately from this report and are referenced in the appropriate sections. For convenience a complete set of figures and tables are located in a separate file folder with the CD version of this report.

DATA SOURCES

The primary source of all digital log data incorporated in the evaluation was provided by the B.C. Ministry of Energy, Mines and Petroleum Resources. TELLURIC Petrophysical Consulting Ltd. provided the digital routine core, drill stem test intervals, and drill stem test recoveries. All required electronic data was loaded, or when required digitized or hand entered. The petrophysical computations were completed using Paradigm Geophysical's GEOLOG 6.6 software.

OBJECTIVES

The primary objectives of this evaluation were as follows:

- To provide petrophysical results over any porous interval: parameters required include reservoir pay thickness, effective porosity, hydrocarbon pore volume, and reservoir fluid saturation.
- The incorporation of routine core analysis (porosity, permeability, grain density) to provide rock parameters end points for the log analysis, core verses core and core verses log correlations.
- To identify where possible any fluid contact interfaces.
- To generate continuous digital log traces for all petrophysical data for future geologic mapping and modeling.

AVAILABLE DATA

CORE DATA

Of the 8 wells analyzed six (6) wells cut core, of these six wells only four had measurements taken. When core was cut it was very limited in length extending only several metres, due to these short intervals depth shifting to match logs was difficult. As previously mentioned no formation tops were provided and consequently no multi-well correlations could be established over similar horizons. Table 2 lists the cored wells and the available measurements.

Table 2. Cored Wells.

Well	Data Available (Yes/No)
a-004-L/093-B-11	Porosity, Kmax, Kvert, Gden, K90, Roil, Rwat
b-016-J/093-B-11	Porosity, Kmax, Kvert, Gden, K90, Rwat
b-022-K/093-C-09	No data available
b-082-C/092-O-14	Porosity, Kmax, Gden, Rwat
c-075-A/093-B-04	No data available
c-095-E/093-B-11	Porosity, Kmax, Kvert, Gden, K90, Roil, Rwat

The main objective for the inclusion of the core data in this study was to provide guidance in the determination of log porosity, as well as assisting in lithology identification by means of the core grain density. The various core measurements are displayed in various formats, namely cross-plots with Figure 1 illustrating the core porosity (POROSITY) verses maximum (KMAX) permeability, and Figure 2, illustrating the maximum permeability verses vertical permeability (KV). A statistical review for each individual core measurement is displayed in cumulative frequency format as Figures 3 through 9.

Core Porosity Discussion

A core porosity cumulative frequency plot in provided as Figure 4 and is composed of three hundred and fifty-three (353) core measurements. The arithmetic core porosity mean is calculated at 4.2% with a high of 15% at c-095-E/093-B-11. An examination of Figure 4 shows that 80% of core measurements are less than 6% porosity and that a typical log normal distribution is attained. A statistical review shows that the arithmetic mean for wells a-004-L/093-B-11, b-016-J/093-B-11, b-082-C/092-O-14, and c-095-E/093-B-11 were 6.6%, 6.4%, 3.4% and 3.7% respectively. What is of interest is the overall low values measured given that numerous intervals were cored from shallow to depths exceeding 2000 metres. These low values are confirmed by log calculated porosity measurements which rarely exceeded 10%. The comparison of core porosity verses log porosity is only possible after core measurements have been depth shifted to match log porosity.

Core Grain Density Discussion

Figure 3 displays the three hundred and thirty-eight (338) core grain density measurements that were available. The statistical analysis shows a wide distribution, the arithmetic means range from a low of 2590 to a high of 2830 k/m3. The former and later readings are typical values for a very shaly lithology with a sandstone component and a dolomite. Once again because no formation tops were available no additional interpretation could be established on a zonal basis. The contribution of the grain densities to the analysis was strictly for lithologic determination and to assist in identifying possible mineralogy.

Core Permeability Discussion

The three core permeability measurements available were KMAX, K90 and KVERT, each are displayed in cross-plots as Figures 1, 2 or as frequency histograms in Figures 5, 6, and 7. The resulting statitics are shown in Table 3.

A very wide distribution in the Kmax permeability is seen, it ranged from a low of 0 mD to a high of 687 mD, given the low porosity environment the later found at b-016-J/093-B-11 is interpreted as being fracture influenced. At the c-095-E/093-B-11 well, another high permeability value of 141 mD was measured, a similar interpretation is taken. A review of Figure 5 shows that approximately 80% of the KMAX values have less than 1.5 mD of permeability, Figure 6 indicates a similar story on the Vertical permeability (KVERT), 80% of vertical permeability measurements are under 1.0 mD. One of the exceptions is at b-016-J/093-B-11 which had a high of 66 mD, this again was interpreted as fracture related and not driven by matrix.

Core Residual Fluid Discussion

Figures 8 and 9 illustrate the residual fluid saturations measured from core. Two of the cored wells measured residual oil, four of the wells measured residual water saturations. At a-004-L/093-B-11 and c-095-E/093-B-11 residual oil saturations were uncharacteristically high reaching 52% and 68% respectively. Typical values for a medium crude at 12% porosity is less than 20%, these high saturations are likely explained by the poor reservoir quality and/or the lack of permeability, in addition I believe that there is a high degree of possible solid hydrocarbons present in the pore space.

Core Porosity verses Permeability Cross-plots

Figures 1 and 2 illustrate core porosity verses KMAX permeability and KMAX verses KV relationships respectively. What is apparent is the excessive scatter of the data on the Figure 1 cross-plot, this scatter is a result of the plotting of multiply formations and lithologies on a single plot. The overall permeability does increase with increasing porosity but due to the scatter and the numerous formations included on the plot no attempt to provide a best-fit regression was performed. Each well's data is identified by a particular color, wells with no data are listed in black.

Table 3. Core Statistics.

Formation	Kmax Arithmetic Range (mD)	Kv Arithmetic Range (mD)	Core Phit Arithmetic Range (%)
Various	0 - 687	0 - 66	0 - 15

Figure 2 however shows a definite trend, here a near 1:1 relationship is established between the KMAX and KV permeability, indicating fluid shows little preference to flow either in a vertical or horizontal direction.

Cumulative Frequency Histograms

The cumulative frequency histograms (Figures 3 to 9) were generated for each of the core measurements. Log statistics for each measurement are displayed in the footer of each Frequency plot, calculations are across all wells. The Frequency plot performs the statistical calculations for variance, standard deviation, skewness, kurtosis, median and mode.

Definitions:

- Variance – the square of the standard deviation
- Standard deviation – a measure of dispersion
- Kurtosis – cumulative frequency curve shape/characteristic.
- Median – the location of the 50th percentile; the Number of Cumulative Bins impacts this value.
- Mode – the most frequently occurring value; the Number of Frequency Bins impacts this value.
- Arithmetic mean (parallel flow) – sum of measured values divided by number of measured values, provides most optimistic resultant.
- Geometric mean (random flow) – most closely approximates the pressure build-up permeability, most closely models actual flow from the well bore.
- Harmonic mean (series flow) – highly dependent on the lowest measured value, most pessimistic resultant.

ELECTRIC LOG DATA

The majority of the wells analyzed were of recent vintage and contained a complete log suite which included three resistivity curves (deep, medium, shallow), sonic, neutron porosity, bulk density, gamma ray, spontaneous potential, bit size, and caliper. The available logs well coverage included:

- 6 wells will complete log suites
- 2 wells with only sonic

Drilling and Mud Data

Log header data provided information on the individual well bore mud properties (resistivities and temperatures), mud type, mud density, and bit size, these data were available for all wells. All wells analyzed were drilled with a water based gel chemical mud system and therefore all fluid densities and fluid transit times reflect this. Temperature corrections to the formation water resistivity were based on the individual bottom hole temperatures recorded at each well.

LOG ANALYSIS

GAS PAY SUMMARY

Under the Summary Section potential net pay sensitivity results have been provided. For each well because of the lack of formation tops, the top and base depths are defined by the surface casing and final total depths reached. Over these intervals net gas pay thickness, average porosity, average water saturation, porosity*meters, and hydrocarbon pore volumes are provided.

Based on the core porosity verses core permeability cross-plot (Figure 1) a minimum porosity of 3% which is equivalent to approximately 0.1 mD permeability was the floor hurdle for gas pay determination. The following pay sensitivity cutoffs were applied to calculate interval results:

Effective porosity	>= 3.0%, 4.0%, 5%, 6.0%
Bulk volume water	not applied
Water saturation	<= 60%
Shale volume	<= 30%

Where reservoir quality exceeds the cutoff parameters above using a 5% porosity cutoff a pay flag (PAY_FLAG05) will display in Track 13 (Petophysical Analysis Log – Figures 10 – 17). An addition gross reservoir sand (GROSS_FLAG05) flag using similar cutoffs but with the water saturation cutoff removed is also provided in the same track.

RESERVOIR FLUID CONTACTS

To assist in identifying the reservoir fluid contacts both the water saturation and bulk volume water curves were examined. For each curve the absolute values as well as their log character profile were reviewed. These curves are displayed in Track 13 on the Petrophysical Analysis Plots. No gas/water contacts were identified.

DETERMINISTIC MODELS

GEOLOG's "deterministic" interpretation methods were run on each of the wells. This method employs a sequential process where the clay volume is determined first and then is followed by the effective porosity, water saturation and pay result calculations. The following methodology/sequence was followed:

DETERMINISTIC MODEL – CORE DATA METHODOLOGY

For the routine core measurements core data was depth shifted, displayed, summarized statistically, and core porosity/permeability cross-plots provided as Figures 1 to 9 under the Figures Section of the report. The following analyses were performed on the core data:

- Routine core data such as total porosity (PHIT_CORE), permeability (KMAX_CORE, KV_CORE, K90_CORE), grain density (GDEN_CORE), residual oil (VOIL_CORE) and residual water (VWAT_CORE) were loaded/entered.
- Cross-plots of core porosity verses the permeability were generation, individual well regressions were performed where possible.
- Frequency histograms were generated for each core measurement to identify the following statistics and to provide measured inputs for the log evaluation:
  - arithmetic, geometric and harmonic means
  - minimum and maximum values
  - data measurement range
- In each well, routine core data was depth shifted to match logs.

LOG EVALUATION METHODOLOGY

Formation Water

There was a definite lack of quality formation water salinity data available for the project water saturation calculations. Drill stem test results were reviewed for formation water recoveries and laboratory results. After review, c-095-E/093-B-11 provided some of the better analysis available, overall the salinities are classified as fresh. Once again because no formation tops were available salinities by formation could not be attempted, rather a salinity verses depth approach was performed. This certainly has its inherent errors but the following resulted:

- depth less than 500 metres: Rw = 5.00 ohmm @ 25 Deg C (2,700 ppm NaCl)
- depth between 500 and 1000 metres: Rw = 3.40 ohmm @ 25 Deg C (3,000 ppm NaCl)
- depth between 1000 and 1500 metres: Rw = 0.88 ohmm @ 25 Deg C (7,800 ppm NaCl)
- depth between 1500 and 2000 metres: Rw = 0.33 ohmm @ 25 Deg C (23,000 ppm NaCl)

The above Rw values were corrected to reservoir temperatures and then applied within the Simandoux water saturation equation. A copy of the laboratory water analysis is provided in the Tables Section of the report.

Determination of Volume of Clay

The linear gamma ray and SP equations were used to determine the shale volume for each of the wells analyzed. Each well was reviewed individually and zoned according to petrophysical characteristics, each zones gamma clean and gamma shale end points were determined from its environmentally corrected gamma ray and then applied. The spontaneous potential was used to assist the gamma ray to identify permeable sands, however one difficulty in using the SP in this environment is the effect the fresh formation water has on the SP deflection. In fresh water the SP deflection is pushed to the right and is referred to as SP reversal, this reversal can nullify the technique entirely. The final output curve shown as VSH is plotted on each of the Petrophysical Analysis Plots in Track 10, in Track 11 is the VSHSP curve. In Tracks 3 and 9 the spontaneous potential curve (SP - red) is shown with the gamma ray (GR – black, GR_COR - green), this allows the effect of the salinity to be identified. An example where heavy weighting was placed on the SP to assist in identifying permeable sands is at b-082-C/092-O-14 at 1288 metres. Also in Track 4 are the bit size and caliper logs, in permeable, clean sands filter cake will develop and is identified by the yellow shading between these two curves. This filter cake build-up also assisted in identifying the clean sands from the high radioactivity.

Determination of Porosity

In the analysis two porosities were calculated, a total and an effective porosity. The total porosity is a non-shale corrected porosity, the effective porosity has had the influence of the shale removed. Six of the eight wells analyzed had both neutron and density data allowing for a cross-plot porosity to be determined, however due to the shale content in a majority of the sands the cross-plot porosity method was not employed. What were employed were shale corrected density and or sonic porosity depending on availability. This was deemed a more accurate approach due to the predominant clastic environment of the reservoirs analyzed. The wells using the sonic log applied transit times which correlated back to equivalent grain density measurements.

In these instances the porosity was determined using the Wyllie Time Average equation and applying a matrix transit time of 182 microseconds per metre. A fluid transit time of 620 microseconds per metre was applied over all intervals and reflects the water based nature of the mud systems used in the drilling process.

The total porosities were then compared with available core porosity measurements (Petrophysical Analysis Plots Track 13 – red dots - Figures 10 – 17) to review the quality of fit. Overall the results were "fair to good", one of the key issues in the quality of fit is the resolution difference between the two measurements.

Determination of Water Saturation

The Simandoux equation was used for the calculation of water saturation. This equation was applied so that the resistivity influence of the clays would be reflected in the saturation determination. The saturation parameters used were:

A	= 1.0
M	= 2.0 (cementation exponent)
N	= 2.0 (saturation exponent)
Rw	= variable ranging from 5.0 to 0.33 ohm ms @ 25 degrees C (equivalent to ap proximately 2,700 to 23,000 ppm NaCl respectively)

Petrophysical Zonation

No formation tops were available for the project

Permeability Index (Ki) Determination

Due to the excessive scatter in the core porosity verses core permeability data and the lack of formation tops no least squares regression fit was attempted on the core porosity verses core permeability cross-plot. No KI index calculation was performed.

Hole Conditions

Overall, the quality of the well logs is rated as "fair to good". Caliper data (Track 1 – Petrophysical Analysis Plots) shows that over the shale intervals the bore hole tends to wash out quite significantly (orange shading) over bit size. Over the porous sand intervals, filter cake occurs suggesting increasing effective permeability and porosity (yellow shading). A BADHOLE flag is provided in Track 1, where it exists borehole conditions are such that the quality of the logs is compromised and results may be suspect.

Log Depth Matching

In order to provide a composite data set, all logging runs were checked for depth match errors. This involved checking log curves within a log combination and between runs in the hole. In all instances a standard procedure was adopted of assuming that the first open-hole run in the hole was considered on depth and hence all subsequent runs were depth matched to this. The first open-hole log run for the wells analyzed was taken as the Resistivity/Sonic/ SP/ Gamma Ray combination. There were no significant errors found within the log combinations. All core data was then depth matched to the open hole log depths.

Log Normalization

The neutron, density and sonic logs were examined and where required normalized using a linear shift.

Volcanic verses Sandstone Lithology Recognition

One of the main challenges of the study was the presence of volcanics within the well bores. Initially, distinguishing quartz from the volcanics was very difficult, but to assist in its recognition the geologic strip log data was incorporated for each of the wells. The depositional environments (Track 9) and lithologic descriptions (Track 10) provided the necessary data to discern sands from volcanics. From the striplog categorizing of the volcanic strata, four main classes were defined, these included lava, basalt, ash and tuff. Each of these classes were examined from a log perspective and indeed each possessed their own log signatures. Table 4 provides the logs signatures by tool for each volcanic class.

After reviewing the logs, the following distinct features of the volcanic classes were identified:

- Lava – flat sonic log (195 +/- 10 us/m), high gamma ray, and neutron minus density porosity of less than 7%.
- Basalt – very low gamma ray (less than 15 gapi) and low sonic transit time (less than 170 us/m).
- Ash – very flat sonic log of 215 +/- 5 us/m, gamma ray 60 +/- 10 gapi and low deep resistivity (<25 ohmm).

Using the above log characters attempts were made to identify each of the volcanic classes, this proved somewhat successful after numerous iterations. Another method was then applied, Facimage is a suite of routines for electrofacies analysis and core data modeling, Faciomage uses Multi-Resolution Graph-Based Clustering (MRGC) algorithms, the MRGC analyzes the underlying structure of data in order to define natural data groups free from operator bias, and can provide a multi-resolution electrofacies classification such that a final model appropriate to the scale of investigation can be selected. The results of the MRGC processing is shown in Tracks 8 and 9 adjacent to the Cuttings Lithology Track. The electrofacies results are inter-

Table 4. Volcanic Class

	Gr	Dt (us/m)	Rt (ohm)	Dpss (%)	Npss (%)
Lava	125	195 +/- 10	125	6 +/- 3	12 +/-3
Basalt	< 15	170 +/- 5	> 500	9 +/- 3	16 +/- 3
Volcanic Ash	60 +/- 10	215 +/- 5	25	18 +/- 3	21 +/- 3
Tuff	80 +/- 5	250 +/- 5	< 10	> 15	> 21

preted using the color assigned, a similar color represents a single electrofacies. To better understand the results identify a sand that is associated with good core porosity or a DST interval that produced significant formation fluids (i.e. good permeability), identify that color and then look for that same color elsewhere in the wellbore. A good example is c-095-E/093-B-11 at 1147 metres. At well locations where only one porosity log was available no electrofacies analysis was completed.

The main purpose for the identification of the volcanics was that where volcanics were present reservoir quality rock was absent. Reservoir quality rock was only present in the quartz rich, clastic deposits.

Drill Stem Tests

All available drill stem tests were examined to identify reservoir quality. All drill stem test intervals, fluid recovered, gas rate, and water resistivity analysis of the recovery fluid is provided in Tracks 14, 13, 15, and 16 respectively. Both the flow and shut-in pressures along with fluid recoveries were reviewed for hydrocarbon production and a permeability assessment. Drill stem test build-ups were reviewed against the calculated log porosity and in almost all instances showed good agreement, increased porosity greater than 5% yielded increased fluid recoveries (c-95-E/093-B-11 Dst #5). Included on the petrophysical displays are the drill stem test recoveries, gas rates, and water analysis resistivities.

APPENDIX ONE - LIST OF TABLES AND FIGURES

Due to the physical size and/or high page count of tables and figures, these may be found in the folder labelled "Petrophysical Analysis Graphics" located on the CD version of the *Nechako Initiative - Geoscience Update 2007.*

TABLES

FIGURES

Figures 1-9 are provided in both Powerpoint and Portable Document Format files on the CD. Fgures 10 through 17 are available in both CGM, JPEG and PDF format in the graphics folder.

APPENDIX TWO - CURVE NOMENCLATURE FOR PETROPHYSICAL DISPLAY PLOTS

No.	Track Description	Details
1	Depth Track	Measured Depth, Subsea Depth (metres0
2	Perforation Track	Perforations
3	Correlation Track	Gamma Ray (GR), Badhole flag, Caliper (CALI), SP
4	Core Track	Cored interval details
5	Resistivity Track	Deep resistivity (RESD), Medium resistivity (RESM), Shallow (RESS), KMAX core permeability
6	Porosity Track (v/v)	DT, Neutron (sandstone unit), PEF, Density Correction (DCOR), Bulk Density (RHOB) Cuttings Litholog
7	StripLog Track	
8	Electrofacies Track	
9	Shale Volume Track	Vsh with Electrofacies shading, Electrofacies Number
10	Shale Volume Track	Vsh from SP
11	Depositional Envir.	
12	Cuttings Track	Cuttings descriptions
13	Porosity and Water Saturation Track (v/v)	Water saturation (SWE), Effective porosity (PHIE), Bulk volume water (VOL_UWAT), Pay Flags 5% and 8% porosity, Hydrocarbons (green), water (blue)
14	DST Track	DST intervals
15	DST Gas Track	DST gas rates (e3m3/d
16	DST Water Track	DST water analysis values

APPENDIX TWO CONTINUED - LOG CURVE NOMENCLATURE

GR:	Gamma Ray (API)
CALI:	Caliper (MM or In)
BADHOLE:	Badhole Flag
BH_CALI:	Badhole Calipers
BH_DRHO:	Badhole Density Correction
BS:	Bit Size (MM or In)
LLS:	Microspherical Focus (OHMM)
ILM:	Medium Induction (OHMM)
LLD:	Deep Induction Log (OHMM)
NPHI:	Neutron Porosity (V/V)
RHOB:	Bulk Density (KG/M3 0r G/C3)
DPSS:	Density Porosity (%) – Sandstone Scale
DT:	Sonic Travel Time (US/M or US/F)
PEF:	Photo-electric Factor (B/E)
DRHO:	Density Correction (KG/M3 or G/CM)
PAY:	Hydrocarbon Pay Flag
PNAX:	Neutron-Acoustic Averaged Porosity (%)
PNDX:	Neutron-Density Cross-plot Porosity (%)
PSDX:	Sonic-Density Cross-plot Porosity (%)
PHIE:	Effective Porosity (%)
NPSS:	Neutron Porosity (Sandstone)(%)
PHIT:	Total Porosity (%)
PHIT_CORE:	Total Porosity (%)
PNDX:	Neutron-Density Crossplot Porosity (%)
PHIT_DT_WY:	Wyllie Sonic Porosity (%)
PHIT_DT_HR:	Hunt/Raymer Sonic Porosity (%)
PHIT_DPLS:	Density Porosity (limestone) (%)
SPHI_WY:	Sonic Porosity – Wyllie Time Average (V/V)
SWT:	Water Saturation (%)
SW_VARI_M:	Water Saturation – variable 'm' (%)
SXOT:	Flushed Zone Saturation (%)
TGAS:	Total Gas (gas chromatography/hot wire)
VOL_UWAT:	Bulk Volume Water (%) (PHIE X SWT)
VOL_XWAT:	Flushed Zone Bulk Volume Water (%) (PHIE X SXOT)
VSH:	Calculated Shale Volume (%)
Pay:	Pay Flag

*extension _SC - shale corrected