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Preliminary Stratigraphic Framework for Selected Kimberlites in the Buffalo Head Hills Region, North-Central Alberta

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Acknowledgments

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Abstract

A preliminary stratigraphic framework is presented for the uppermost Cretaceous strata of the southeastern Buffalo Head Hills, north-central Alberta. The stratigraphy is based on the study of sedimentary rock cores from 14 drillholes that evaluated 10 separate kimberlite targets within the Buffalo Head Hills kimberlite field. These descriptions and interpretations will serve as a basis for stratigraphic correlation of individual and inter-field kimberlite targets, and provide a better understanding of kimberlite-host rock relationships required to assess potential mechanisms of kimberlite emplacement.

The oldest sedimentary rocks in the area belong to the Albian Fort St. John Group. The youngest sedimentary rocks in the area belong to the Campanian Wapiti Group and are apparent in a stratigraphic study hole drilled collaboratively by the Geological Survey of Canada and Alberta Geological Survey. The kimberlites appear to be hosted within lower Cenomanian to Campanian strata, time equivalent to the Shaftesbury and Dunvegan formations, Smoky Group and Wapiti Formation.

Sedimentological interpretation of the selected cores suggest uppermost Cretaceous Buffalo Head Hills paleoenvironments ranged from lower shoreface below wave base to tidal flat/channel to fluvial (continental) environments. Based on radiometric emplacement ages (Eccles et al., in press a) and palynostratigraphic determination (Sweet et al., in prep.) of kimberlite and mudstone in the Buffalo Head Hills kimberlite field, it is suggested that the tidal flat/channel to fluvial (continental) environments were predominant during emplacement of the majority of the kimberlites in the Buffalo Head Hills.

1 Previous Work and Introduction

As of May 2007, 48 occurrences of kimberlitic rocks have been discovered in three separate regions of northern Alberta: two occurrences are located at Mountain Lake in northwestern Alberta, 38 occurrences are located on the southeast flanks of the Buffalo Head Hills in north-central Alberta and 8 occurrences are located in the Birch Mountains area of northeastern Alberta. Since the mid-1990s, the Alberta government has been involved in a focused effort at regional and thematic characterization of provincial kimberlitic deposits (e.g., Dufresne et al., 1996; Skupinski and Langenberg, 2002; Paganelli et al., 2003; Eccles 2004; Eccles et al., 2003, 2004, in press a, b) and associated sedimentary rocks (e.g., Dufresne et al., 2001; Chen and Olson, 2005; Pawlowicz et al., 2005a).

A collaborative initiative to study the relationships between northern Alberta kimberlites and their respective host rocks was recently undertaken by the Geological Survey of Canada (GSC), Alberta Geological Survey (AGS) and industry. This report presents the stratigraphic context and facies interpretations for the sedimentary rocks surrounding the Buffalo Head Hills kimberlite occurrences for which drillcore was available. In this study, unlike previous regional wireline cross-section work (i.e., Chen and Olson, 2005) the stratigraphic context of the host rocks for individual kimberlites has been determined using bedrock cores. These descriptions and interpretations will serve as a basis for correlation within and between individual kimberlite targets. In addition, incorporation of sedimentary host rock interpretations presented herein will support future exploration in Alberta and western North America by enhancing bedrock geology and Cretaceous stratigraphy in northern Alberta.

2 Purpose and Methods

The primary objective of this study is to present a preliminary stratigraphic framework based on regional wireline log picks from Chen and Olson (2005) and the study of 30 drillcores that represent the sedimentary rock hosting selected Buffalo Head Hills kimberlite occurrences (Figure 1; Table 1; Appendix 1). The sedimentary rock cores from 30 drillholes were donated by Ashton Mining of Canada Ltd. (currently Stornoway Resources Ltd.). These drillholes were used to evaluate 10 separate kimberlite targets, the sedimentary portion of which is presently archived at the ERCB/AGS Mineral Core Research Facility (MCRF) in Edmonton, Alberta. After drillcore logging, digital photography and facies description, the facies were combined into larger-scale facies associations; these larger-scale associations were then used to interpret the depositional setting of the host strata for the kimberlite bodies.

The original drill logs as made publicly available by Ashton (Skelton and Bursey, 1998, 1999) are presented in Appendix 1, together with the detailed sedimentary core logs from this study. Both the Ashton and detailed logs were combined for selected kimberlite targets to form representative structure sections; these are presented as figures throughout this report. In addition to the Ashton drillholes, drillcore from a 2004 stratigraphic study hole, which was drilled collaboratively by the GSC and AGS, are presented in Appendix 1 and discussed here.

The regional stratigraphic framework of the Buffalo Head Hills–Peerless Lake area was modeled by Chen and Olson (2005). In building their wireline log framework, it was noted that many of the wells in the Buffalo Head Hills region do not have suitable logs for picking the uppermost Cretaceous stratigraphic tops. Wells that were unsuitable for picking stratigraphic tops in the shallow, near-surface zones include three types: old wells with poor logs, wells that were too deep (i.e., cased through the Late Cretaceous) and wells that showed unusual log responses. Over 50% of the wells in the area were cased below the uppermost Late Cretaceous formations of interest; it is difficult to pick tops through casing.

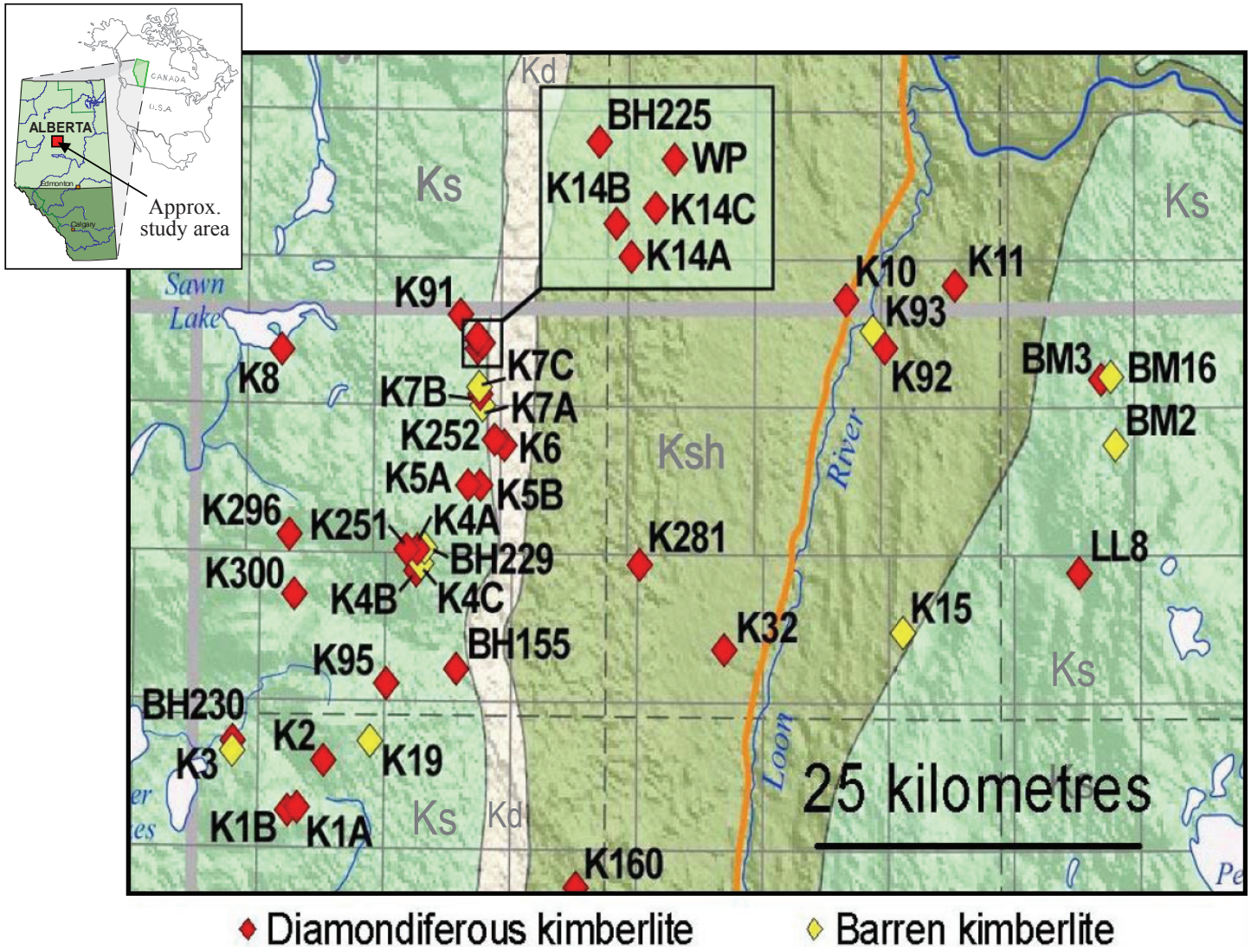

Figure 1. Kimberlite rock occurrences within the Buffalo Head Hills kimberlite field on the bedrock geology base map (Hamilton et al., 1999). Bedrock abbreviations Ksh, Ks and Kd reference middle to Upper Cretaceous bedrock units Shaftesbury Formation (shale and silty shale), Smoky Group (shale and silty shale and Dunvegan Formation (sandstone).

Table 1. Location, survey data and apparent dip corrections for Buffalo Head Hills kimberlite field cores used in the present study

		UTM	UTM	UTM	UTM	Unique well	Elevation	Core	Collar	Bedding Attitude	Dip in Degrees	End of	Cosine	True Thick	Surficial Material	True Thick
Target	Drillhole	Easting	Northing	Zone	Datum	identifier	(masl)	Orientation	Incline	To Core Axis (TCA)	[90 - TCA]	Hole (m)	[90 - TCA]	EOH (m)	Overburden (m)	Overburden
K1A	DDH1A-1	569562	6284752	11	27	08-08-089-12W5	733	Vertical	-90	60	30	160.2	0.866	138.7	20.42	17.68
K1A	DDH1A-3	569563	6284751	11	27	08-08-089-12W5	733	Inclined	-58	67.5	22.5	78.3	0.924	72.33	35.1	32.43
K5A	DDH5A-1	582687	6306035	11	27	08-14-091-11W5	634	Vertical	-90	45.5	44.5	139.3	0.713	99.35	14.3	10.2
K5A	DDH5A-5	582333	6306058	11	27	07-14-091-11W5	682	Vertical	-90	N/D*		90.52		90.52	8.53	8.53
K5A	DDH5A-6	582334	6306058	11	27	07-14-091-11W5	683	Inclined	-58	45	45	96.62	0.707	68.32	8.63	6.1
K5A	DDH5A-7	582488	6306213	11	27	10-14-091-11W5	687	Inclined	-58	55.5	34.5	127.1	0.824	104.74	4.5	3.71
K5A	DDH5A-8	582488	6306212	11	27	10-14-091-11W5	687	Inclined	-80	55	35	127.1	0.819	104.12	3.96	3.24
K5A	DDH5A-9	582442	6305766	11	27	07-14-091-11W5	659	Vertical	-90	N/D		72.26		72.26	56.99	56.99
K5A	DDH5A-10	582490	6306217	11	27	10-14-091-11W5	688	Inclined	-58	75	15	154.5	0.966	149.23	4	3.86
K5B	DDH5B-1	582812	6306408	11	27	09-14-091-11W5	633	Vertical	-90	N/D		148.43		148.43	49.7	49.7
K6	DDH6-7	585549	6308383	11	27	15-19-091-10W5	574	Inclined	-60	53	37	160.62	0.799	128.27	85.5	68.28
K6	DDH6-10	585262	6308732	11	27	15-19-091-10W5	574	Inclined	-75	N/D		197.2		197.2	30.48	max 30.48
K6	DDH6-12	585515	6308573	11	27	15-19-091-10W5	600	Vertical	-90	N/D		101.19		101.19	N/D	N/D
K6D	DDH6D-1	585334	6307691	11	27	06-19-091-10W5	579	Vertical	-90	80	10	108.81	0.985	104.98	93.57	92.15
K6E	DDH6E-1	585927	6309409	11	27	08-30-091-10W5	569	Vertical	-90	80	10	93.57	0.985	92.15	81.38	80.14
K14	DDH14-6	583162	6315101	11	27	04-13-092-11W5	605	Vertical	-90	N/D		114.9		114.9	N/D	N/D
K14	DDH14-7	583162	6315101	11	27	04-13-092-11W5	605	Inclined	-60	61	29	245.96	0.875	215.12	N/D	N/D
K14B	DDH14B-1	582820	6315277	11	27	04-13-092-11W5	620	Vertical	-90	75.5	14.5	89	0.968	86.16	12.87	12.46
K14B	DDH14B-3	582820	6315277	11	27	04-13-092-11W5	620	Vertical	-90	N/D		92.05		92.05	21.33	21.33
K14B	DDH14B-4	582820	6315277	11	27	04-13-092-11W5	620	Inclined	-60	62.5	27.5	95.05	0.887	84.31	22.24	19.73
K14C	DDH14C-1	583029	6315357	11	27	04-13-092-11W5	610	Vertical	-90	35	55	81.83	0.819	67.04	14.7	12.04
K14C	DDH14C-2	583029	6315357	11	27	04-13-092-11W5	609	Inclined	-70	N/D		87.47		max 87.47	19.81	max 19.81
K14C	DDH14C-3	583029	6315357	11	27	04-13-092-11W5	609	Inclined	-70	75.5	14.5	82.9	0.968	80.26	18.9	18.28
K14C	DDH14C-4	583029	6315357	11	27	04-13-092-11W5	609	Inclined	-75	N/D		69.19		max 69.19	24.75	max 24.75
K14C	DDH14C-5	583029	6315357	11	27	04-13-092-11W5	609	Inclined	-60	60	30	58.52	0.866	50.68	21.94	19
K14C	DDH14C-6	583029	6315357	11	27	04-13-092-11W5	609	Vertical	-90	60	30	69.19	0.866	59.92	27	23.38
K14C	DDH14C-7	583029	6315357	11	27	04-13-092-11W5	609	Inclined	-70	60	30	76.8	0.866	66.51	24.38	21.11
K19	DDH19-1	575033	6289102	11	27	03-25-089-12W5	735	Vertical	-90	N/D		133.19		133.19	5.09	5.09
K91B	DDH91B-1	581386	6316531	11	27	13-14-092-11W5	667	Vertical	0	72.5	17.5	93.57	0.954	89.24	48.2	45.97
Strat well	DDH302-1	619871	6319547	11	27	01-27-092-07W5	490	Vertical	-90	60	30	168.9	0.866	146.27	N/D	N/D
Strat well	BHH04-KHR-2	577884	6300970	11	27	05-32-090-11W5	777	Vertical	-90	N/D		105.16		105.16	N/D	N/D

*N/D not determined

In some cases, wells occur in areas proximal to mapped kimberlites, but it is unknown whether these wireline logs relate to unmapped kimberlite zones or to other geophysical targets in the area. To obtain correlation between oil and gas wireline logs and logs from kimberlite target drillcore, the apparent thicknesses and drillcore depths from the Ashton logs were converted to true thicknesses and true vertical depths to correct for inclined drillholes (Table 1). Comparisons between the drillcore logs and the wireline logs were done by comparing the elevations of the drillcores to the elevation data on the structural log sections; these were obtained by subtracting the depth of given markers to the kelly bushing (KB) elevation (since all depths are above sea level).

3 Stratigraphic Nomenclature and Context

The stratigraphic nomenclature in north-central Alberta is largely formalized although it has evolved over the years (Glass, 1990; Sweet et al., in prep.). Regional east-west cross-sections across the Buffalo Head Hills is given in Chen and Olson (2005). In the Buffalo Head Hills area, the Lower Cretaceous and younger units form a uniform blanket of successions and were unaffected by glaciation. The top of the Spirit River Group (Notikewin sandstone) and the top of the Harmon Formation (Harmon shale) were picked, while the underlying units in the Fort St. John Group were not (due to the stratigraphic datum being Harmon shale). Other overlying units picked on wireline logs include, from base to top, the Cadotte (or Paddy-Cadotte), Fish Scales zone of the Shaftesbury Formation (Figure 2), and units that could not be reliably identified as they were masked behind casing. For the present study area, the overlying successions of the Dunvegan Formation and Smoky Group are either not preserved or are masked by well casings, and therefore, not easily discernable on conventional wireline logs. In some locations, strata from the Dunvegan Formation or Kaskapau Formation (Smoky Group) were recovered in drillcore.

3.1 Spirit River Formation

The Spirit River Formation is Middle Albian in age and unconformably overlies the Devonian Banff or Wabamun carbonate successions in the area. The Spirit River Formation is equivalent to the Clearwater and Grand Rapids formations of northeastern Alberta, and correlates with the Moosebar-Gates formations of northeastern British Columbia (Figure 2; Alberta Energy and Utilities Board, 2002; Alway and Moslow, 1997). The uppermost part of the Spirit River Formation consists of the Notikewin Member, which is a yellowish and greenish-grey, fine to medium-grained clayey sandstone, with interbeds of light to dark-grey shale and siderite. There are traces of glauconite in the sandstone and, locally, well-preserved trace fossils. Rare ammonites occur within the uppermost sandstone, mainly as resedimented shells.

3.2 Harmon Member, Peace River Formation

The Middle Albian Harmon Member of the Peace River Formation ranges in thickness from 120 m in western Alberta to less than 10 m in the Peace River area, and unconformably overlies the Spirit River Formation (Figure 2; Glass, 1990). The Harmon Member may be correlative, in part, to the portions of the Mountain Park Formation in central Alberta (Glass, 1990). The Harmon Member consists largely of non-bioturbated, marine shale with lesser amounts of finely interbedded, very fine-grained sandstone and siltstone. It is thought to have been deposited in an offshore-marine setting and, through the use of biostratigraphy, has been dated as older than the Joli Fou shale (Caldwell et al., 1978). Locally, bentonites are common within the Harmon Member, where they may be interbedded with thin sandstones and siltstones. Trace fossils are locally common where there are coarser interbeds. Sandstone beds increase

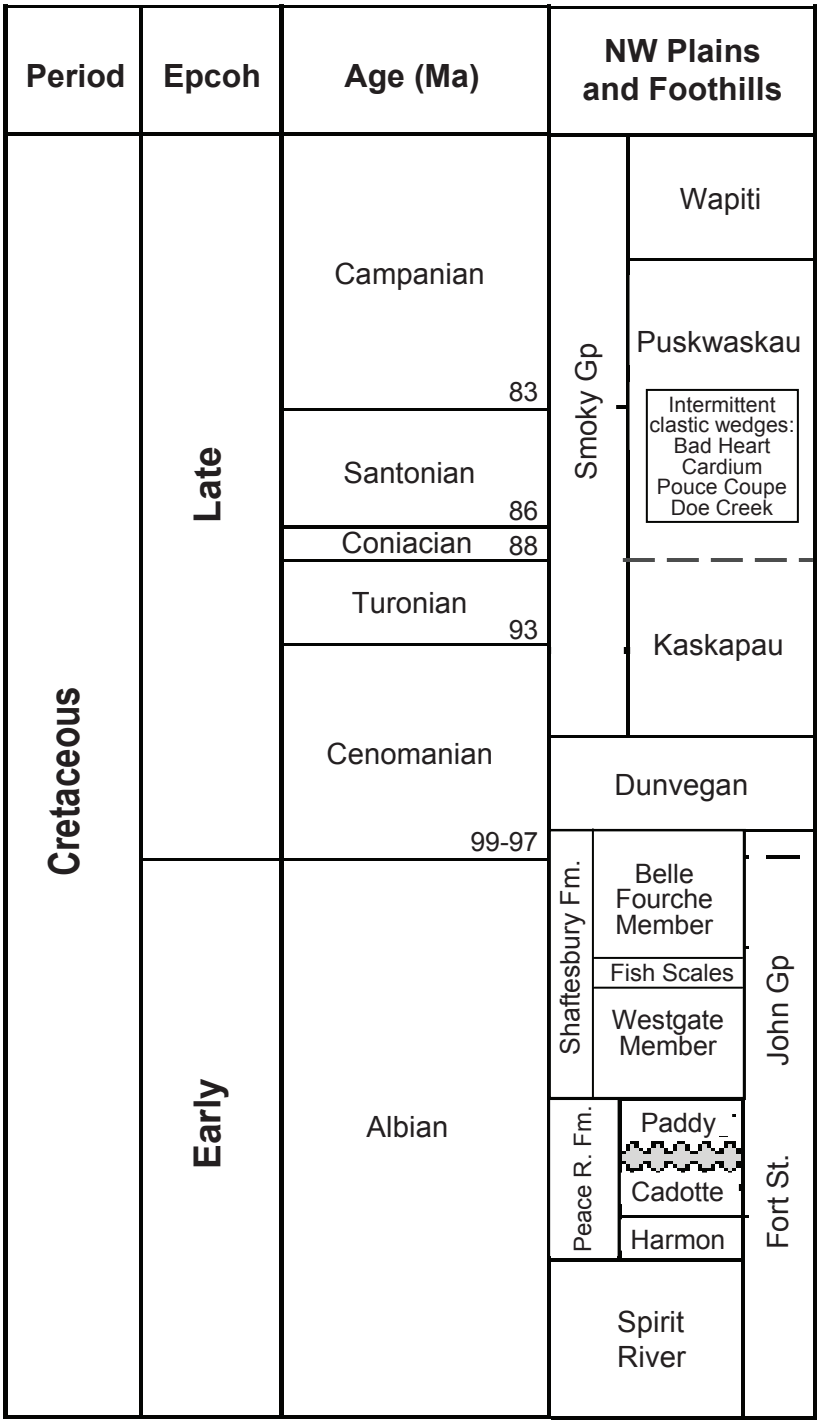

Figure 2. Detailed stratigraphic nomenclature for foothills and plains regions of the Western Canada Sedimentary Basin (WCSB), with age given in million of years (Shaftesbury Formation modified from Bloch et al., 1993).

in thickness and frequency toward the top of the Harmon Member, where it is conformably overlain by sandstones of the Cadotte Member of the Peace River Formation. The top of the Harmon Member is often used as a stratigraphic datum because its log response is a diagnostic marker unit with this zone of strata.

3.3 Cadotte (or Paddy-Cadotte) Member, Peace River Formation

The Cadotte and Paddy members form the upper part of the Peace River Formation and extend continuously from the Rocky Mountains east to central Alberta, where they appear to be correlative with the Joli Fou Formation (Figure 2). The Paddy is a non-marine succession (estuarine-incised valley fills, fluvial and coastal plain successions) of the Peace River Formation, whereas the Cadotte is more of a marine unit (largely shoreface sandstones) with an irregular and siderite-cemented disconformity separating the two (Glass, 1990; Reinson et al., 1994). In drillcore, the Paddy Member sandstones are compositionally immature (mainly lithic-dominated, with a high shale content), whereas Cadotte sandstones are more mature, quartz-dominated, with local concretions. Locally ammonite and bivalve (*Inoceramus*) shells occur within the sandstone beds. In the present study, the Paddy Member was generally not recognized, but with further exploration it may be possible to recognize locally preserved remnants of the unit. The Cadotte Member sandstone is disconformably overlain by the Shaftesbury Formation (Reinson et al., 1994).

3.4 Shaftesbury Formation (and Fish Scales Member)

In northern Alberta, the Shaftesbury Formation marine shale succession underlies much of the lowlands adjacent to the Peace, Hay and Chinchaga Rivers in the west, and extends eastward around the lower slopes of the Caribou Mountains, Buffalo Head Hills and northeastern margin of the Birch Mountains. The Albian to Cenomanian Shaftesbury Formation (Leckie et al., 1990, 1992) belongs to the Fort St. John Group, is disconformable to unconformable with the underlying Peace River Formation, and is conformable with the overlying Dunvegan Formation (Figure 2; Glass, 1990; Reinson et al., 1994; Bhattacharya, 1994).

The Shaftesbury Formation includes a fish scale and bone-dominated 'central layer' that serves to divide the formation into three lithostratigraphic units: the lower Westgate, Fish Scales and uppermost Belle Fourche members (Bhattacharya, 1994). By contrast, Bloch et al. (1993) in their regional study of the Western Canada Sedimentary Basin (from the Peace River Arch in Alberta to southern Manitoba) identify the same units (Westgate-Fish Scales and Belle Fourche) as different formations within the Colorado Group (Bloch et al., 1993; Figure 2). The lowermost Westgate Member is largely light to dark grey mudstone with black, blocky, sulphur-rich mudstone. This contrasts markedly with the uppermost Belle Fourche succession, which comprises alternating light grey to light olive-grey mudstone, fine to very fine sandstone and siltstone with thin interbeds of bentonite and minor siderite.

One of the most important units for regional correlation is the Fish Scales Member, which marks the contact between the Lower and Upper Cretaceous and is commonly used as a regional stratigraphic datum within Cretaceous successions of Alberta. However, in the present study area, the Fish Scales zone is either not frequently intersected by the wells or this marker is obscured by casing. Therefore, the top of the Harmon Member is often used as a stratigraphic datum because it generally can be picked on wireline logs from most wells.

3.5 Dunvegan Formation

The Dunvegan Formation is exposed in the Peace River area, the Buffalo Head Hills, the Caribou Mountains and the northern margin of the Birch Mountains. This middle Cenomanian (lowermost Upper Cretaceous) lithostratigraphically defined unit comprises an extensive, southeasterly thinning, sandy clastic wedge that is confined to northwestern Alberta, northeastern British Columbia, and as far north as the Northwest Territories. The Dunvegan Formation is underlain by the Shaftesbury Formation, and

overlain by the Kaskapau Formation of the Smoky (Alberta) Group (Figure 2; Bhattacharya, 1988). The Dunvegan has a gradational, locally diachronous, lower and upper contact with the Shaftesbury and Kaskapau formations (Bhattacharya, 1988, 1994). The Dunvegan Formation consists of marine and nonmarine sandstone, interbedded with shale, coquinas and coal. Sandstones are yellow/buff to light grey, and may be crossbedded or massive. Because the Dunvegan succession is mainly behind casing in the oil and gas wells, it is difficult to pick this unit on wireline logs.

3.6 Kaskapau Formation

The Kaskapau Formation—latest Cenomanian to early Turonian—occurs at the base of the Smoky (Alberta) Group and contains a series of five northeast-trending, shingled (back stepping), shallow-marine sandstone bodies encased in marine mudstone (Wallace-Dudley and Leckie, 1993). In central Alberta, it is equivalent to the Blackstone Formation, while to the northeast correlates to the Second White Specks Formation of the Colorado Group (Figure 2). In the study area, the Kaskapau Formation has a gradational lower contact with the Dunvegan Formation. It is unconformably overlain by Quaternary deposits or by Campanian strata most likely belonging to the Wapiti Formation (Eccles et al., 2001; Pawlowicz et al., 2005a; Sweet et al., in prep.). Further to the west and northwest, the Kaskapau Formation is disconformably overlain by sandstone of the Bad Heart Formation (Plint, 1990; Weiss et al., 2005). The Kaskapau Formation consists mainly of dark grey, fissile shale with ironstone concretions. Sandstones occur at or near the base and as thin beds near the top of the formation. The Kaskapau succession is mainly behind the cased interval in the oil and gas wells, and therefore, is difficult to pick on wireline logs.

3.7 Wapiti Formation

In northwestern Alberta, the lower Wapiti Formation is approximately 1100 m thick in northwestern Alberta and lies stratigraphically above the Puskwaskau Formation (Figure 2; McMechan and Dawson, 1995). The Wapiti is not presently mapped in the Buffalo Head Hills area (Hamilton et al., 1999) and as such, has not been identified on wireline logs. However, several studies have recognized a component of Campanian strata based on palynology of the few surface exposures of bedrock within the Buffalo Head Hills kimberlite field (Eccles et al., 2001; Pawlowicz et al., 2005a). This hypothesis has been verified by Sweet et al. (in prep.), who suggest the maximum age of deposition is likely about 78 Ma. The Wapiti group is generally composed of light grey, fine-grained, interbedded silty mudstone, siltstone and sandstone.

3.8 Quaternary

The Quaternary succession was described if it was recovered in Ashton drillcore. Most of the facies are glacial till (diamict), with less common occurrences of subglacial or glaciofluvial outwash, and glaciolacustrine units. Due to the restricted drillcore coverage and recovery of the Quaternary succession in the core, it was not possible to map or correlate these facies separately. A full description and interpretation of the origin of the Quaternary successions is given in Trommelen et al. (2006). The importance of understanding the Quaternary history of the area in relation to kimberlite exploration is summarized by Fenton et al. (2003), Prior et al. (2005) and Pawlowicz et al. (2005b).

4 Description of Drillcores

4.1 Summary of Oil and Gas Wells

In the northern part of the Buffalo Head Hills kimberlite field, only two wells (02/16-30-092-11W5/2 and 05-26-092-11W5) have uncased sections that intersect the top of the Shaftesbury Formation. There are slight differences between the structural and stratigraphic sections in the subsea elevations of the Spirit River, Cadotte and Fish Scales for the 15-23-092-11W5 well. Otherwise, all stratigraphic picks are readily discernable with sedimentary packages having relatively uniform thicknesses across the area.

The middle part of the Buffalo Head Hills kimberlite field correlates with the wireline log cross-section AA' of Chen and Olson (2005). The casing for individual wells is generally deep and it is only possible to detect the top of the Shaftesbury Formation with confidence in two wells: 16-21-091-11W5 and 11-34-091-11W5. Most of the units show very little variation in thickness or subsea elevation across the area.

Casings for individual wells in the southernmost part of the Buffalo Head Hills kimberlite field are deeper than those of the north, so that the topmost pick discernable on logs is the Fish Scales. Relative to the Harmon datum, both the Cadotte and Fish Scales vary, with a possible paleotopographic high present in well 08-06-089-12W5. This interpretation raises the possibility of an up-faulted horst in the southern part of the field; a feature that would explain both the enhanced stratigraphic thickness and repeated units in some of the drillcores recoverd in this area.

4.2 Kimberlite Target K1A in Township 89, Range 12, W 5th Meridian

Drillcores from the kimberlite target K1A (DDH97-1A-1 and DDH97-1A-3) intersected an apparent depth of 160.2 m drilled at an elevation of 732.5 m asl that represents a true stratigraphic thickness between 72 m and 139 m, including an overburden thickness between 18 m and 33 m (Table 1). Oil and gas wireline log cross-sections in the vicinity of the K1A body do not have suitable logs for picking the uppermost Cretaceous stratigraphic tops (Chen and Olson, 2005). Palynological determinations on the same cores used in this study, indicate the presence of a major depositional hiatus between Cenomanian-Turonian and Coniacian-Santonian mudstone successions (Sweet et al., in prep.). Using the Ashton drill log descriptions combined with the drillcore logged in the present study (Appendix 1), a composite structural section was built for the DDH97-1A-1 and DDH97-1A-3 drillholes (Figure 3).

In the stratigraphically higher DDH97-1A-3 drillcore, thick till overlies a thin kimberlite zone. On the Ashton drill logs, carbonate veinlets occur throughout the kimberlite zone, ranging from 0.2 cm to 3 cm in diameter. The concentration of veinlets within the kimberlite is usually < 3 vol. %, but, in rare instances (e.g., from 40.4 m to 41.76 m core depth), the concentration of carbonate veinlets and carbonate alteration is so high that the rock has turned light grey. The mudstone in DDH97-1A-3 is interpreted as mainly lower shoreface bioturbated mudstone, locally pyritic, with low angle to parallel and graded laminations. This unit disconformably overlies a deeper marine, bioturbated and well-laminated mudstone succession, and grades up into a thin, sandy, coarsening-up succession that is capped by a bentonite.

In the stratigraphically lower DDH97-1A-1 drillcore, there is a thinning of overburden, and an enhanced thickening of kimberlitic rocks (Figure 3). The main kimberlite zone overlies a 4–5 m thick interval of interbedded kimberlite and clastic sediment, although this core was not available for study.

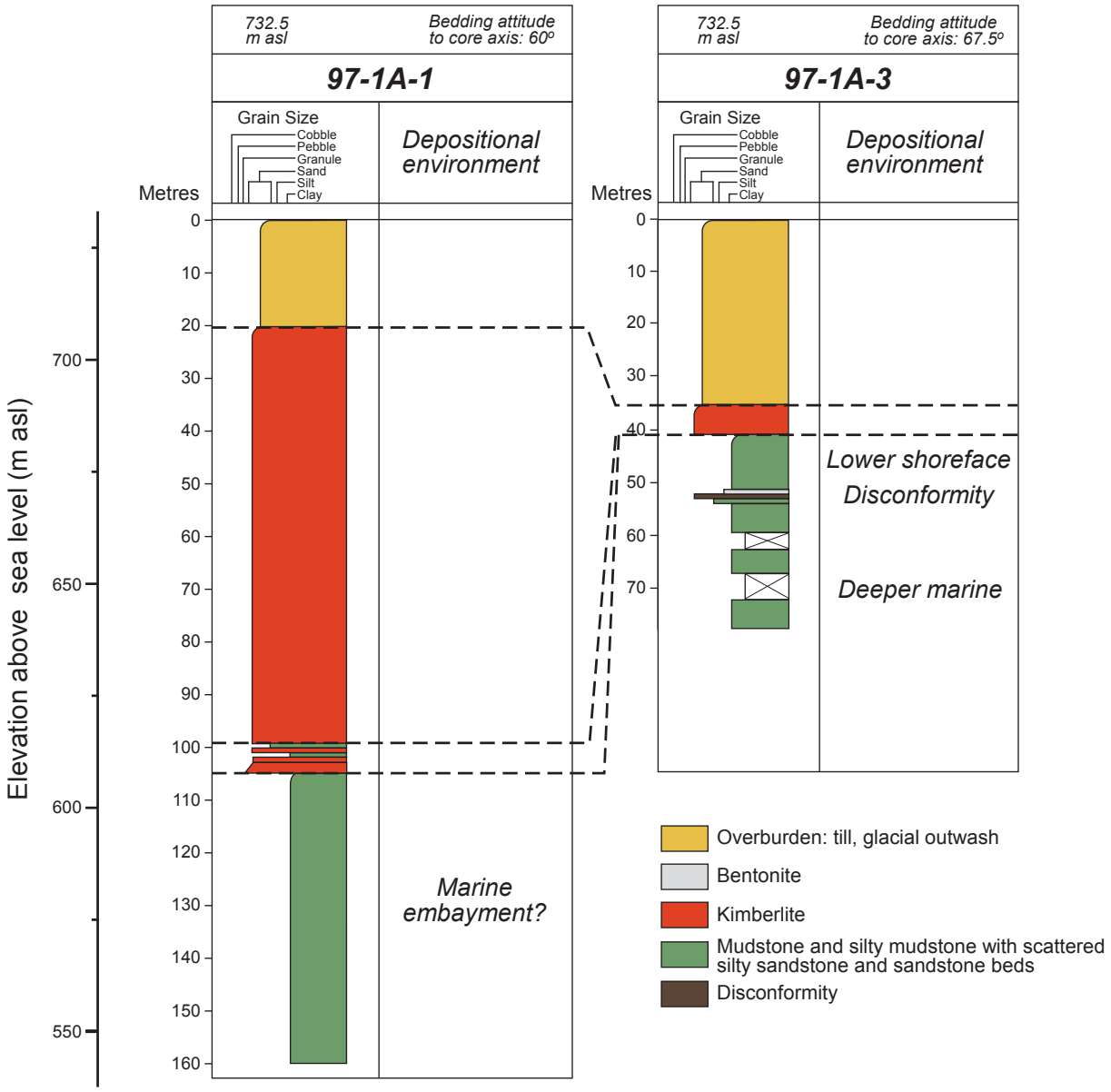

Figure 3. Simplified drillcore section for the kimberlite K1A target to illustrate inter-hole relationships and depositional environment. Datum is sea level. Detailed sedimentary core log interpretations are in Appendix 1.

The underlying succession consists of lower shoreface laminated siltstone and mudstone, which are interpreted as marine embayment deposits.

4.3 Kimberlite Target K1B in Township 92, Range 11, W 5th Meridian

Only the lower part of the DDH97-1B-1 drillcore (from about 140 m to 155 m drillcore depth) was available at the MCRF for examination. The drillcore consists of fragmented and altered interbedded sandstone and mudstone. Sands are quartz litharenites that alternate with broken, light grey, altered, and massive mudstone. A 0.3 m thick layer of rusty, iron-stained, calcareous sandstone was noted to appear

quite badly weathered (or altered) and may be kimberlitic. Burrows appear throughout the section, mainly discernable within the coarser interbeds that are more competent, and not as highly altered. In addition, there are some parallel laminations and low-angle crossbedding preserved in the coarser-grained sand and siltstone interbeds, which, along with the common traces, are indicative of a lower shoreface marine setting. This interpretation is supported by preliminary palynological analysis of the associated mudstone (Sweet et al., in prep.).

Sections for the DDH97-1B-1 and DDH97-1B-2 drillcores are presented in Figure 4. In the DDH97-1B-1 drillcore, glacial till overlies an interval of kimberlite and sandstone boulders, which in turn overlies a thick kimberlite unit. Although it is not stated in the Ashton drill logs, the boulder interval may represent a pre-glacial lag or a subglacial outwash deposit. As noted from the Ashton drill logs, the underlying kimberlite is mainly massive and has a distinct hydrocarbon odour. The kimberlite abruptly overlies a bentonitic mudstone succession. In the DDH97-1B-2 drillcore, there is no boulder interval and glacial till directly overlies the kimberlite. The clastic succession underlying the kimberlite consists of interbedded mudstone, siltstone and sandstone, which is interpreted as a lower shoreface succession with a possible paleosol horizon at the top.

4.4 Kimberlite Targets K5A and K5B in Township 91, Range 11, W 5th Meridian

Drillcores from the kimberlite target K5A (DDH97-5A-1, DDH97-5A-5 to DDH97-5A-10) intersected apparent depths between 72 m and 155 m, drilled at elevations between 633 and 688 m asl (Table 1; Appendix 1). These intersections represents a true (corrected) stratigraphic thickness of up to 150 m and overburden thicknesses that range from 3 m to 10 m (Table 1).

Comparisons to nearby wells with oil and gas wireline logs suggest core depths that correspond to the Shaftesbury Formation (Chen and Olson, 2005). However, the palynological interpretations for mudstone at the base of the DDH97-5A-10 core indicate that the mudstone is Cenomanian age (Sweet et al., in prep.). Thus, it is logical to infer that sandstone overlying the basal mudstone at the bottom of the drillhole belongs to the Cenomanian Dunvegan Formation. This indicates that the cored intervals are, in fact, younger than has previously been interpreted by wireline log interpretation and correlation.

The composite structural section for the K5A drillholes, using the Ashton drill log descriptions combined with the drillcore logged in the present study (Appendix 1), is given in Figure 5. Quaternary deposits consist of a relatively thin succession of glacial till, which thickens in the DDH97-5A-6 and DDH97-5A-1 drillcores. At DDH97-5A-9, a glacial succession of gravel-boulder outwash is overlain by a thick glacial lacustrine unit. K5A kimberlite intersections typically consist of a thin kimberlite breccia at the overburden-kimberlite contact, grading down into bedded kimberlite and interbedded bedded kimberlite and breccia (Skelton et al., 1998).

In all of the cores, kimberlite is underlain by sedimentary rocks at the bottom of the hole. In the DDH97-5A-1 drillcore the kimberlite abruptly overlies a succession of deeper marine (below wave base, offshore shelf or deep bay-fill), thinly laminated and bioturbated shales. In most of the other wells (DDH97-5A-6, -7, and -8) the underlying marine shale is highly fractured, generally with a network of closely spaced calcite vein fills. For example, in the Ashton DDH97-5A-7 drill log, a 2.5 m thick shale has extreme carbonate veining or fracture fill (116.5–121.01 m core depth); and in the DDH5A-8 drillcore the basal shale is brecciated with calcite veins/fracture fill occurring at 30º to 45º to the core axis. The DDH97-5A-9 kimberlite breccia is underlain by highly fractured, thinly laminated mudstone, in which it is difficult to discern sedimentary structures. In the DDH97-5A-10 drillcore, the bedded kimberlite overlies a kimberlite breccia zone, which is in abrupt contact over the sedimentary succession. This

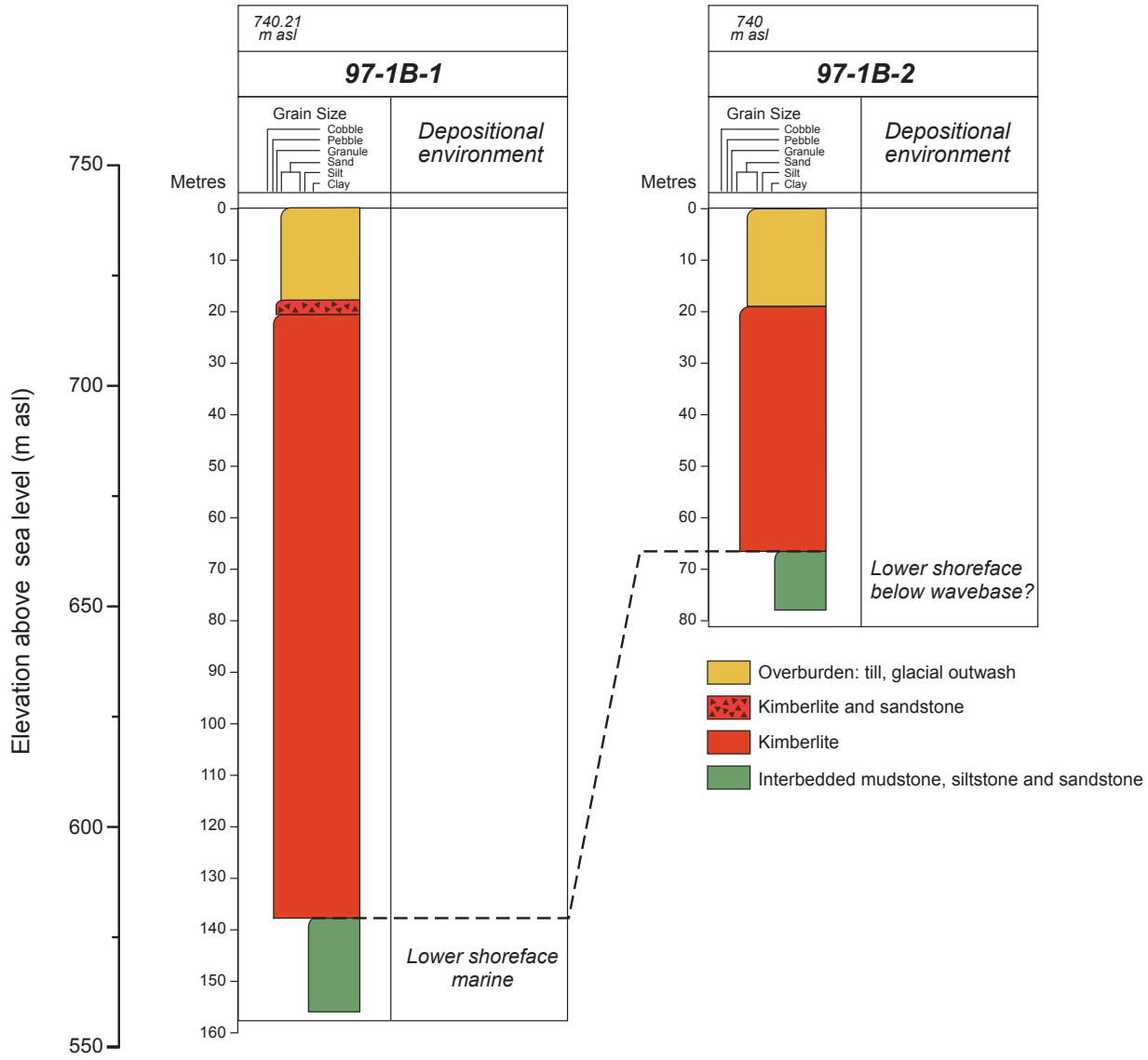

Figure 4. Simplified drillcore section for the kimberlite K1B target to illustrate inter-hole relationships and depositional environment. Datum is sea level. Detailed sedimentary core log interpretations are in Appendix 1.

lower succession consists of bioturbated, coarsening-upwards mudstone to sandstone, followed by fining-upwards sandstone to mudstone. The degree of bioturbation, the presence of complex grading patterns and the occurrence of mainly low-angle to parallel laminations support an interpretation of a lower shoreface succession.

The kimberlite target K5B was tested by vertical drillhole DDH97-5B-1 at a collared elevation of 633 m asl, total depth of 148.43 m and an overburden depth of 49.7 m (Table 1). Comparisons to nearby wells with wireline logs (Chen and Olson, 2005), show that the mudstone at the base of the core may correspond to the Fish Scales Member within the Shaftesbury Formation. Palynological analysis has not been completed on mudstone from this drillhole. The sedimentary part of the DDH97-5B-1 drillcore examined at the MCRF consists of broken, medium to light-grey fissile shale that is badly weathered. There were no obvious sedimentary structures. The Ashton drill log descriptions indicate that in the

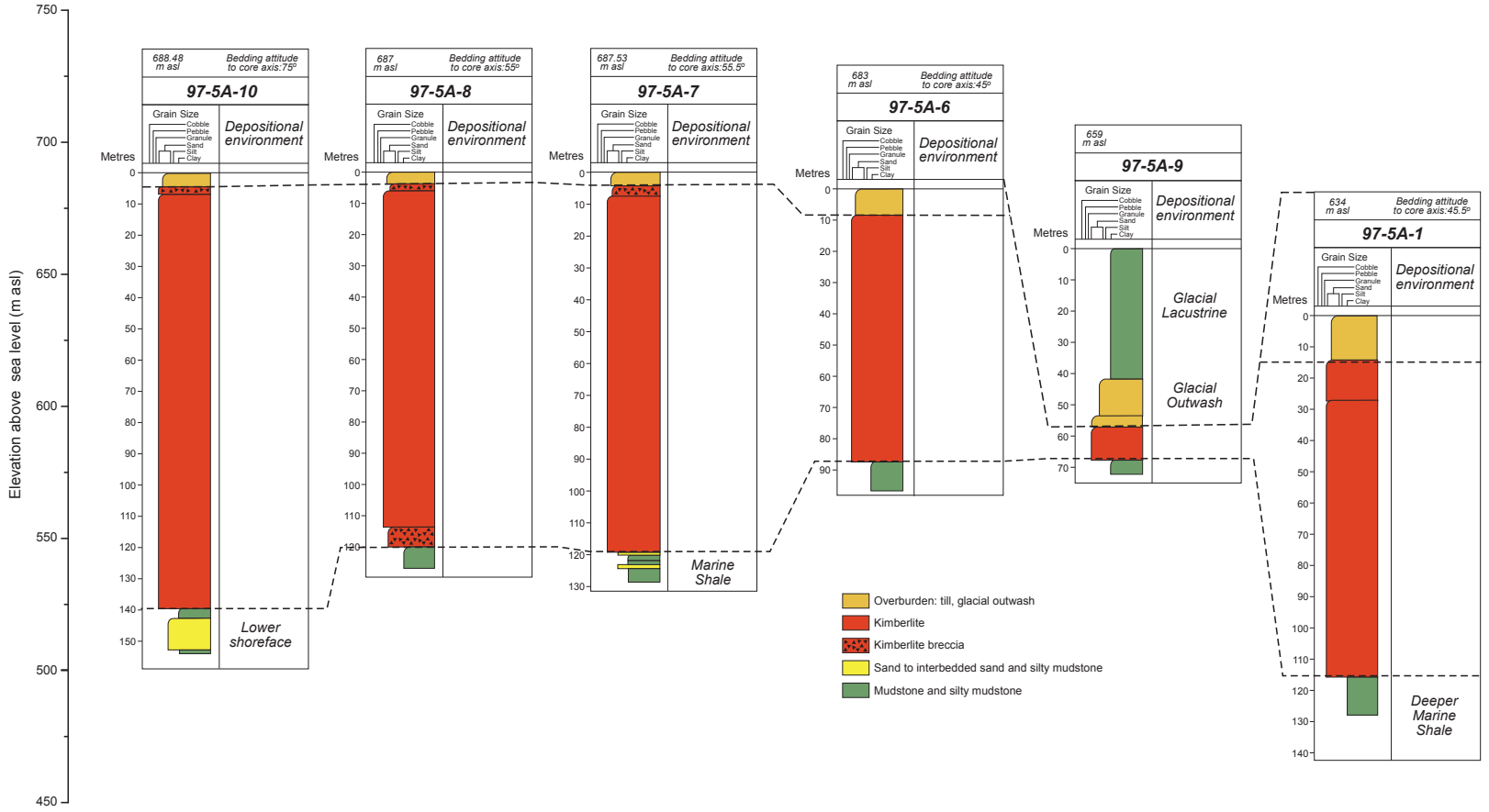

Figure 5. Simplified drillcore section for the kimberlite K5A target to illustrate inter-hole relationships and depositional environment. Datum is sea level. Detailed sedimentary core log interpretations are in Appendix 1.

DDH97-5B-1 drillcore a thick glacial till overlies kimberlite, which, in turn, abruptly overlies a mudstone succession with intercalated serpentinized kimberlite (Figure 6). The emplacement of the kimberlite 'layers' into the mudstone unit, with subsequent serpentinization, might be the result of either syn-depositional or post-depositional injection of kimberlitic veins into the surrounding mudstone host rock. Regardless, the process appears to have obliterated any primary sedimentary structures in the DDH97-5B-1drillcore.

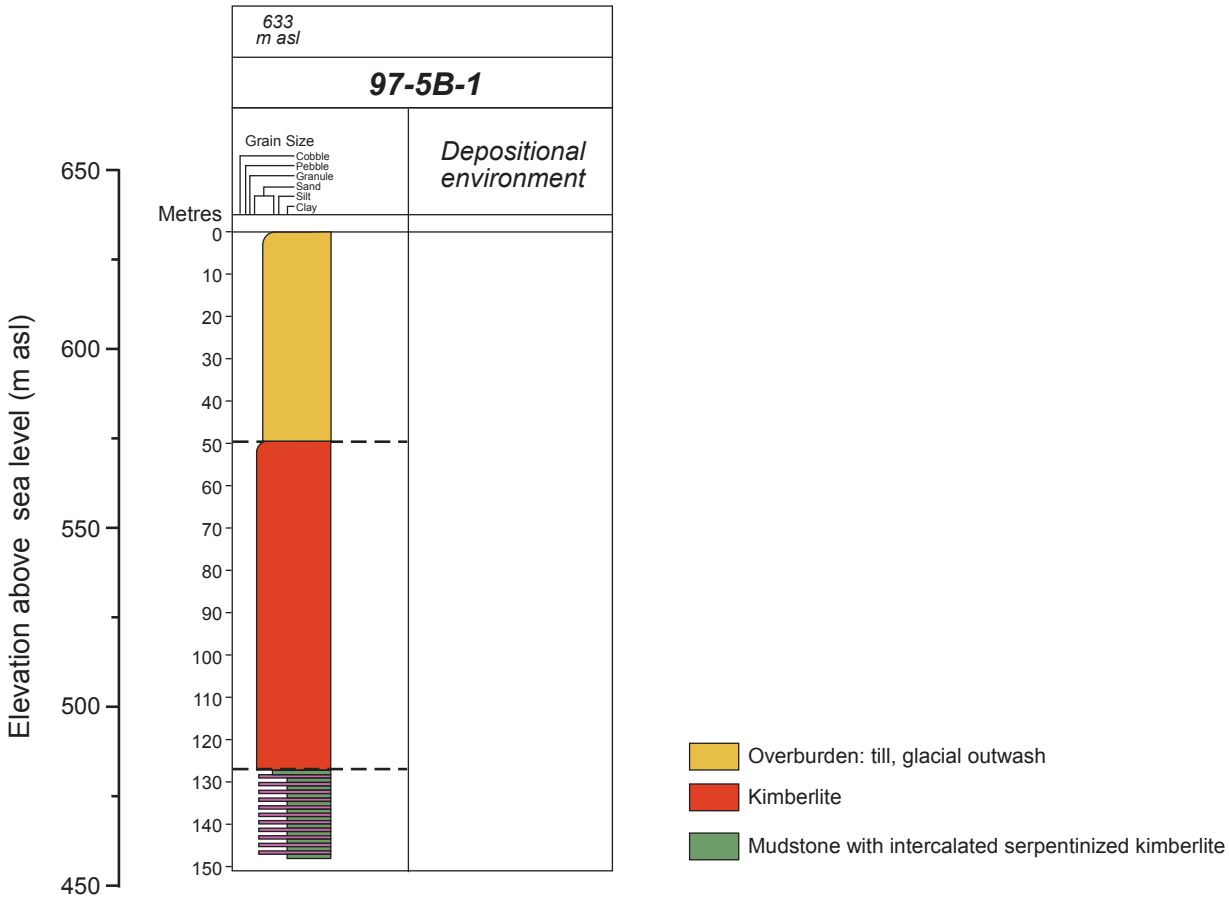

Figure 6. Simplified drillcore section for the kimberlite K5B target to illustrate depositional environment. Datum is sea level. Detailed sedimentary core log interpretations are in Appendix 1.

4.5 Kimberlite Target K6 in Township 91, Range 10, W 5th Meridian

Drillcore from the kimberlite target K6 (DHH97-6-3, DHH97-6-4, DHH97-6-7, DHH97-6-8, DHH97-6-9, DDH97-6-10, DHH97-6-12; DHH97-6D-1, DHH97-6E-1) were drilled at elevations between 569 and 600 m asl and intersected apparent depths between 30.48 m and 197.2 m (Appendix 1). This intersection represents a maximum true stratigraphic thickness of 197.2 m, including an overburden thickness between 30.48 m and 92.15 m (Table 1).

Based on the wireline log sections (Chen and Olson, 2005), the true depths for most of the drillcores correspond to the Quaternary succession, and thus, the cased interval for oil and gas wells in the area. The exceptions are the lower parts of the DHH97-6D-1, DHH97-6-E1, DHH97-6-3, DHH97-6-7 and DDH97-6-10 drillcores, which intersect clastic successions of the Shaftesbury Formation, most likely

below the Fish Scales Member. Palynological results for samples from the DDH97-6D-1 and DDH97-6-7 drillcores indicate Early Cenomanian and Late Albian palynological ages, respectively, (Sweet et al., in prep.), supporting correlation with the Shaftesbury Formation.

A composite structural section is presented in Figure 7 using the Ashton drill log descriptions (Skelton and Bursey, 1998, 1999) combined with the sedimentary core logged in the present study (Appendix 1). Two of the drillcores (DDH97-6-9 and DDH97-6-12) penetrated till only and were terminated prior to intersection with the kimberlite zone and/or sedimentary rocks (Figure 7). Drillholes DDH97-6E-1 and DDH97-6D-1 intersected a thick section of surficial deposits and terminated in mudstone, while drillholes DDH97-6-3, DDH97-6-4, DDH97-6-7 and DDH97-6-8 intersected till and kimberlite and terminated in sedimentary rocks.

The composite section shows dramatic variation in kimberlite, host sedimentary rocks and surficial deposits near the K6 target. Drillholes collared adjacent to holes with minimal till and thick kimberlite intersections (e.g., DDH97-6-3 and DDH97-6-4) penetrated thick surficial deposits with no kimberlite penetrated (e.g., DDH97-6E-1 and DDH97-6D-1). In the DDH97-6D-1 drillcore, the mudstone is carbonaceous, bioturbated and well laminated, including stacked coarsening-upward successions of mudstone, siltstone and sandstone. The coarser intervals locally contain siderite concretions. There is a change in the distribution of kimberlite from the barren hole DDH97-6D-1 to the DDH97-6-3 and DDH97-6-4 drillcores, where the kimberlite has an apparent thickness of 90 m and 164 m, respectively. Kimberlite in the DDH97-6-4 drillhole is reported in the Ashton drill logs as massive. In the thicker DDH97-6-3 occurrence the kimberlite appears to be a composite unit, with locally bedded and massive facies, some stacked fining-upward successions and calcite veining (Skelton and Bursey, 1998).

Complex histories of kimberlite emplacement are also recorded in the kimberlite-sedimentary host rock relationships of the DDH97-6-8 and DDH97-6-7 drillcores. In the DDH97-6-8 drillcore, the Ashton drill logs indicate that a thin intersection of kimberlite overlies an interbedded succession of kimberlite, kimberlite breccia and mudstone. A similar occurrence is in the DDH97-6-7 drillcore where thin layer of kimberlite overlies a succession of interbedded mudstone, kimberlite and bentonitic shale, capping a lower shoreface clastic succession. In the DDH97-6-7 drillcore, only the lower mudstone was available for logging and the uppermost contact with the kimberlite was not available for study. The mudstone consists of ‘poker chip’ silty shale with pronounced fissility. Thin-altered, light green, bentonitic shale occurs about 0.5 m from the top of the drillcore interval. The DDH97-6-7 basal mudstone consists of well-laminated, interbedded mudstone and sandy siltstone that might be correlative with the upper part of the succession recovered in the DDH97-6-10 drillcore. Laminations are mainly horizontal and parallel with well-developed complex grading patterns indicative of tidal laminations. Less common are unidirectional ripple and flaser crossbeds in the coarser sandy siltstone interbeds. The lack of trace fossils, wave ripples or other interference ripples, complex grading patterns, fine sediment size, and delicate interlaminations of bedding styles are interpreted as a depositional setting below wave base, perhaps as a deep tidal embayment. Capping the interpreted tidal embayment succession is a massive mudstone, with platy and fissile fractures, and minor silty interbeds. This upper massive mudstone was not observed in the DDH97-6-10 drillcore.

In the DDH97-6-10 drillcore, thickly bedded, coarse-grained, lithic lower shoreface sands occur at the base (191–195 m drillcore depth). The lithic sandstone is bioturbated, with well-developed low-angle crossbedding, minor ripple crossbedding, local mudstone intraclasts and dispersed organic detritus. The percentage of lithic fragments increases toward the base of the drillcore. The basal lower shoreface succession is capped by a transgressive lag deposit, which, in turn, is overlain by a thin layer of organic material and a bentonitic shale unit.

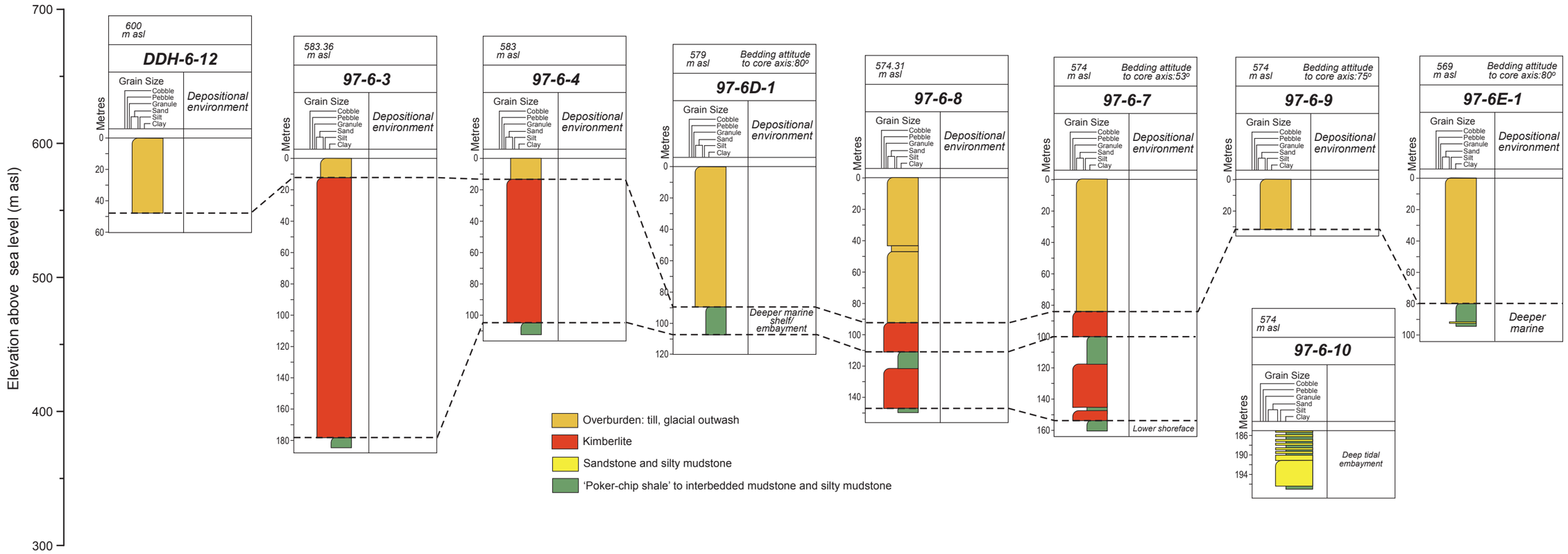

Figure 7. Simplified drillcore section for the kimberlite K6 target to illustrate inter-hole relationships and depositional environment. Datum is sea level. Detailed sedimentary core log interpretations are in Appendix 1.

4.6 K14 Complex

Drillcore from the K14 complex (DDH97-14-6, DDH97-14-7, DDH97-14B-3, DDH97-14B-4, DDH97-14C-2, DDH97-14C-3, DDH97-14C-5, DDH97-14C-6) penetrated to apparent depths of between 58.52 m and 245.96 m. The holes were drilled at elevations between 605 and 620 m asl (Table 1). The cores represent true stratigraphic thicknesses of 50.68– 215.12 m, including an overburden thickness between 12.04 m and 24.75 m (Table 1). Comparisons with the cross-sections of Chen and Olson (2005) indicate that the true depths for most of the drillcores near the kimberlite target K14 correspond to the cased interval for oil and gas wells in the area.

Using the Ashton drill log descriptions combined with the drillcore logged in the present study (Appendix 1), three composite structural drillcore sections were built for K14A, K14B and K14C (Figures 8 to 10), and will be discussed separately below.

4.6.1 K14A Kimberlite Target

K14A kimberlite drillcores available for this study included both DDH97-14-6 and DDH97-14-7 (Figure 8; Appendix 1). In comparison to other kimberlite in the Buffalo Head Hills, the K14 complex has been the target of numerous drilling programs. Palynological results on mudstones directly below kimberlite intersections in DDH97-14-6 and DDH97-14-7 indicate an age of Early to middle Cenomanian (~99-96 Ma; Eccles et al., in press a; Sweet et al., in prep.).

In the DDH97-14-6 drillcore, till extends to about 80 m drillcore depth, where the underlying sediment is a fissile mudstone without dispersed clasts. Notes from the Ashton drill logs indicate that top of the drillcore is a thick organic horizon (8–54 m) that overlies a thick upper till succession (Figure 8; Appendix 1). The till observed in drillcore is a lower till that was recovered beneath an interbedded kimberlite and clastics succession. The interbedded kimberlite includes both coherent kimberlite and resedimented kimberlite within till and outwash gravels. The apparent interbedding of till, outwash material and coherent kimberlite is difficult to explain and may have resulted from drilling problems (i.e., pulling the rods), or alternatively, post-glacial faulting and slumping.

The contact of the till with the underlying bedrock is difficult to discern due to both the massive aspect of the underlying mudstone and the clay in the glacial diamict resembling the bedrock mudstone. In drillcore logged during the present study, the upper bedrock contact was picked where there is an increase in fissility, a loss of dispersed clasts, and subtle changes in mudstone colouration. Lower down the drillcore the mudstone is less massive and consists of laminated grey, fissile mudstone, with interbedded siltstone. The coarser intervals locally contain siderite cement. In muddier, finer-grained intervals, there is a yellow efflorescence of sulphur or sulphur compounds on the drillcore surface. Due to such factors as the overall fine-grained nature of the bedrock, the lack of dispersed organic detritus, the absence of rooted, coal, or paleosols, and the fine fissility, this unit, then, is interpreted as a deep marine mudstone deposited below wave base.

In the top of the DDH97-14-7 drillcore, there was an upper till with a resedimented kimberlite clast (Figure 8). Beneath the kimberlite, is a thick basinal mudstone succession, interbedded with lower shoreface sands. Mudstones are mainly structureless, with some fissility and thin laminations, with rare burrow structures preserved. Associated sandstone and siltstone interbeds show low-angle cross stratification and are bioturbated. By contrast, a thin sandstone at the base of the drill-cored interval has well-laminated (parallel, low-angle, tidal-herringbone), with increased bioturbation, structures and iron staining. The upper contact between the sandstone and overlying basinal mudstone is abrupt, and

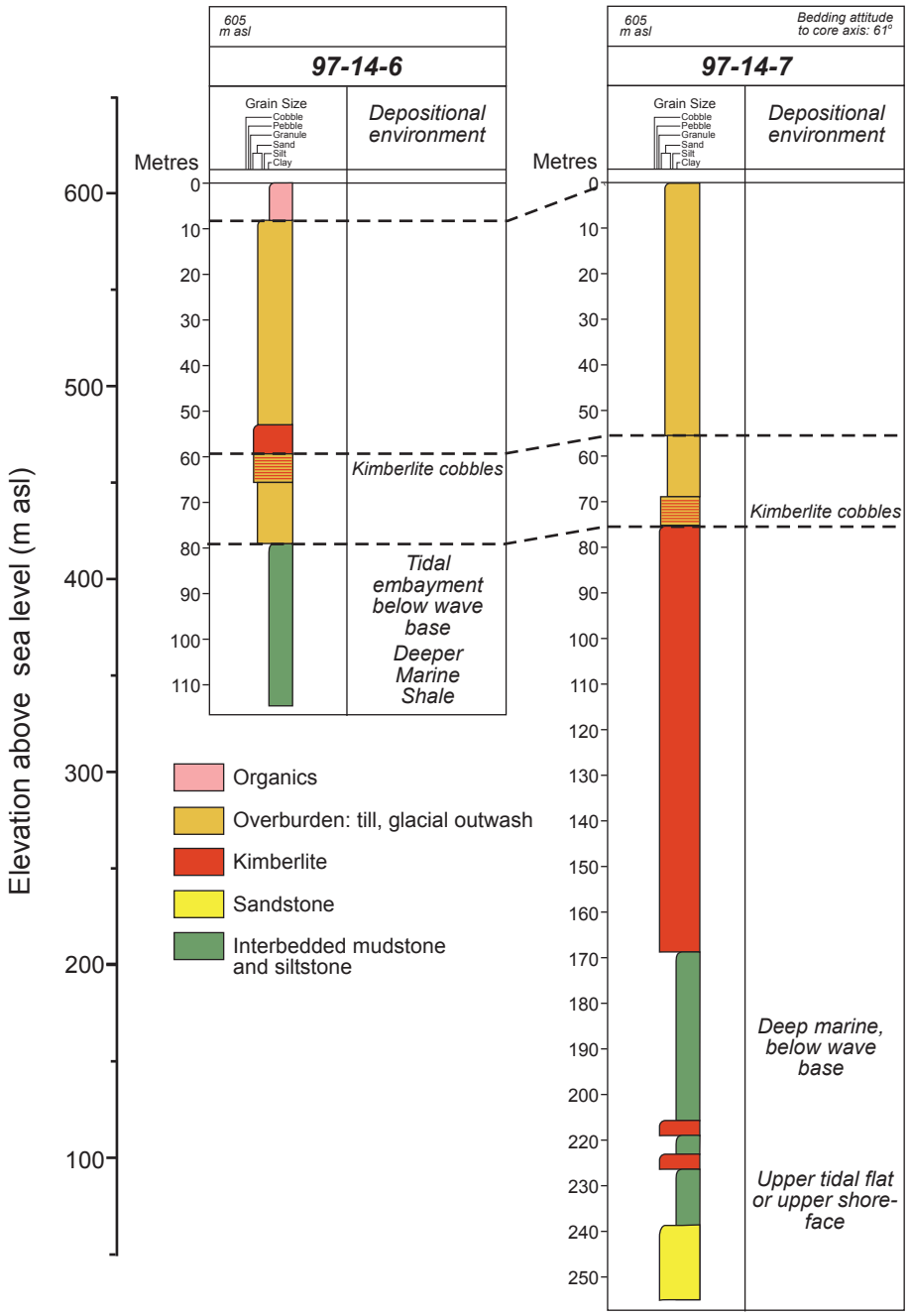

Figure 8. Simplified drillcore section for the kimberlite K14A target to illustrate inter-hole relationships and depositional environment. Datum is sea level. Detailed sedimentary core log interpretations are in Appendix 1.

possibly tectonized, with a fine network of millimetre to centimetre-scale calcite veins cutting both the sandstone and mudstone near the contact. Brecciation of the sandstone unit also occurs, both between and within the calcite vein fills. This lower sandstone is interpreted as upper tidal flat or upper shoreface succession, while the overlying mudstone is interpreted as a deep marine mudstone deposited below wave base.

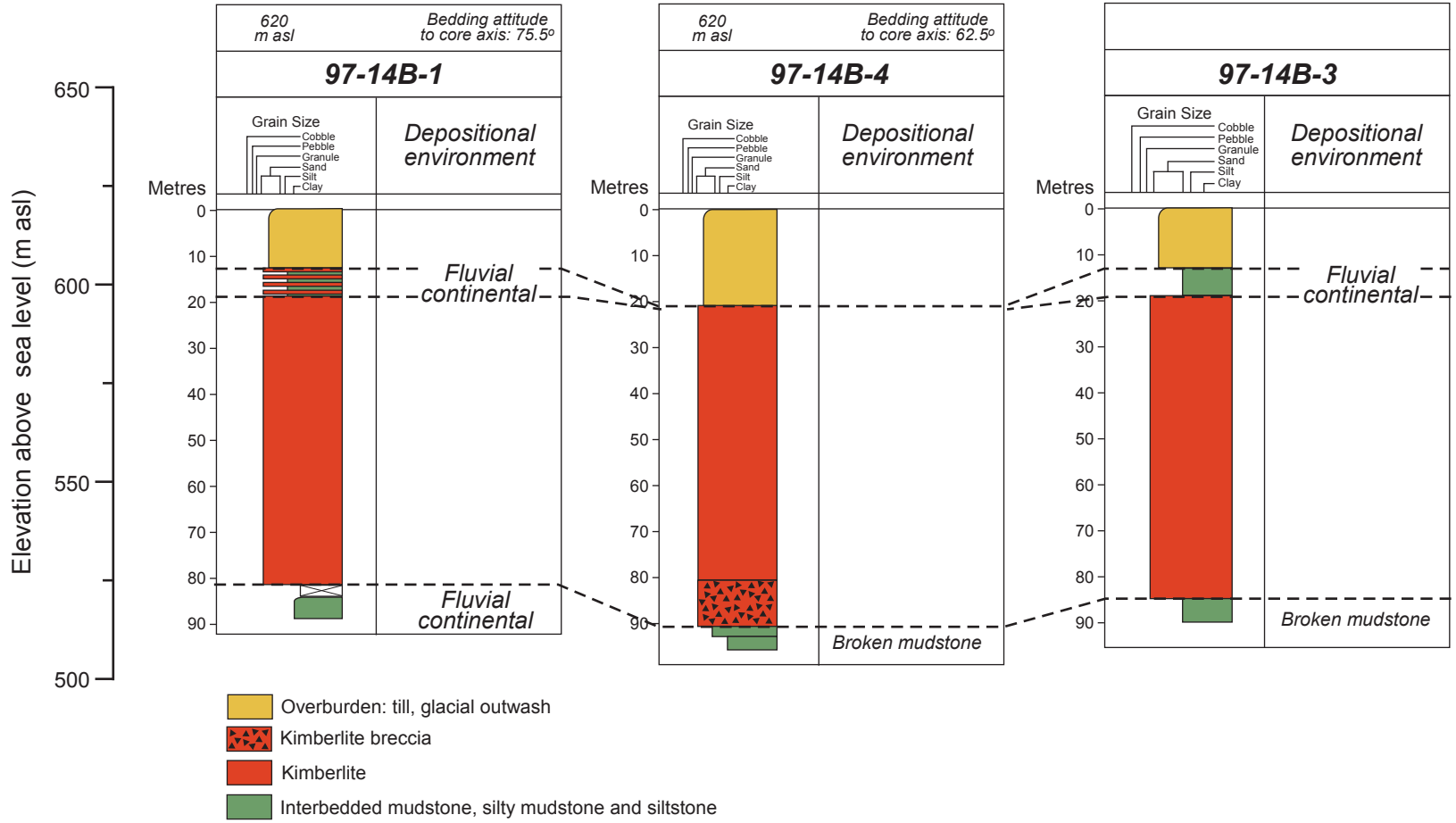

Figure 9. Simplified drillcore section for the kimberlite K14B target to illustrate inter-hole relationships and depositional environment. Datum is sea level. Detailed sedimentary core log interpretations are in Appendix 1.

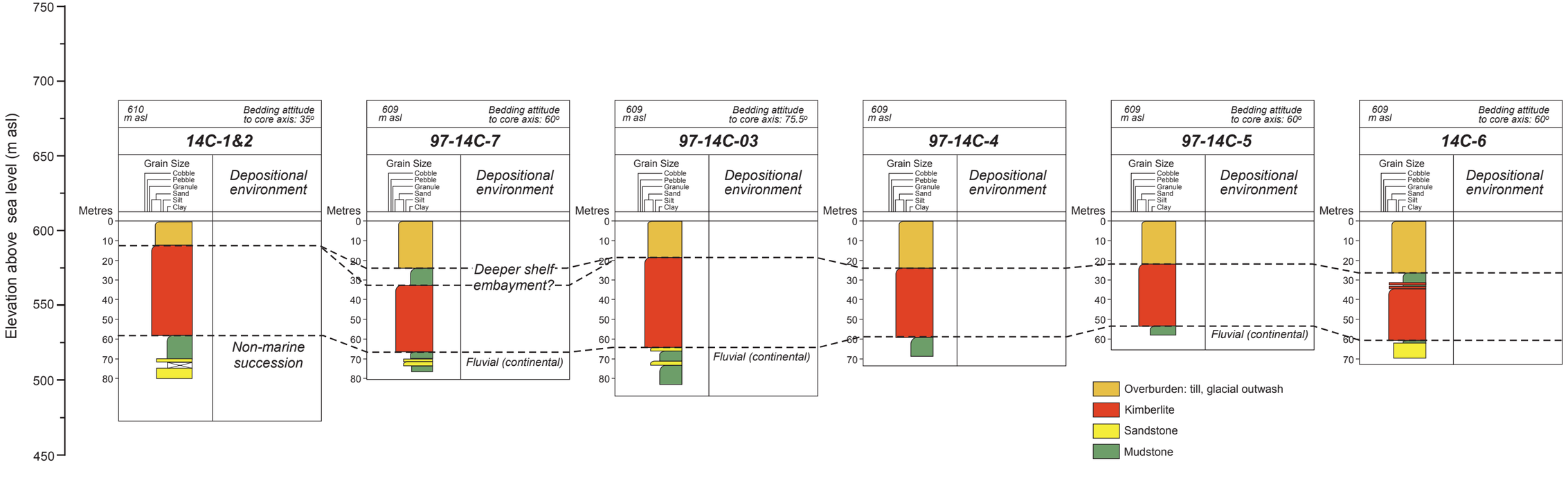

Figure 10. Simplified drillcore section for the kimberlite K14C target to illustrate inter-hole relationships and depositional environment. Datum is sea level. Detailed sedimentary core log interpretations are in Appendix 1.

4.6.2 K14B Kimberlite Target

Drillcore available for examination from the K14B kimberlite target included DDH97-14B-1, DDH97-14B-3 and DDH97-14B-4 (Figure 9; Appendix 1). All three drillholes penetrated a significant kimberlite zone and bottomed out in clastic sedimentary rocks. Palynological results from these cores directly below and above the kimberlite indicate a mid-Coniacian to Santonian age (~88-84 Ma; Eccles et al., in press b; Sweet et al., in prep.).

The DDH97-14B-1 drillcore consists of the following succession from top to base: till, interbedded kimberlite and mudstone, a thick interval of kimberlite, and finally, a dark, fractured, blocky mudstone with minor siltstone interlaminae. The mudstone at the base of the core lacks fissility and is mainly massive. There is a possible paleosol near the upper contact of the basal mudstone with the kimberlite. Notes from the Ashton drill logs indicate that the kimberlite within the upper mudstones consists of mainly broken fragments (mainly pebble size and angular), with some talc alteration. In the upper interbedded kimberlite and mudstone interval, the kimberlite is pale green-grey with some serpentization. The mudstone is largely fragmental with mudstone fragments pebble to cobble size, and locally, a kimberlitic clay matrix between the fragments. In the lower basal mudstone, some of the coarser interbeds show ripple and/or small-scale trough crossbedding, and a paleosol (marked by pedogenic mottling, local calcite cementation, and dispersed organic detritus) occurs near the upper contact with the overlying thick kimberlite zone. These features, along with the absence of bioturbation, indicate that the sediments associated with the kimberlite in this drillhole may be non-marine. Associated palynomorphs are non-marine.

The DDH97-14B-4 drillcore consists of thick till that overlies shale with kimberlite interbeds, in turn underlain by a thick massive kimberlite interval. The lower contact of the kimberlite is brecciated and disturbed, and overlies tectonized, broken mudstone (Figure 9). The drillcore from the lower mudstone in this drillhole is in poor condition and appears to be badly weathered and/or tectonically shattered. It consists of a medium to light grey, slightly fissile silty mudstone. Recovery varies from < 25% to nearly full recovery. Fissility increases toward the base. From the Ashton drill logs this interval was described as being a grey-brown, poorly consolidated unit with no apparent bedding. It is locally brecciated with angular mudstone/shale clasts set in a mud clay matrix, and the Ashton drill logs indicate that shale is broken, altered and permeated with bituminous oil layers. Due to its highly broken and weathered nature, it is difficult to tell whether the mudstone is marine or non-marine. No bioturbation was observed.

The portion of the DDH97-14B-3 drillcore available at the MCRF consists of a mainly massive mudstone with very little preservation of primary sedimentary structures (Figure 9).

4.6.3 K14C Kimberlite Target

K14C kimberlite drillcores available for this study included the following: DDH97-14C-01, DDH97-14C-02. DDH97-14C-03, DDH97-14C-04, DDH97-14C-05, DDH97-14C-06 and DDH97-14C-07 (Figure 10; Appendix 1). Ashton K14C kimberlite target drill logs show a uniform glacial till veneer. All drillholes penetrated kimberlite and ended in mudstone. Drillholes DDH97-14C-06 and DDH97-14C-07 penetrated mudstone both above and below the kimberlite. Palynological results on mudstone from DDH97-14C-1 through to 14C-6 (below kimberlite) and DDH97-14C-7 (above and below kimberlite) indicate an age of Cenomanian or Turonian (~96-92 Ma; Eccles et al., in press b; Sweet et al., in prep.). Additionally, the palynological work indicated an overwhelming dominance of terrestrially derived organic material with a Middle Cenomanian age (Dunvegan Formation-equivalent).

The clastic succession overlying the kimberlite in DDH97-14C-7 consists of grey to dark brown, fissile, platy shale with minor burrowing (*Planolites*). Associated sedimentary structures consist of delicate laminations, rare flaser ripples, complex grading patterns, small load and flame structures, which are interpreted as a possible deep marine (below wave base) environment. Most of the sandstone and mudstone underlying the kimberlite interval is interpreted as non-marine. In the DDH97-14C-3 drillcore, the sedimentary rock beneath the kimberlite is mainly a siltstone/silty mudstone with conchoidal fractures throughout. Coarser silty to sandy interbeds are trough crossbedded and consist of fine-grained micaceous quartz arenite. Pedogenic structures are in the cored interval, and the succession is interpreted as a fluvial succession with overbank deposits. In the DDH97-14C-5 drillcore, either glacial till or badly weathered kimberlite was mainly recovered. The basal part of the drillcore consists of badly weathered, bentonitic, silty shale, with ochre-colouration. It is noncalcareous, massive and—in the absence of any burrow structures or other primary sedimentary structures—may be part of the non-marine succession recovered in the DDH97-14C-7 drillcore. The clastic succession at the base of the DDH97-14C-7 drillcore consists of poorly consolidated, weathered, light grey lithic sand, which is badly weathered or altered with ochre colouration. Locally, in coarser interbeds with iron cementation, primary sedimentary structures are preserved, including: calcareous (and possibly bentonitic) rippled litharenite; shales with crossbedded sandstones lacking trace fossils; and, iron-stained, noncalcareous sandstone. This unit is interpreted as a possible non-marine succession. By contrast, the DDH97-14C-6 drillcore may be marine. Here, the succession underlying the kimberlite zone is hydrocarbon-stained, poorly consolidated sand that alternates with blocky silty shale. The sand is ochre-coloured, noncalcareous and iron stained. Small-scale trough crossbedding occurs with a few ill-defined burrows at the top of the sand interval.

4.7 Kimberlite Target K19 in Township 89, Range 12, W 5th Meridian

Only the bottom portion of the DDH97-19-1 drillcore was available at the MCRF for examination. This drillcore was drilled from an elevation of 735 m asl and penetrated approximately 5 m of glacial till, reaching a total depth of 133.19 m (Table 1). Since the drillcore boxes and core from this drillhole were badly weathered and damaged, it was difficult to positively identify box numbers. It is important to note, therefore, that we present sedimentary rock information below using a best guess at the order and depth of the core. Sections from wireline logs for surrounding oil and gas wells in the area indicate that the stratigraphic interval intersected by this drillcore falls within the cased interval (Chen and Olson, 2005). No palynological data are available.

The DDH97-19-01 drillcore is badly weathered (or altered) and consists of a light-grey siltstone with about 20% of interbedded sandstones. The sandstone is iron-stained and badly weathered with an ochre colouration and minor sulphide mineralization. Minor brecciation of the sandstones occurs with pyrite mineralization along fracture surfaces. Just below the upper contact with the overlying kimberlite zone (0.3 m below the top of the clastic unit), the sediment is a bentonitic silty shale. Overall, the silty mudstone within this drillcore is blocky weathered, with only a slight increase in fissility at depth. Although there is nothing definitive in drillcore for the paleoenvironmental interpretation, the notable absence of burrowing, along with the massive, blocky character, and lack of fissility, are suggestive of a non-marine succession.

A section for the drillcore in the K19 target area is presented in Figure 11. A thin glacial till occurs at the top of all drillcores. In drillcore DDH97-19-2, the till contains kimberlite, granite and quartzite clasts. Underlying kimberlite zones vary in character. In the DDH97-19-1 drillcore, the kimberlite is mainly massive, whereas in the other drillcores it shows a variable amount of bedding and/or interbedding with associated sediment (Skelton and Bursey, 1998). The DDH97-19-2 drillcore has some bedding in the kimberlite zone, which abruptly overlies sandstone with convoluted bedding and an underlying mixed

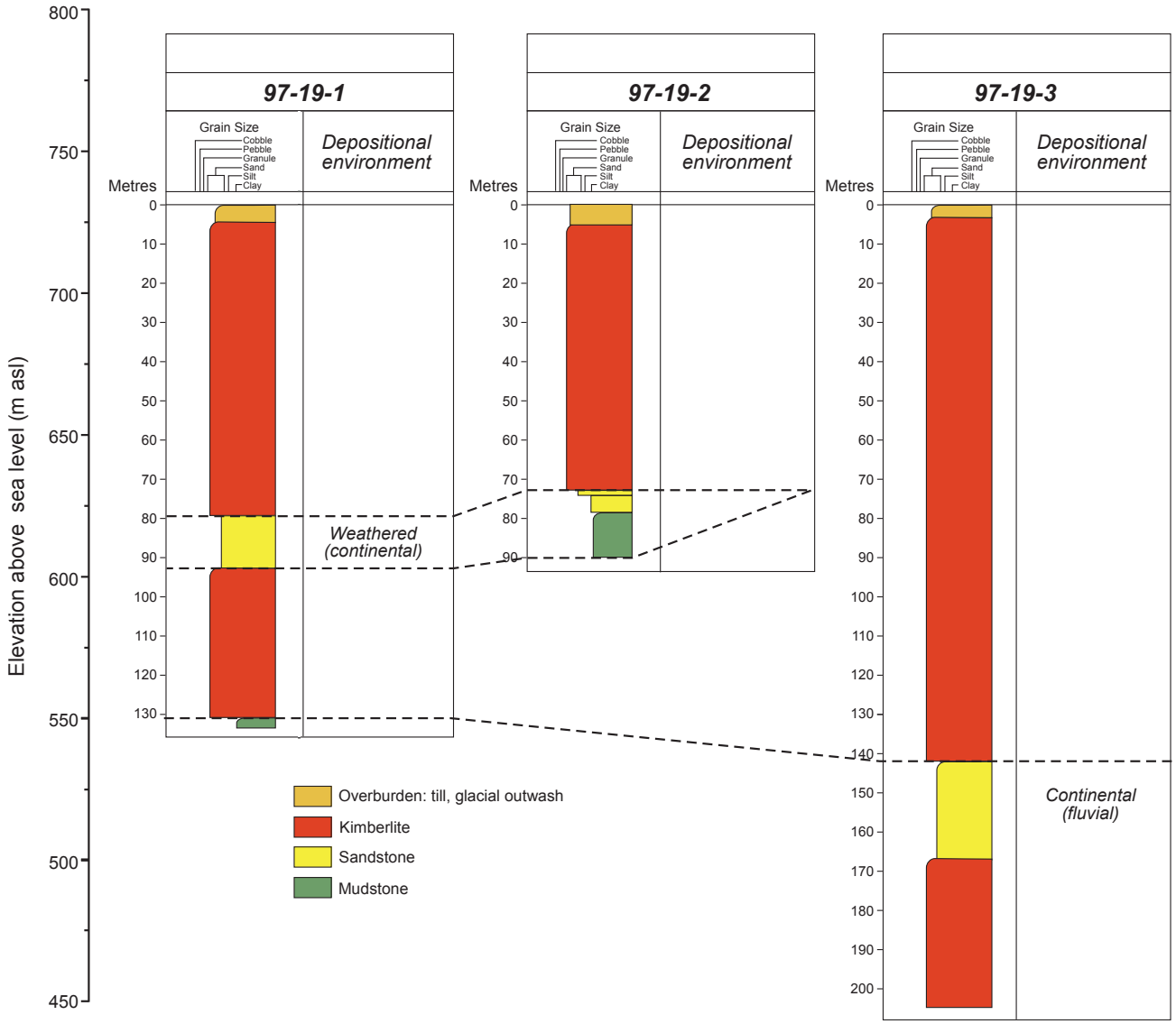

Figure 11. Simplified drillcore section for the kimberlite K19 target to illustrate inter-hole relationships and depositional environment. Datum is sea level. Detailed sedimentary core log interpretations are in Appendix 1.

mudstone/kimberlite horizon. The convoluted sandstone contains wood fragments. In the DDH97-19-3 drillcore, the kimberlite is interbedded with sandstone and mudstone, locally contains wood fragments, and is thickly bedded and mud-rich toward the base. As with the observed DDH97-19-01 drillcore from this target area, it is difficult to make an environmental interpretation of the sediment into which the kimberlite was emplaced, but the features noted in the Ashton drill logs are consistent with a continental (fluvial) interpretation.

4.8 Kimberlite Target K91 in Township 92, Range 11, W 5th Meridian

Only the bottom portion of DDH91B-1 drillcore was available for examination. This drillcore, which did not intersect kimberlite, was drilled from an elevation of 667 m asl, with a total depth of 89.24 m; over half of the drillcore consists of glacial till and outwash sediment (45.97 m; Table 1).

No palynological data are available. Depth comparisons to sections from wireline logs for surrounding oil and gas wells in the area (Figure 6) indicate that the stratigraphic interval intersected by this drillcore falls within the Shaftesbury Formation (Chen and Olson, 2005), however, the sedimentological features do not correspond to the Shaftesbury Formation. The DDH91-B1 drillcore from the upper part of the sedimentary succession at the base of the core consists of a well-laminated mudstone succession, with minor sandstone beds that increase in abundance toward the base of the mudstone. Although the mudstone is mainly structureless, locally there are some graded-laminations with complex patterns, and local root structures, which may be indicative of a tidal flat environment (Figure 12). The sandstones at the base of the drillcore have a gradational, fining-upward contact with the overlying mudstone succession. Internally, the sandstone is well-laminated with tidal (complexly graded) fine laminations. The sandstones are interpreted as possible sandy tidal flat and/or tidal channel deposits. It is likely that the mudstone and associated sandstone belong to the Cenomanian Dunvegan Formation. This indicates that the cored interval is younger than the correlation with wireline logs might indicate (similar to the DDH97-5A-10 core).

Notes from the Ashton drill logs demonstrate that the glacial till blankets the nearby DDH91-01 and DDH91-03 drillcores, although the till encountered in these drillcores is about one-third the thickness of that observed in the DDH91B-1 drillcore. The kimberlite zone becomes appreciably more massive with a decrease in the interbedded kimberlite/clastics zones from DDH91-01 to DDH91-03. Interestingly, the Ashton drill logs indicate that within the kimberlite zone oil accumulation stains olivine to an uncharacteristic brownish-black colour. The underlying clastic succession in both the DDH91-01 and DDH91-03 drillcores is a grey to black, silty mudstone.

4.9 Kimberlite Target BH302-01 in Township 92, Range 7, W 5th Meridian

The drill testing of target BH302-01 by Ashton in Township 92, Range 7, W 5th Meridian did not intersect kimberlite, but enabled this study to observe a thick clastic interval lower in the Cretaceous succession than those seen in other drillcores examined in the present study. There are two separately labelled cores from this drillhole: one, the initial BH302-01 and two, BH301-01, which was drilled as a re-entry of the BH302-01 (Figure 13; Appendix 1). These drillholes were collared at an elevation of 490 m asl and intersected at a total depth of 168.9 m. General correlations to the west and to the south of the regional cross-section of Chen and Olson (2005; A-A' section) indicate that the sandstone intersected at the top of the BHH 302-01 drillcore could be Notikewin Member (Spirit River Formation) or Paddy and Cadotte Members (Peace River Formation; Figure 2).

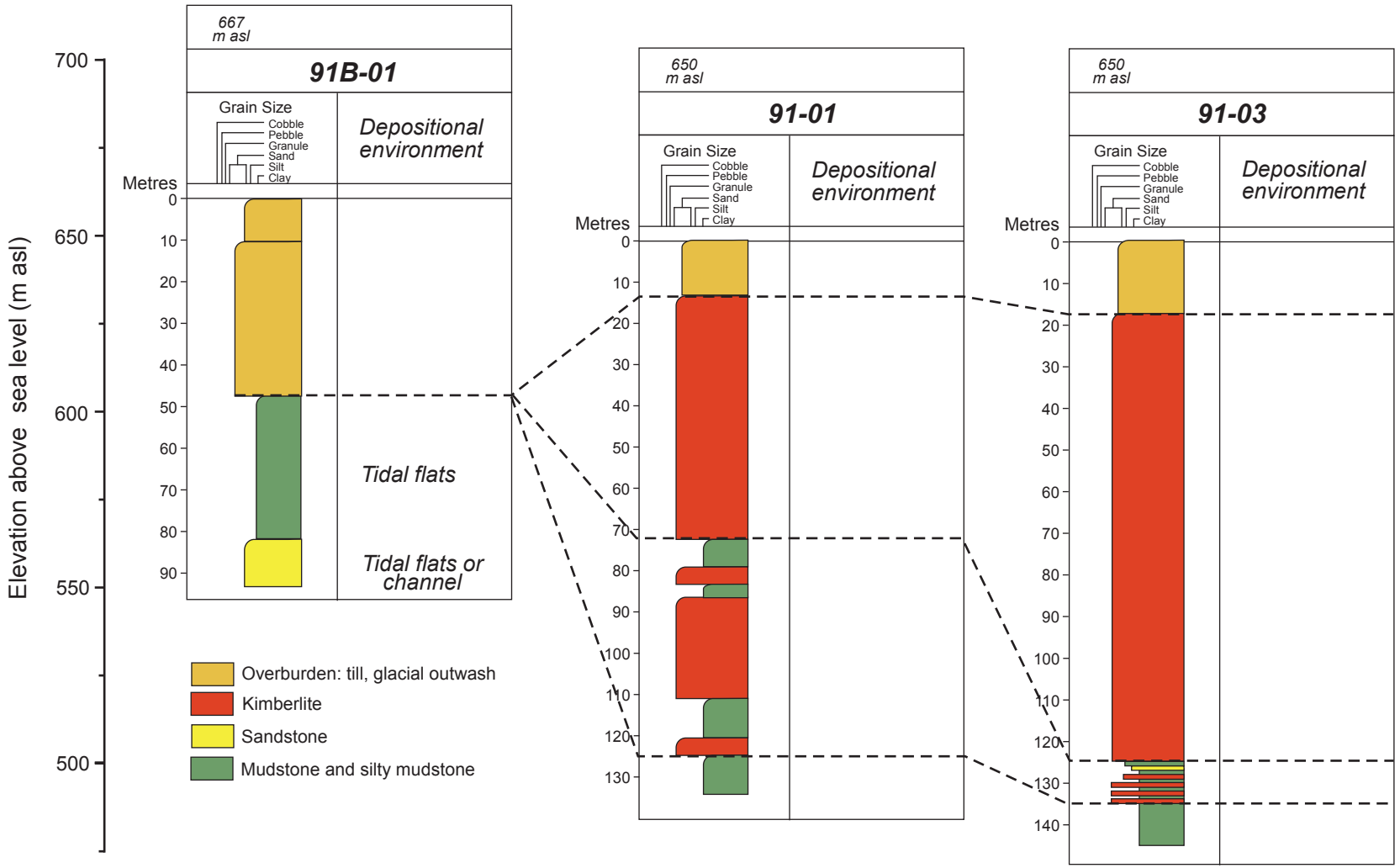

Figure 12. Simplified drillcore section for the kimberlite K91 target to illustrate inter-hole relationships and depositional environment. Datum is sea level. Detailed sedimentary core log interpretations are in Appendix 1.

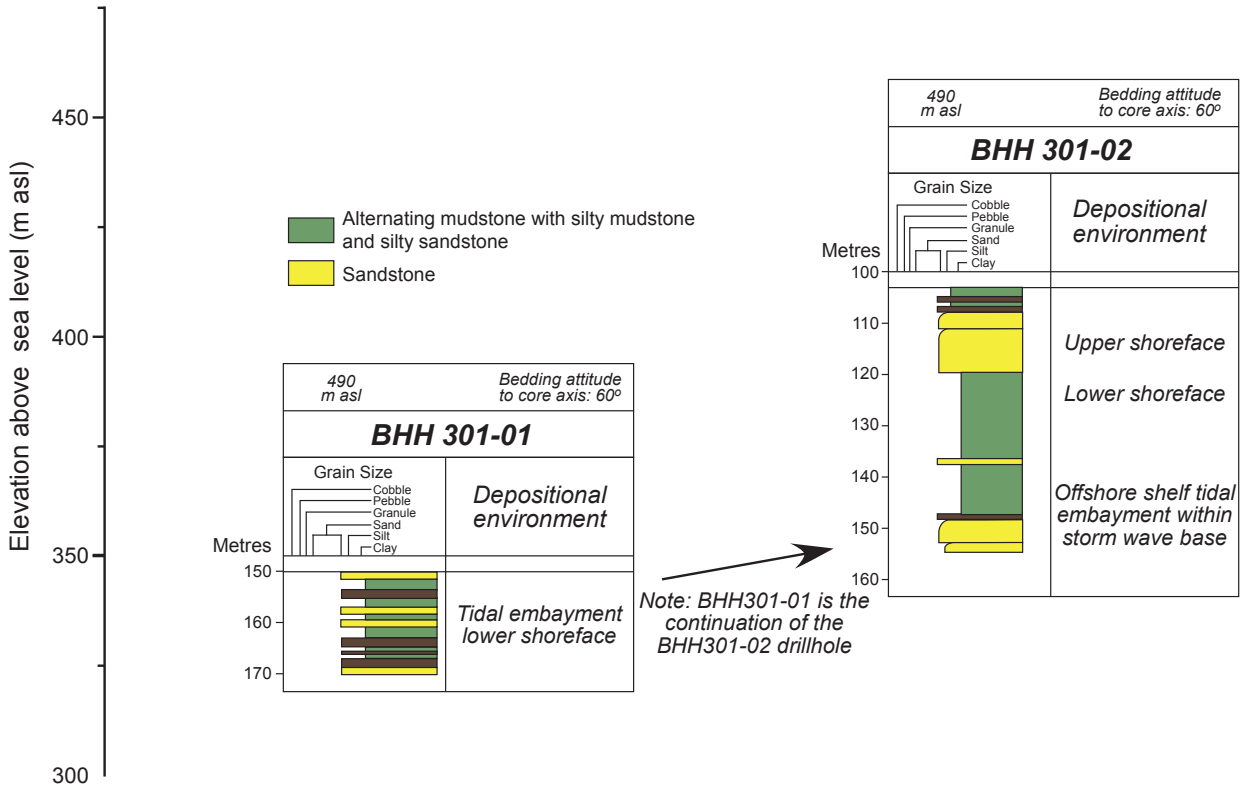

Figure 13. Simplified drillcore section for the kimberlite BHH301 target to illustrate depositional environment. Datum is sea level. Detailed sedimentary core log interpretations are in Appendix 1.

The BH302-02 drillcore intersected offshore tidal shelf deposits that grade up into a sand-dominated succession of more quartz-rich, lower and upper shoreface sands, which are separated by a disconformity. Locally, the topmost upper shoreface sandstones contain concretions. The top sands are also heavily oil-stained and bituminous, and grade up into a burrowed sandy shale and organic shale succession. These sandstones likely represent the Cadotte and Paddy Members of the Peace River Formation, which are separated by an unconformity.

The BH301-01 drillcore intersected the lower part of the stratigraphic succession, which consisted of a heavily bioturbated, lower shoreface succession of alternating sandstone and mudstone (Figure 13). The sandstones are quartz-litharenites, which locally show hydrocarbon staining. Primary sedimentary structures include flaser crossbedded, graded laminations, and tidal couplets in the laminated sandy mudstones, which alternates with more fissile and organic shale, with minor parallel lamination and bioturbation. This lower part of the cored interval is interpreted as offshore tidal embayment deposits. Upsection, in the coarser sand interbeds, are small hummocky and swaley cross-stratification, suggesting deposition above storm wave base.

4.10 Stratigraphic Well BHH04-KHR-2 in Township 90, Range 11, W 5th Meridian

This drillhole was drilled collaboratively by the GSC and AGS with the aim of intersecting the uppermost Late Cretaceous sedimentary rocks in the Buffalo Head Hills area. The drillhole was collared in Township 90, Range 11, W 5th Meridian at an elevation of 777 m asl and penetrated to a depth of 105 m (Figure 14; Appendix 1).

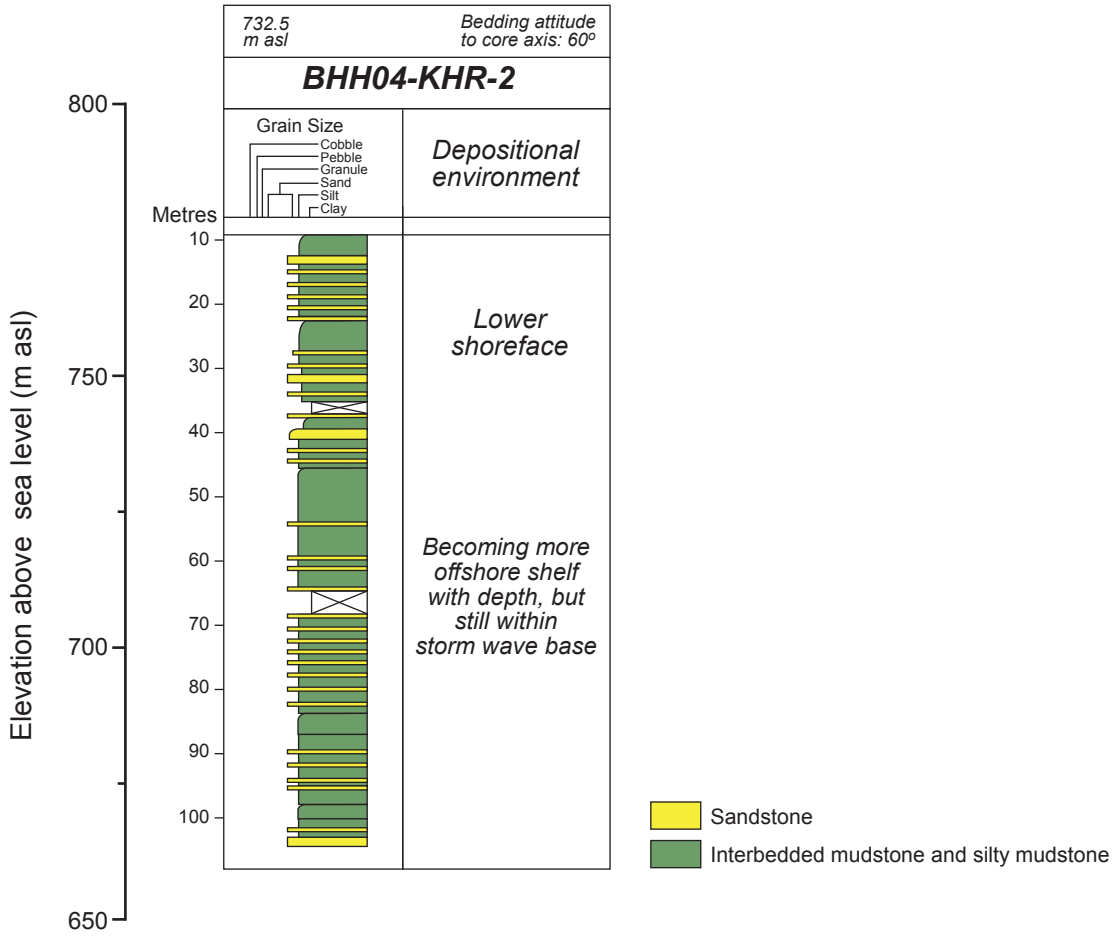

Figure 14. Simplified drillcore section for stratigraphic well BHH04-KHR-2 to illustrate depositional environment. Datum is sea level. Detailed sedimentary core log interpretations are in Appendix 1.

Comparisons with nearby oil and gas wells, and the regional cross-section of Chen and Olson (2005; A-A' section) indicate that the stratigraphic interval intersected in this drillcore most likely belongs to the Puskwaskau Formation of the upper Smoky Group. Palynological interpretations by Sweet et al. (in prep.) indicate an abrupt change from Campanian to Santonian assemblages within the mudstone succession (contact at an approximate core depth of 82 m) correlative to Wapiti Group and Puskwaskau Formation, respectively.

The drillcore is mainly massive mudstone, with variable proportions of interbedded siltstone and sandstone. The drillcore is unslabbed and it is therefore difficult to discern sedimentary structures. Overall, it appears that the BHH04-KHR-2 drillcore intersected a heavily bioturbated, lower shoreface sandy-silty mudstone. The depositional environment is interpreted as lower shoreface, offshore shelf, becoming more distal with depth. At the base of the drillcore is a slightly coarser sandy interval, which is separated from the overlying succession by a disconformity or unconformity. Due to the depth of the core intersection and wireline log correlations to surrounding oil and gas wells, the sandstone at the base of the core is too deep to belong to either the Cardium or Dunvegan formations. This coarser sandy unit may represent the older Paddy-Cadotte (Albian) succession. If this is correct, then a major unconformity (perhaps associated with faulting and uplift) separates the lower coarser sandstone (Albian) unit at the

base from the overlying Santonian mudstone succession. This would mean that the total succession from late Albian to late Turonian is missing. This hypothesis has yet to be validated by palynology.

5 Stratigraphic Summary for the Different Kimberlite Targets

The youngest sedimentary rocks identified in the area are Campanian and time-equivalent to the Wapiti Group (BHH04-KHR-2). Cores from the K1A kimberlite target are second youngest, and helped Sweet et al. (in prep.) define a major depositional hiatus between the Santonian-Campanian mudstone (Puskwaskau Formation, DDH97-1A-3) and the Cenomanian-Turonian mudstone (Kaskapau Formation, DDH97-1A-1). The K5, K14A, K14B, K14C and K91 kimberlites all appear to be hosted within Cenomanian strata, which are time equivalent to the Smoky Group and Dunvegan Formation. The lowest stratigraphically emplaced kimberlites belong to the K6 occurrence and appear to be hosted primarily within Cenomanian strata, which are time equivalent to the Shaftesbury Formation. The oldest sedimentary rocks documented were from the BH302-01 drillhole, which did not intersect kimberlite; these rocks are Albian in age and time equivalent to the Shaftesbury to Joli Fou formations.

Sedimentological interpretation of the selected cores suggest the paleoenvironments in the uppermost Cretaceous strata of the Buffalo Head Hills ranged from lower shoreface below wave base to tidal flat/channel to fluvial. Based on radiometric emplacement ages (Eccles et al., in press a) and palynological ages (Sweet et al., in prep.) of kimberlite and mudstone in the Buffalo Head Hills kimberlite field, respectively, it is possible that the latter two environments were predominant during emplacement of the majority of the kimberlite in the Buffalo Head Hills. This model would imply kimberlite emplacement during a major Coniacian depositional hiatus.

Variability in apparent thickness of kimberlite between drillcores (e.g., K6, K14), and the presence of intercalated sandstone and mudstone-dominated successions either below, above or adjacent to the main kimberlite body (e.g., K14A, K14B, K14C and K91) suggest the possibility of mixing between the kimberlite and adjacent sedimentary rocks. Pervasive fracturing and the development of carbonate-veinlet networks (e.g., K1A, K5A and K6) suggest disturbance and/or shattering of both the mudstone and overlying kimberlite, perhaps during emplacement of the kimberlite.

6 General Observations and Directions for Future Work

- Sedimentological interpretation of the selected cores examined in the present study suggest the paleoenvironments in the uppermost Cretaceous strata of the Buffalo Head Hills ranged from lower shoreface below wave base to tidal flat/channel to fluvial, with the tidal flat/channel and fluvial environments possibly being predominant during emplacement of the Buffalo Head Hills kimberlite. Continued work on the sedimentological depositional setting into which the kimberlite and associated bentonites were emplaced should be done to further understand the mechanisms of kimberlite emplacement in this setting.

- The lithologic, depositional environment and stratigraphic interpretations presented here should be integrated with ongoing palynological work on the same cores by Art Sweet, GSC-Calgary. At the time of writing, there was no opportunity to integrate these results; however, a cursory overview of the general conclusions of the palynological study (Sweet et al., in prep.; A. Sweet, pers. comm., 2006) is consistent with the interpretations presented in this report.

- Stratigraphic and palynological interpretations presented in both this study and Sweet et al. (in prep.) paradoxically support and contradict the radiogenic ages of Eccles et al. (in press a) that suggest two distinct ages of kimberlite emplacement: ~88-81 Ma and ~64-60 Ma. Although there is sedimentological evidence to support the two separate episodes of volcanic activity, there is also a possibility that younger volcanic rocks penetrated older sedimentary rock layers. Thus, detailed work is required to either determine whether there are older ages of kimberlite emplacement not yet determined, or to investigate the possibility of younger kimberlite 'injected' into older sedimentary strata.

- Ultimately, the stratigraphic and structural models should be integrated to completely understand the emplacement history of the Buffalo Head Hills kimberlite field.

- There is significant evidence of hydrocarbon staining within the kimberlite and the associated host rock sediments. From this preliminary work, it is unclear whether the hydrocarbons were emplaced prior to the igneous activity, or if they represent a later-stage migration into the fracture network developed during kimberlite emplacement. In some cases, such as the bituminous coating on kimberlitic olivine, hydrocarbon migration is clearly post-kimberlite. In other cases, the hydrocarbons may be pre-kimberlite, as in the hydrocarbon staining observed in the deeper stratigraphic wells not directly associated with the kimberlites. It is possible future geochemical and vitrinite reflectance studies on the bitumen will help understand the temperatures during emplacement and post-emplacement of the kimberlites, the quenching-history and collapse infill of the volcanic complex, and the influence of the kimberlite emplacement on hydrocarbons in the area.

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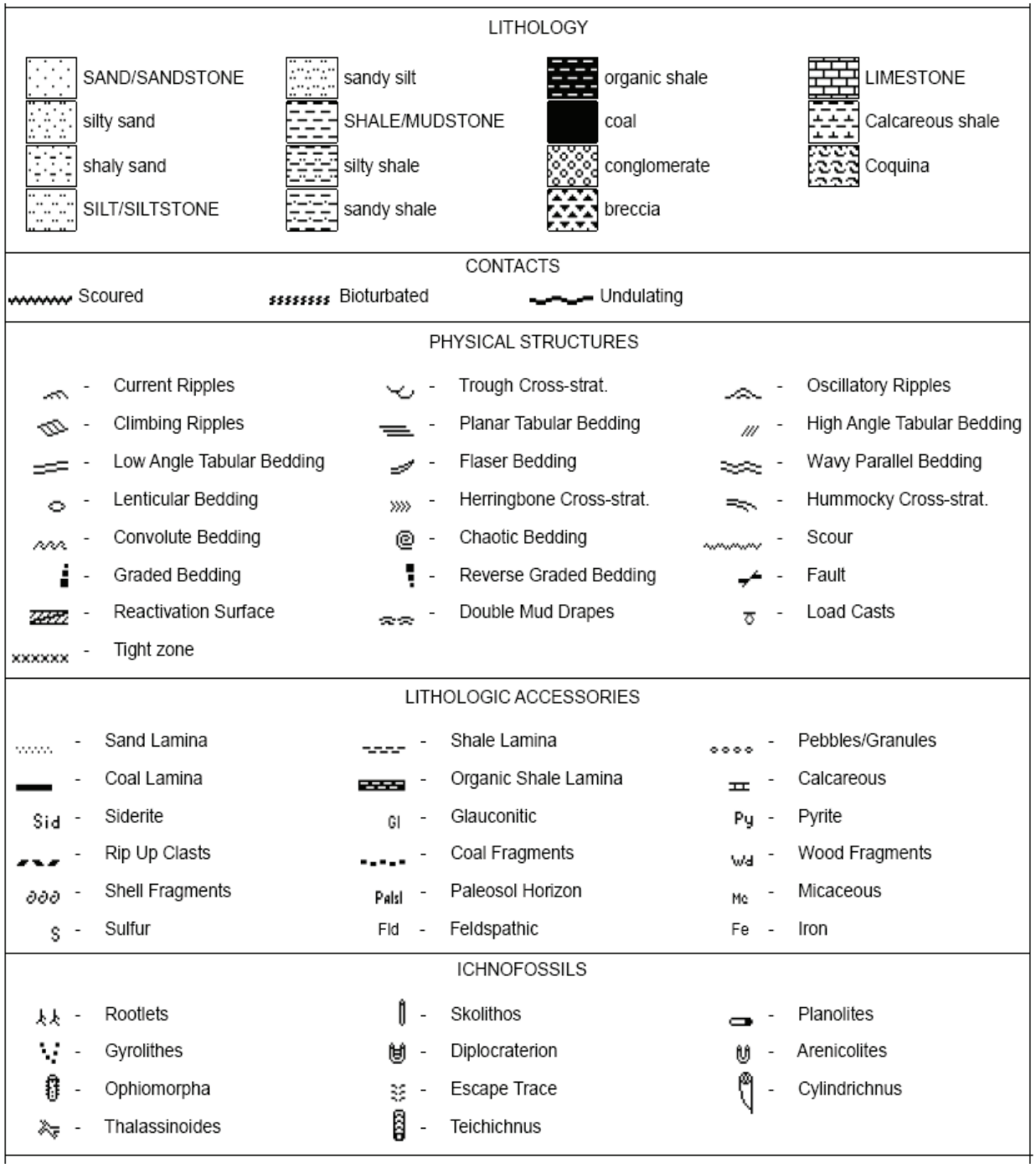
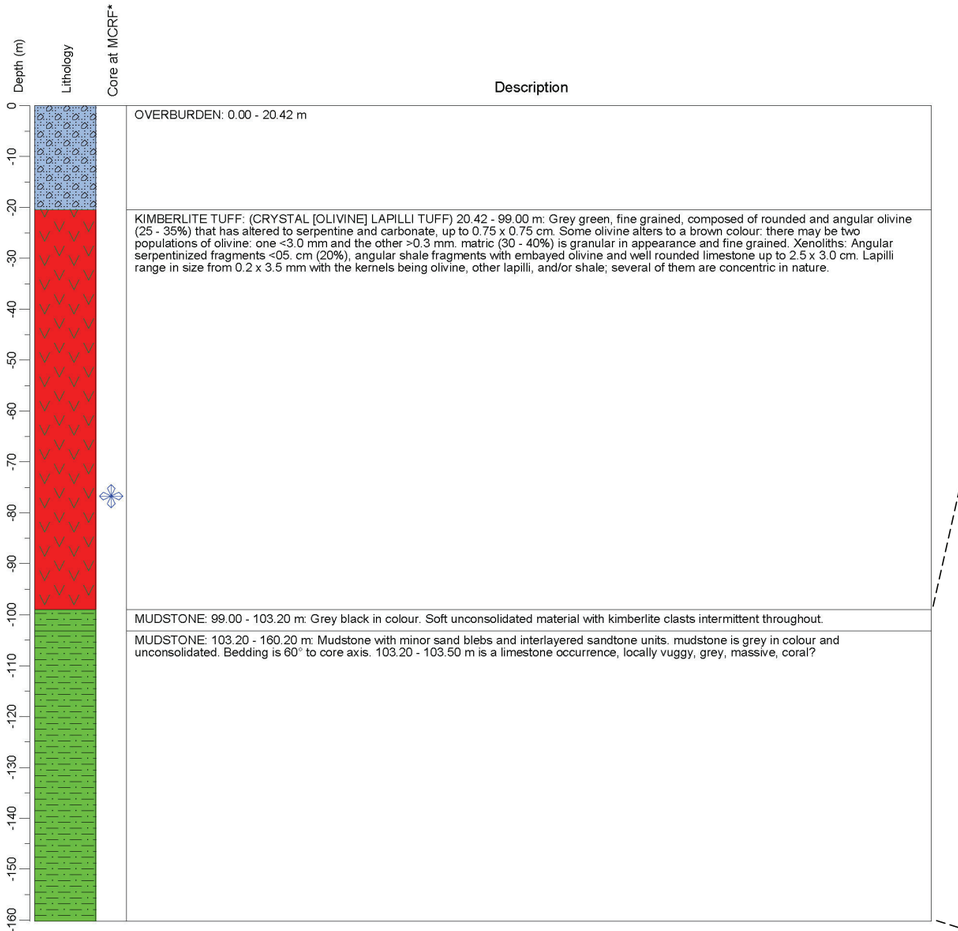
Appendix 1. Original Kimberlite Target Drill Logs from Skelton and Bursey (1998, 1999) with Detailed Sedimentary Logs from this Study.

Graphic Key and Legend

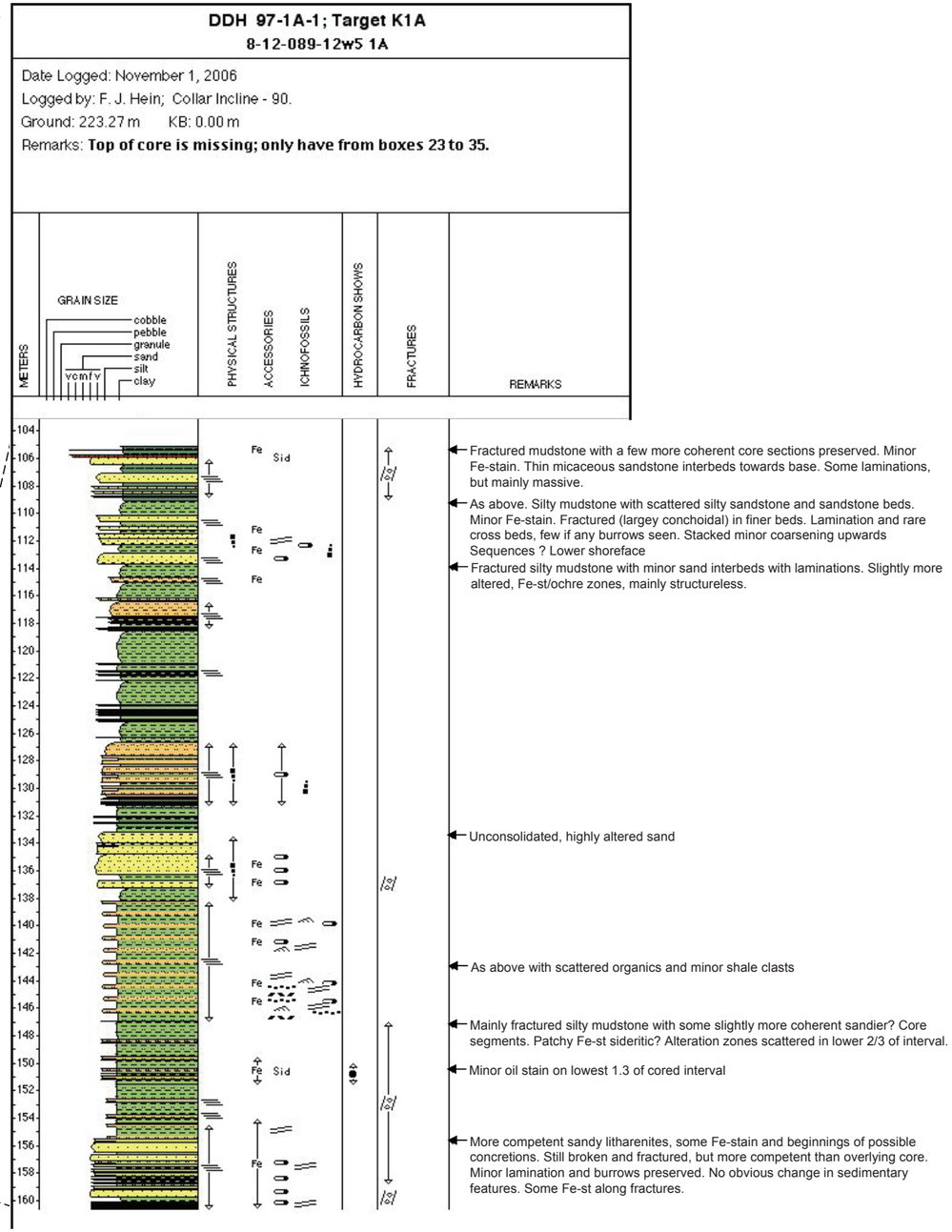


A)

Target:	**K1A**	**Company:**	**Ashton Mining Canada Inc.**
Drill Hole:	1A-1	Collar Azimuth:	N/A °
Location:	569562E , 6284752N	Collar Incline:	-90 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	63.5 mm (HQ)
Elevation:	732.50 m above sea level (asl)	Geologist Logging:	Derrick Strickland
Start - End Date:	07/5/1997 - 07/7/1997	End of hole (EOH):	160.20 m



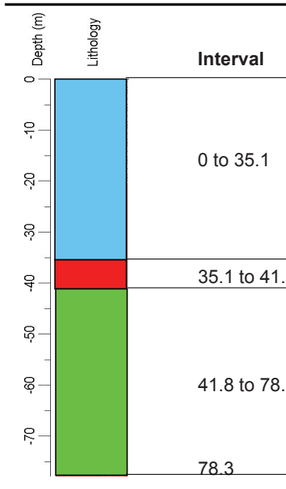
B)



Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-1A-1: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	K1A	Company:	Ashton Mining of Canada Inc.
Drill hole:	1A-03	Collar Azimuth:	N/A
Location:	569563E, 6284751N	Collar Incline:	-58
Zone & Datum:	Z11, NAD 27	Core Diameter:	63.5 mm (HQ)
Elevation:	733 m above sea level (asl)	Geologist Logging:	D. Strickland
Start-End Date:	12/7/1997-14/7/1997	End of hole (EOH):	78.3 m



Interval	Rock Type	Description
0 to 35.1	OB	Overburden
35.1 to 41.8	MAVK	Macrocrystic volcaniclastic kimberlite
41.8 to 78.3	MUDST	Mudstone
78.3	EOH (m)	

B)

DDH97-1-A3 Buffalo Hills

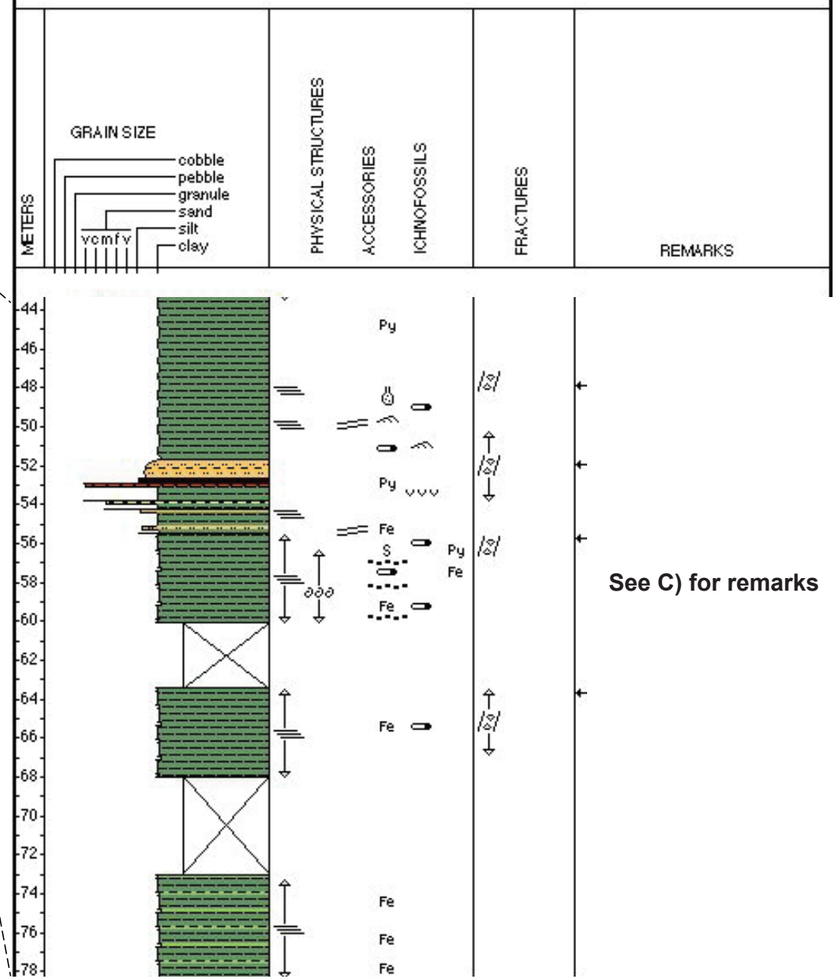
8-8-089-12w5 A3

Date Logged: November, 2006

Logged by: F. J. Hein; Collar Az180, Collar Incline -58.00

Ground: 732.53 m KB: 0.00 m

Remarks: **Boxes 1, 2, 7 and 9 are missing.**



See C) for remarks

C) Sedimentary core remarks

41.95 m
Laminated gray mudstone, with minor burrowing and Fe-stain alteration rims around burrows. Aside from laminations few sedimentary structures apparent. Well laminated mudstone alternates with more fractured, pyritic, yellow-ochre altered fractured mudstone. Minor dispersed organic detritus.

47.79 m
As above, slightly less brecciated, Fe-st bioturbated Glossifungites ? at 48.35 m depth; ? unconformity/disconformity surface.

51.89 m
Heavily broken, and fractured silty shale, with minor more coherent core sections. Prominent alteration, both within a highly fissile, black organic shale, at the top and base of the organic zone. Apparently subsampled previously. Bright ochre - yellow alteration colour.

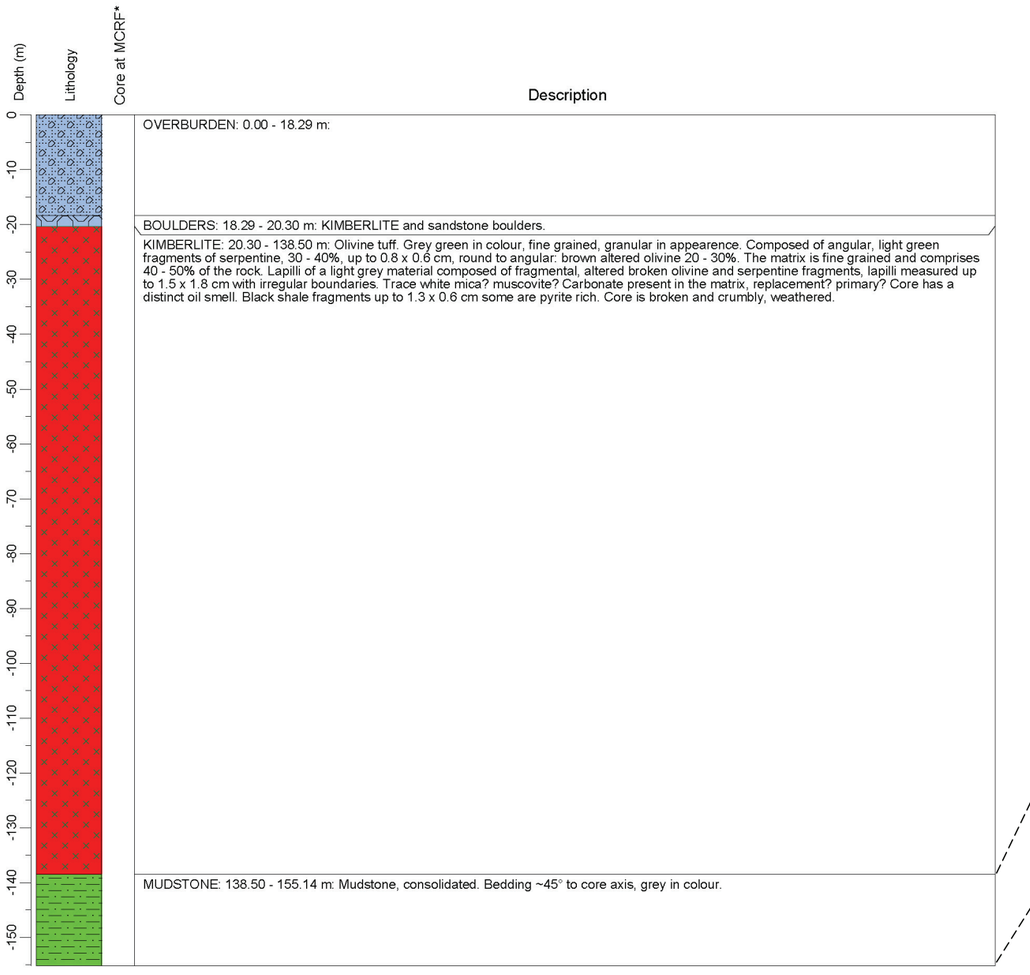
55.67 m
Light gray mudstone, laminated, with burrows, and Fe-st alteration; minor altered zone, after pyrite or other sulphides ?. Minor ripples and lamination, some burrows, more competence to the core section compared with overlying core. Fairly structureless, minor disseminated scattered shell fragments. Ammonite at 59.5 m depth.

63.62 m
Light gray mudstone, laminated, with alternations to more broken core sections. Few apparent structures or burrows.

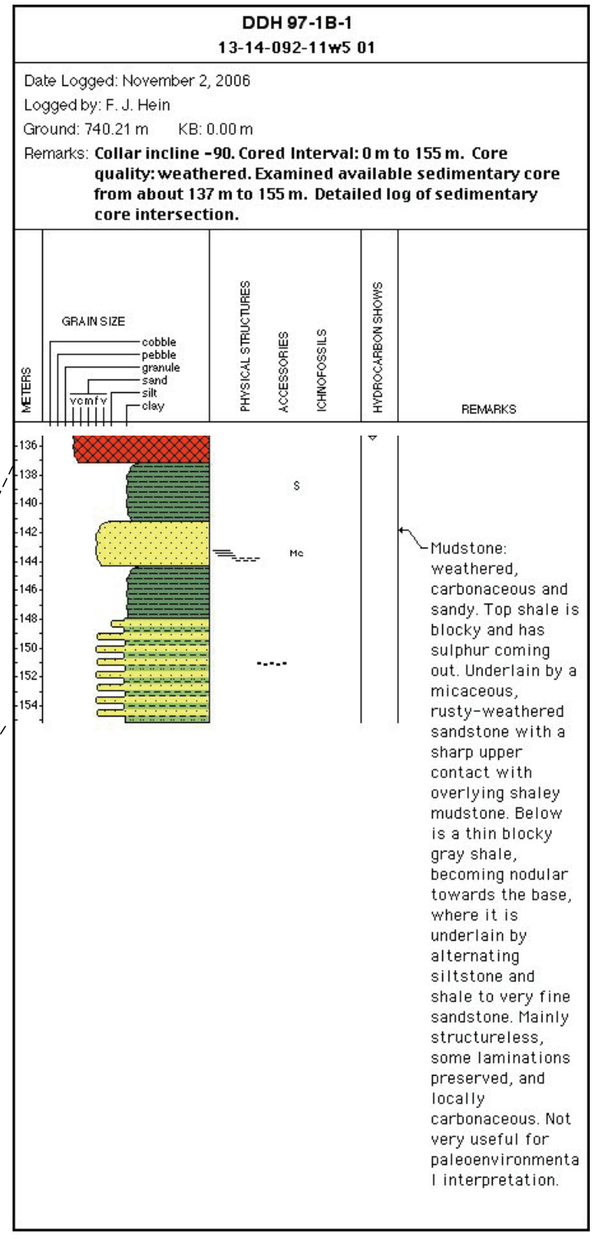
Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-1A-03: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study; C) drill log remarks.

A)

Target:	**K1B**	**Company:**	**Ashton Mining Canada Inc.**
Drill Hole:	1B-1	Collar Azimuth:	N/A °
Location:	568989E , 6284585N	Collar Incline:	-90 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	63.5 mm (HQ)
Elevation:	740.21 m asl	Geologist Logging:	Derrick Strickland
Start - End Date:	07/07/1997 - 11/07/1997	End of hole (EOH):	155.14 m



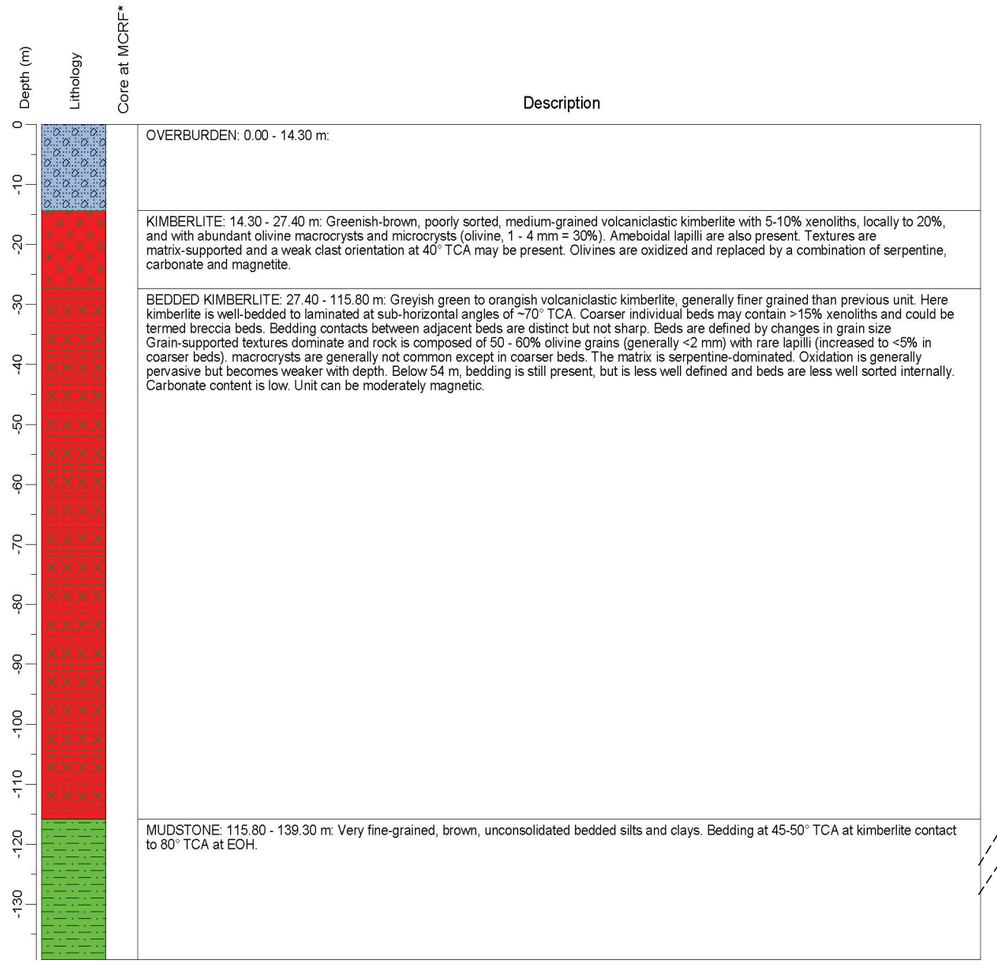
B)



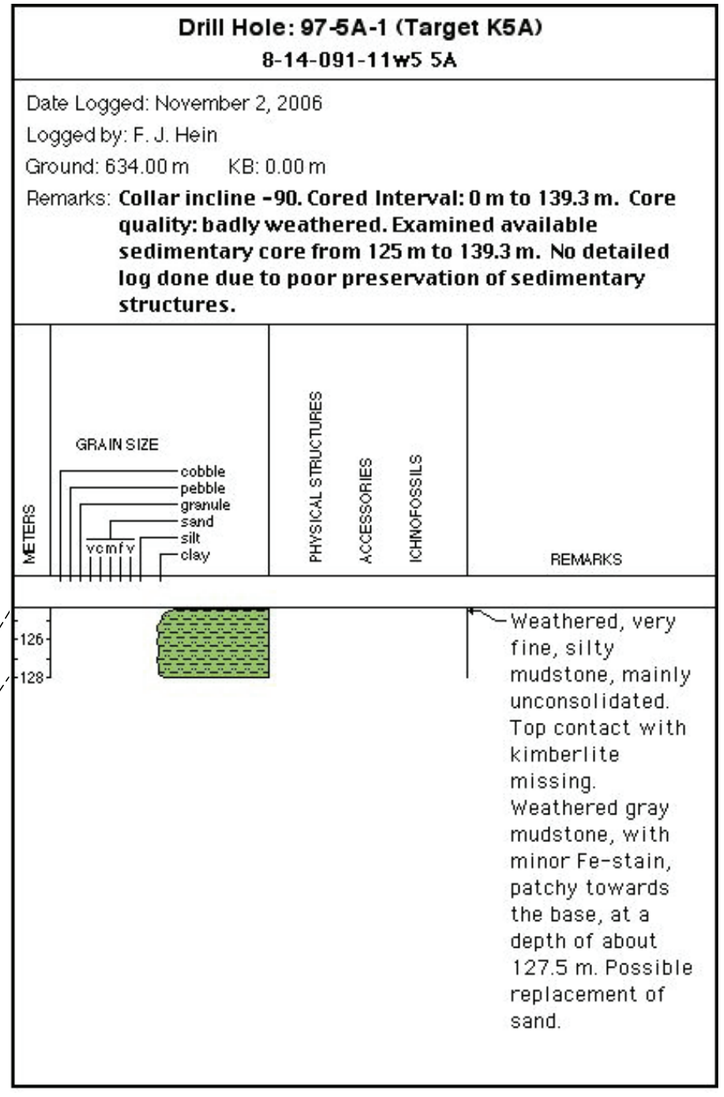
Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-1B-01: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	**K5A**	**Company:**	**Ashton Mining Canada Inc.**
Drill Hole:	5A-1	Collar Azimuth:	N/a °
Location:	582687E , 6306035N	Collar Incline:	-90 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	47.6 mm (NQ)
Elevation:	634 m asl	Geologist Logging:	A. Berry, BSS, mm
Start - End Date:	04/02/1997 - 06/02/1997	End of hole (EOH):	139.30 m



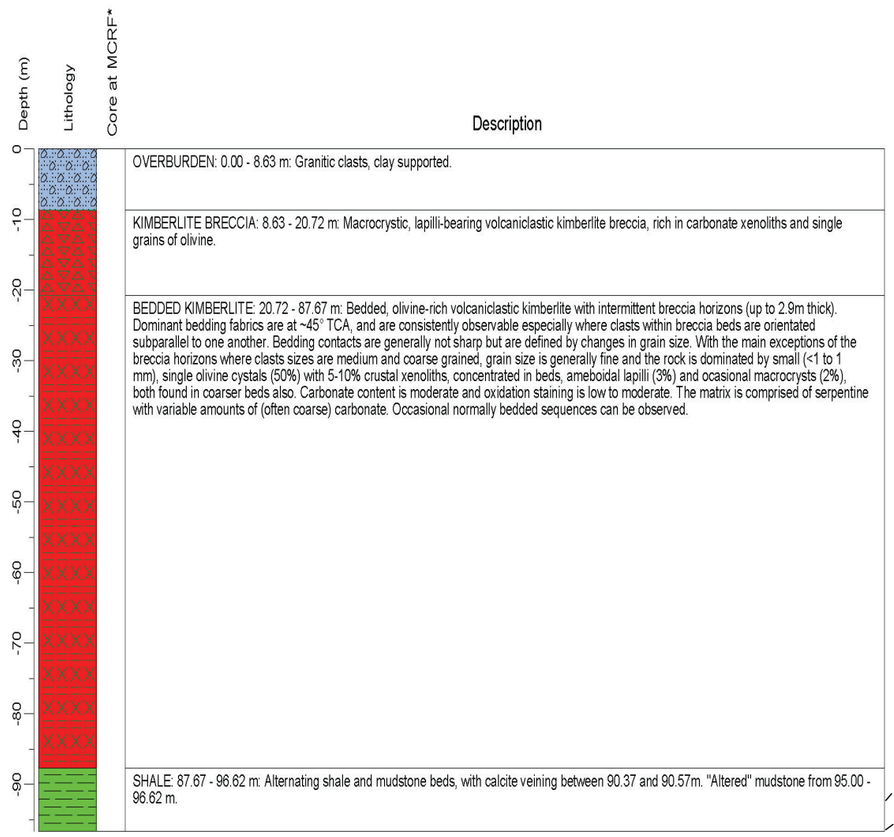
B)



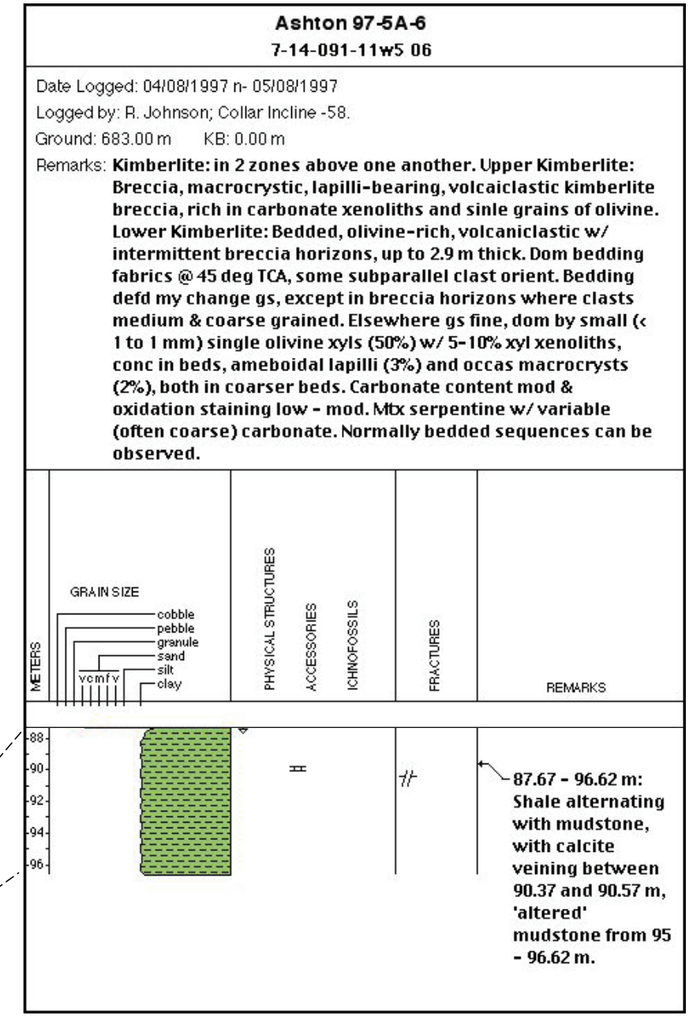
Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-5A-01: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	**K5A**	**Company:**	**Ashton Mining Canada Inc.**
Drill Hole:	5A-6	Collar Azimuth:	090 °
Location:	582334E , 6306058N	Collar Incline:	-58 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	63.5 mm (HQ)
Elevation:	683 m asl	Geologist Logging:	R. Johnson, MM
Start - End Date:	04/08/1997 - 05/08/1997	End of hole (EOH):	96.62 m



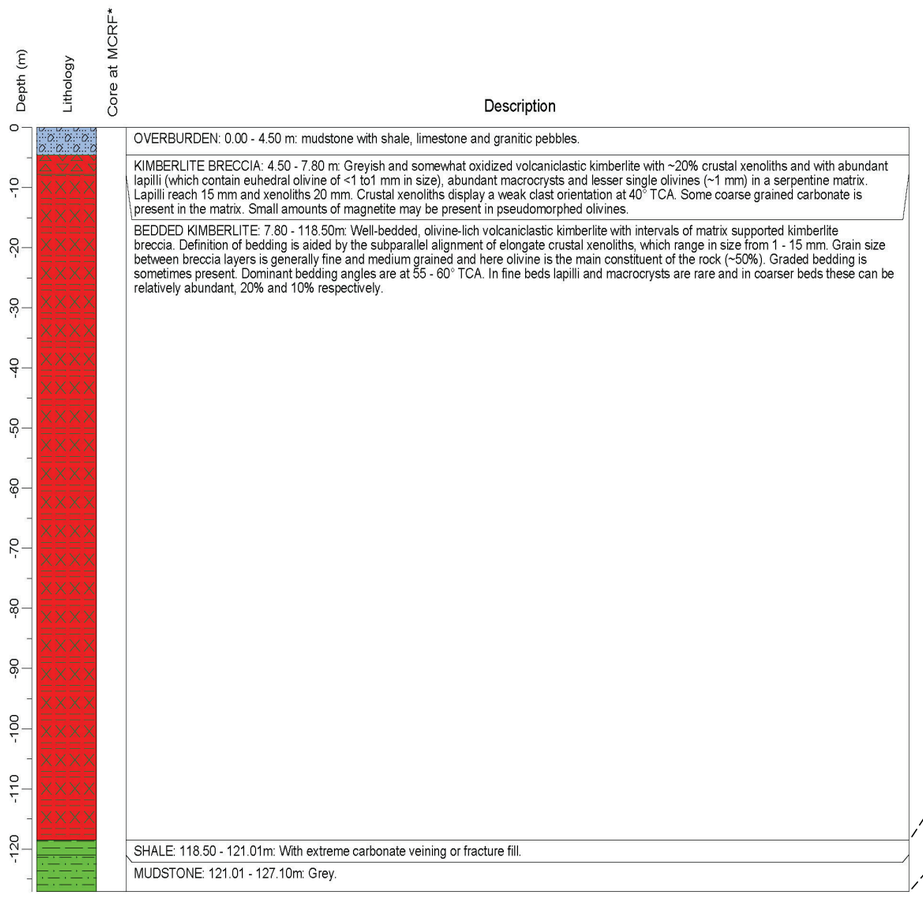
B)



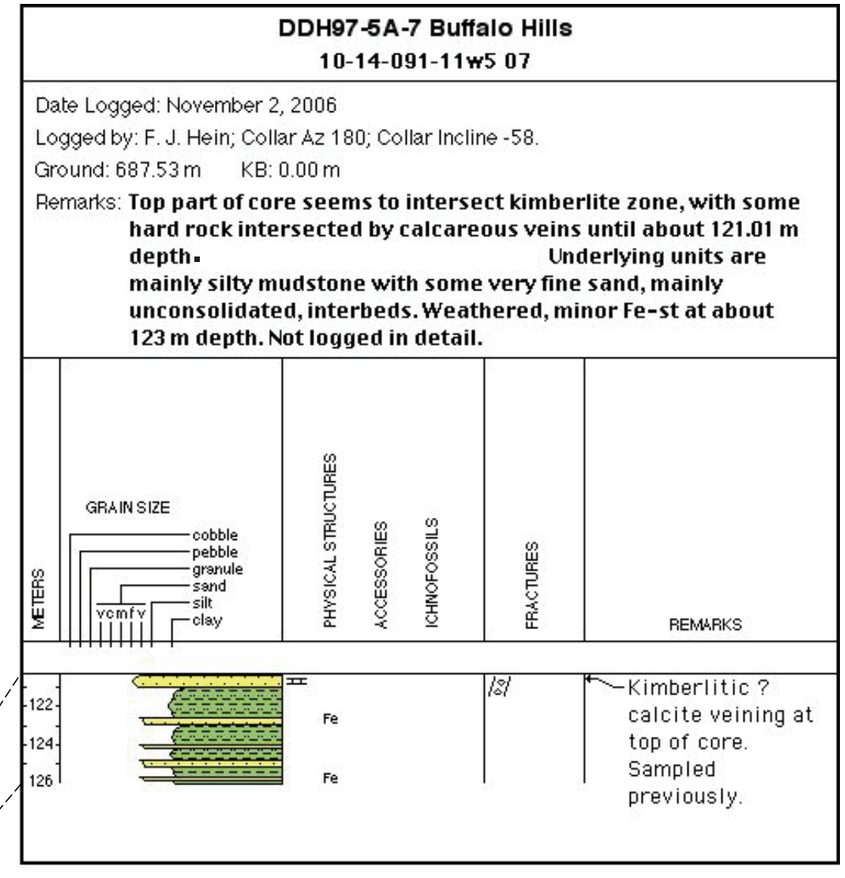
Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-5A-06: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	**K5A**	**Company:**	**Ashton Mining Canada Inc.**
Drill Hole:	5A-7	Collar Azimuth:	180 °
Location:	582488E , 6306213N	Collar Incline:	-58 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	63.5-47.6 mm (NQ)
Elevation:	687 m asl	Geologist Logging:	R. Johnson, MM
Start - End Date:	03/08/1997 - 05/08/1997	End of hole (EOH):	127.10 m



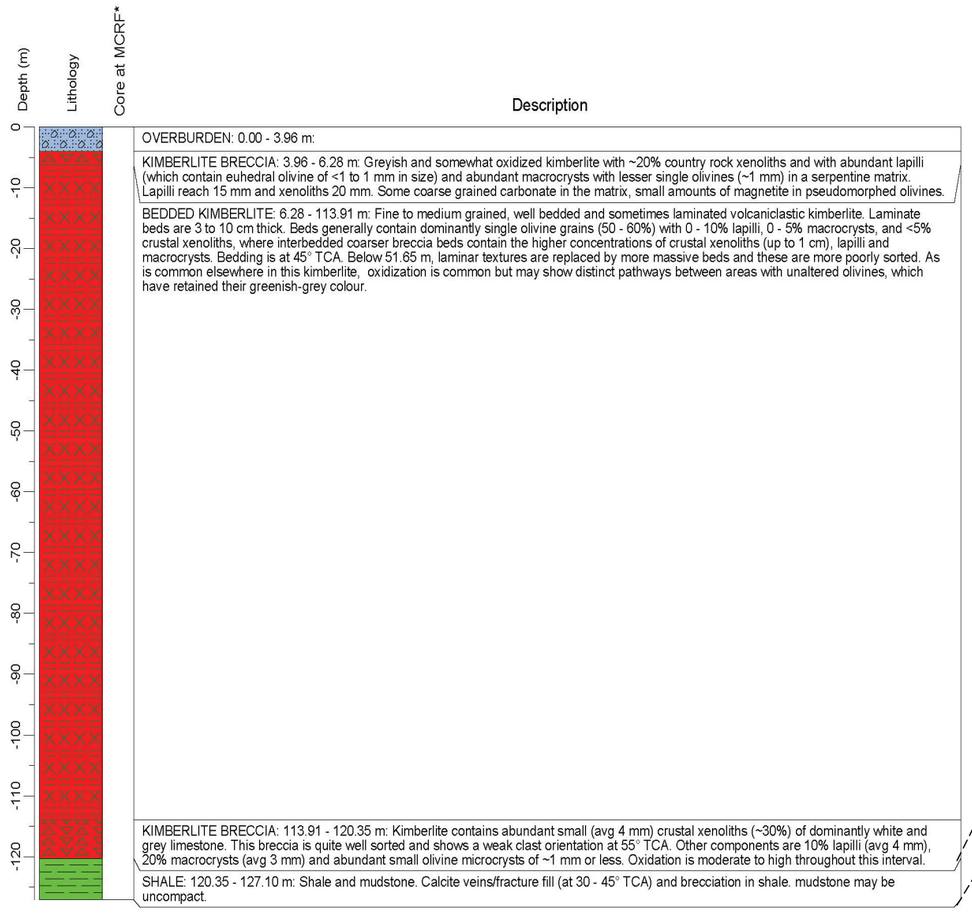
B)



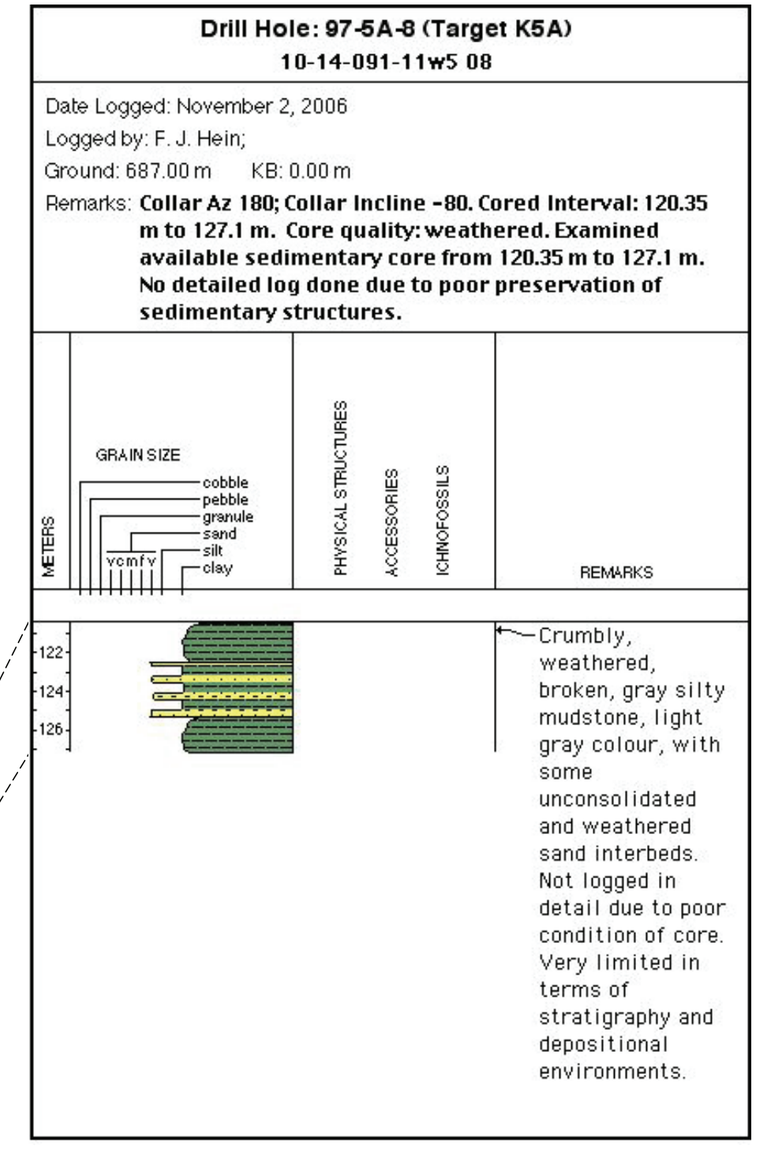
Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-5A-7: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	**K5A**	**Company:**	**Ashton Mining Canada Inc.**
Drill Hole:	5A-8	Collar Azimuth:	180 °
Location:	582488E , 6306212N	Collar Incline:	-80 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	63.5 mm (HQ)
Elevation:	687 m asl	Geologist Logging:	R. Johnson, MM
Start - End Date:	05/08/1997 - 06/08/1997	End of hole (EOH):	127.10 m



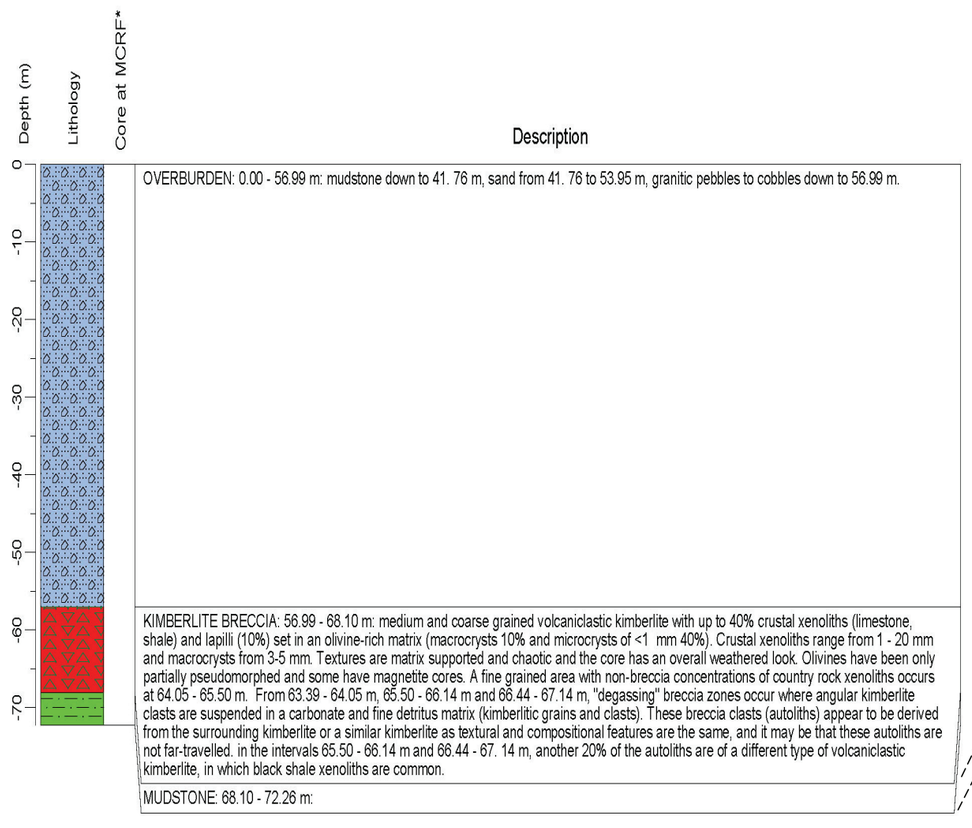
B)



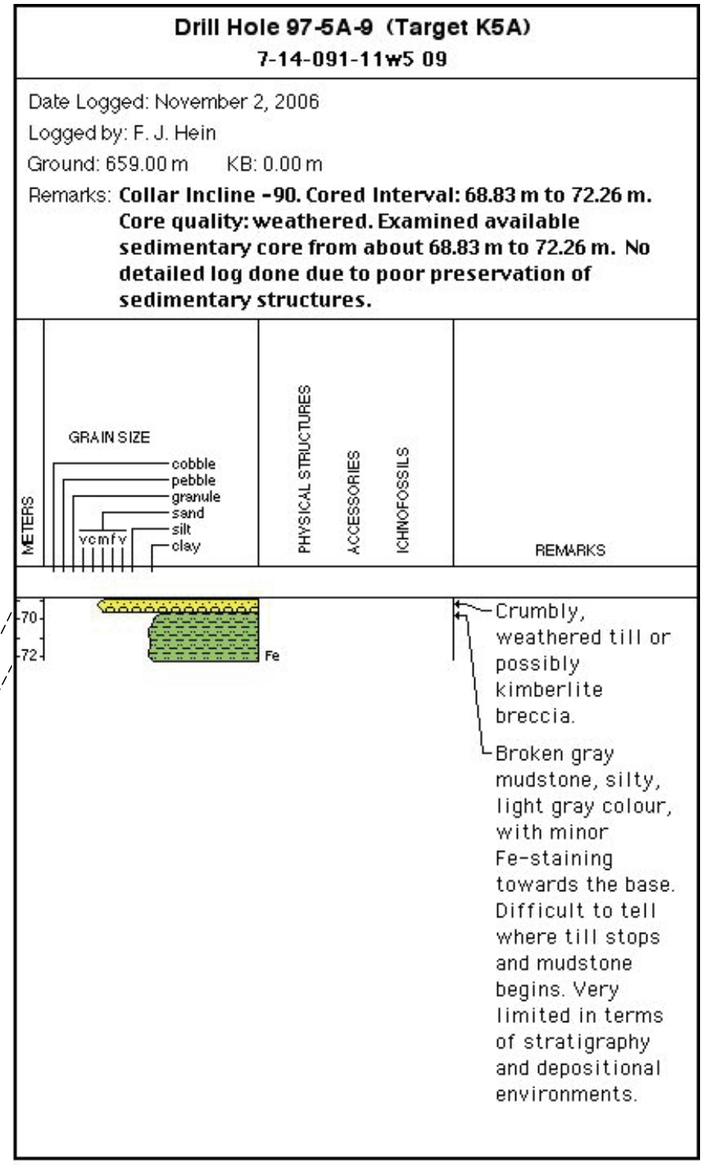
Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-5A-8: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	**K5A**	**Company:**	**Ashton Mining Canada Inc.**
Drill Hole:	5A-9	Collar Azimuth:	N/A °
Location:	582442E , 6305766N	Collar Incline:	-90 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	63.5 mm (HQ)
Elevation:	659 m asl	Geologist Logging:	R. Johnson, MM
Start - End Date:	05/08/1997 - 06/08/1997	End of hole (EOH):	72.26 m



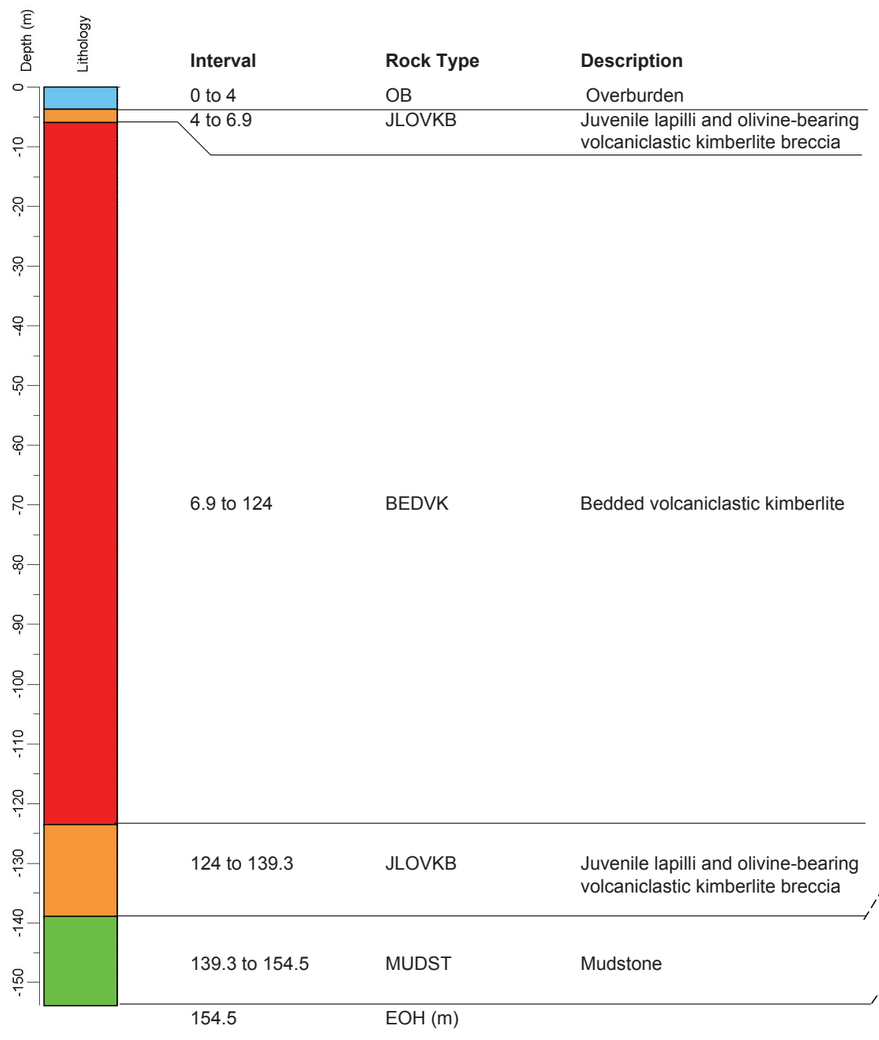
B)



Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-5A-9: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	K5A	Company:	Ashton Mining of Canada Inc.
Drill hole:	5A-10	Collar Azimuth:	N/A
Location:	582490E, 6306217N	Collar Incline:	-58
Zone & Datum:	Z11, NAD 27	Core Diameter:	63.5 mm (HQ)
Elevation:	688 m above sea level (asl)	Geologist Logging:	M.K.
Start-End Date:	07/8/1997-09/8/1997	End of hole (EOH):	154.5 m

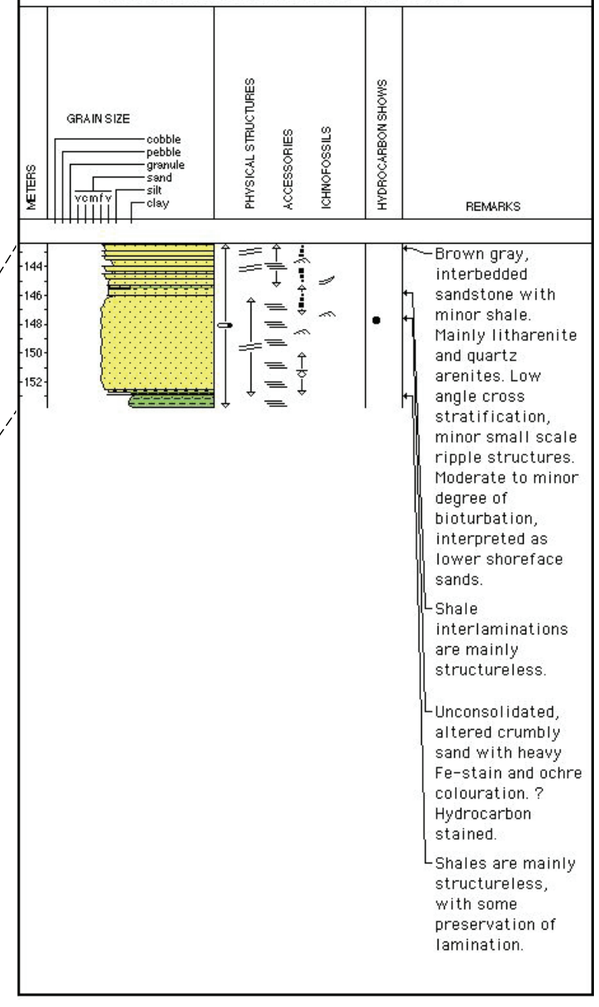


Interval	Rock Type	Description
0 to 4	OB	Overburden
4 to 6.9	JLOVKB	Juvenile lapilli and olivine-bearing volcaniclastic kimberlite breccia
6.9 to 124	BEDVK	Bedded volcaniclastic kimberlite
124 to 139.3	JLOVKB	Juvenile lapilli and olivine-bearing volcaniclastic kimberlite breccia
139.3 to 154.5	MUDST	Mudstone
154.5	EOH (m)	

B)

Drill Hole: 97-5A-10 (Target K5A)
10-14-091-11w5 10

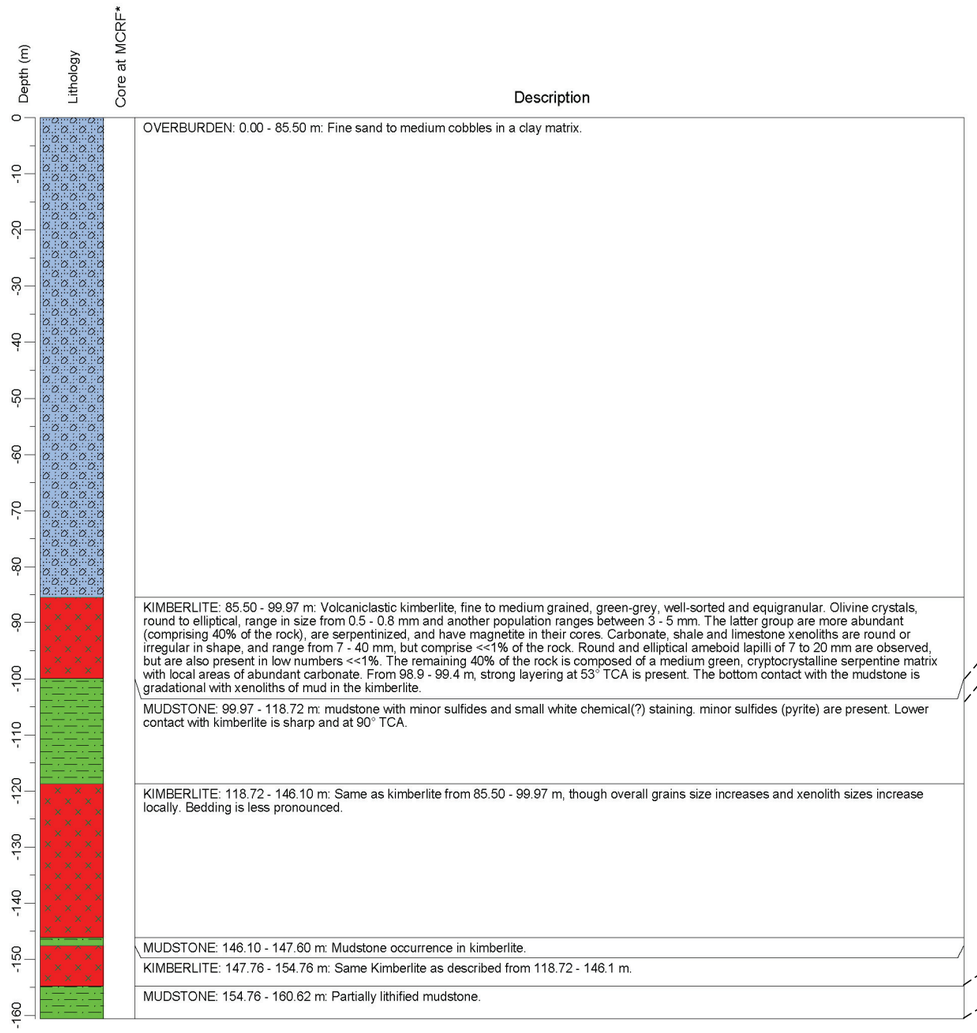
Date Logged: November 2, 2006
Logged by: F. J. Hein;
Ground: 688.48 m KB: 0.00 m
Remarks: **Collar azimuth 45; Collar incline - 58. Cored Interval: 142.34 m to 153.75 m. Core quality: badly weathered. Examined available sedimentary core from about 142.34 m to 153.75 m. Detailed log of sedimentary intersection.**



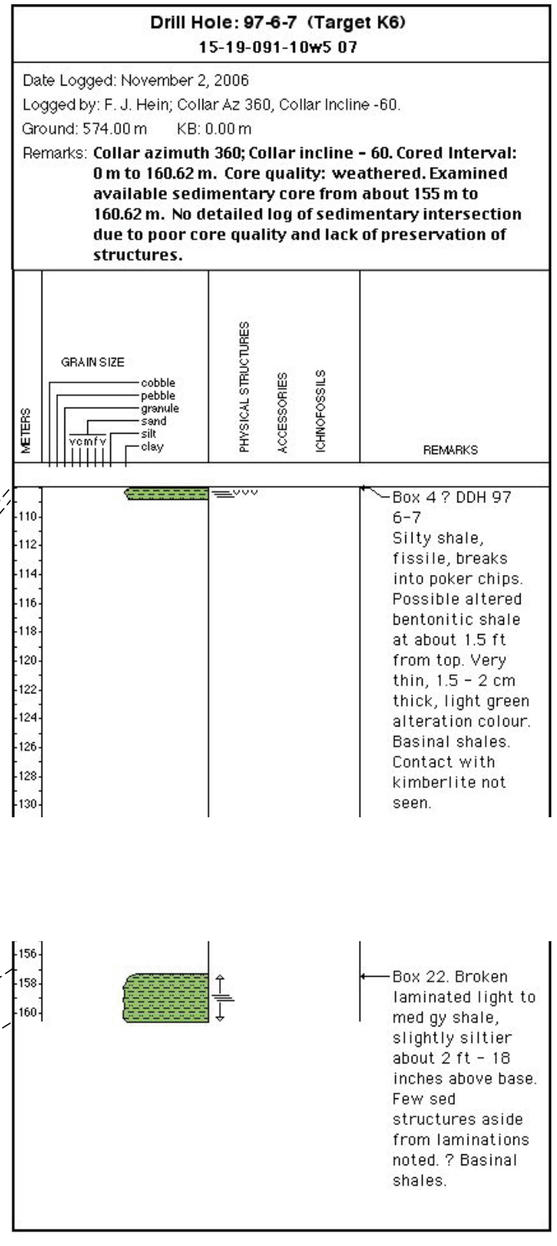
Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH-5A-10: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	**K6**	**Company:**	**Ashton Mining Canada Inc.**
Drill Hole:	6-7	Collar Azimuth:	360 °
Location:	585549E , 6308383N	Collar Incline:	-60 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	47.6 mm (NQ)
Elevation:	574 m asl	Geologist Logging:	R. Johnson
Start - End Date:	20/08/1997 - 22/08/1997	End of hole (EOH):	160.62 m



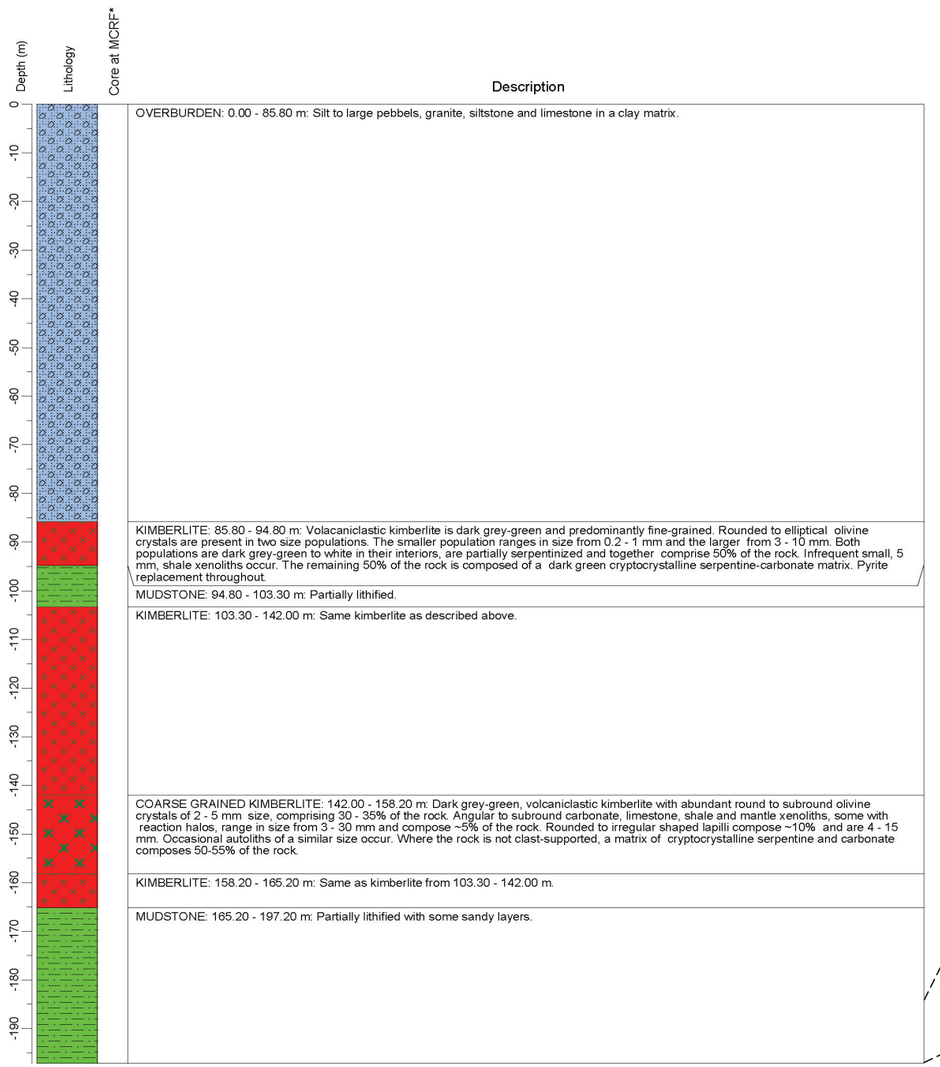
B)



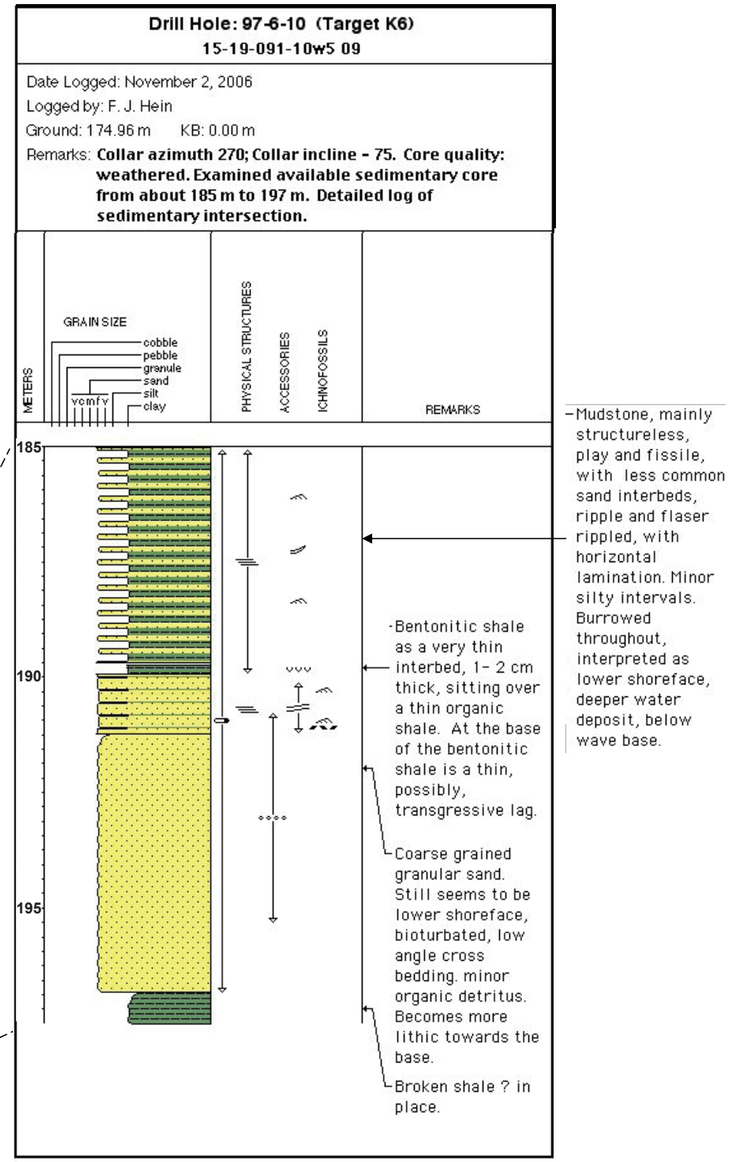
Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-6-7: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	**K6**	**Company:**	**Ashton Mining Canada Inc.**
Drill Hole:	6-10	Collar Azimuth:	270 °
Location:	585550E , 6308382N	Collar Incline:	-75 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	63.5 - 47.6 mm (NQ)
Elevation:	547 m asl	Geologist Logging:	R. Johnson
Start - End Date:	26/08/1997 - 28/08/1997	End of hole (EOH):	197.20 m



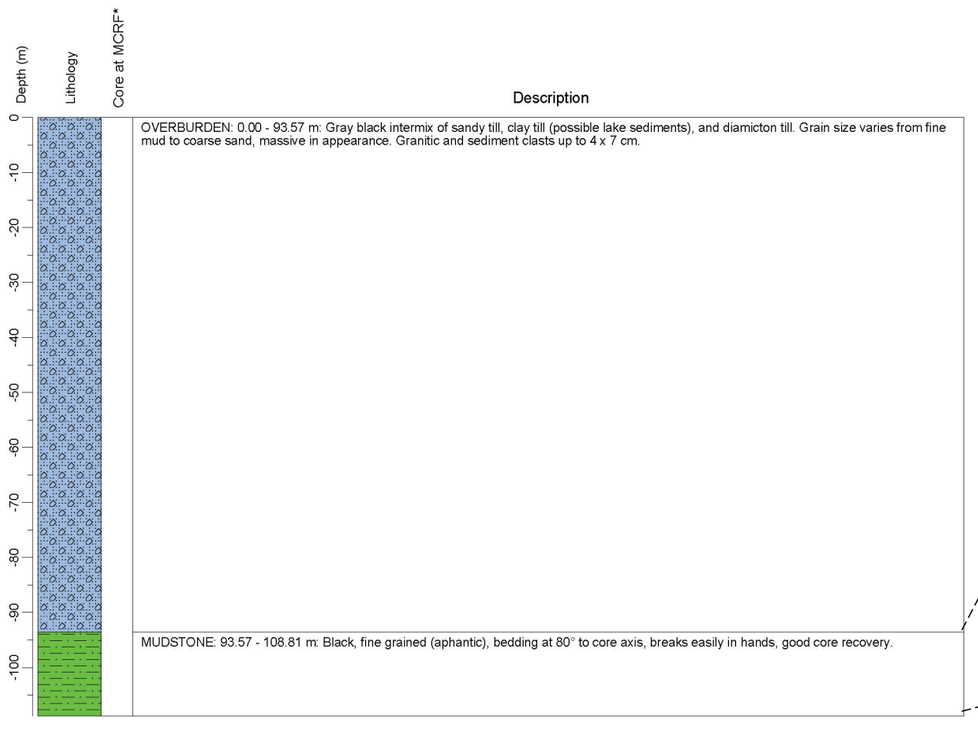
B)



Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-6-10: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

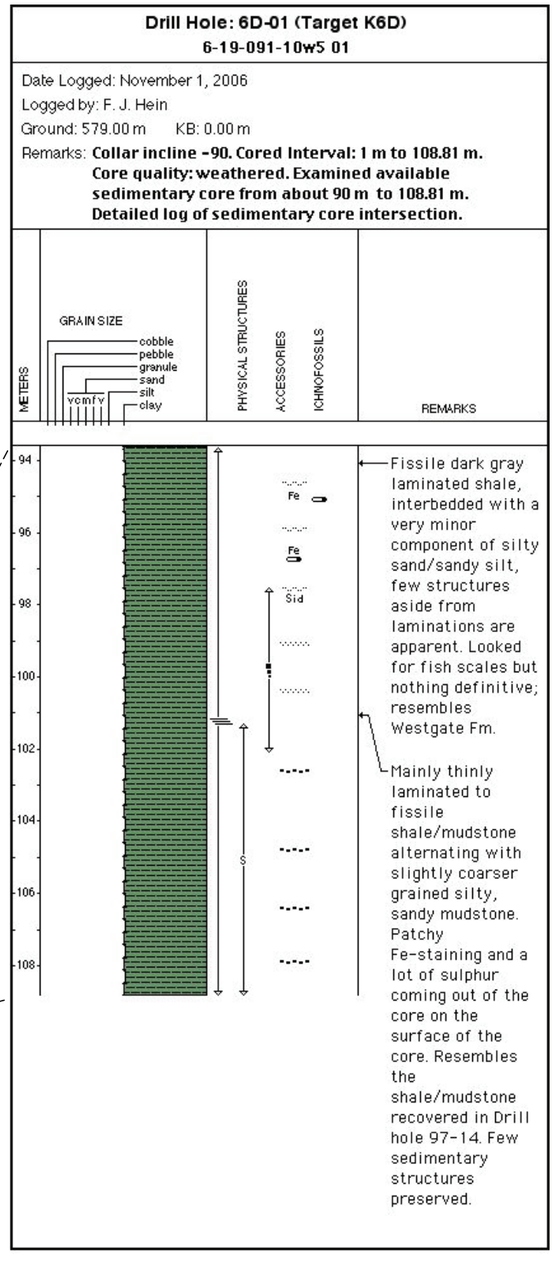
A)

Target:	**K6D**	**Company:**	**Ashton Mining of Canada Inc.**
Drill Hole:	DDH6D-01	Collar Azimuth:	°
Location:	585334E , 6307691N	Collar Incline:	-90 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	63.5 mm (HQ)
Elevation:	579 m asl	Geologist Logging:	Derrick Strickland
Start - End Date:	10/10/1997 - 13/10/1997	End of hole (EOH):	108.81 m



* Symbol denotes hand-sized sample of core is available at Mineral Core Research Facility at Alberta Geological Survey

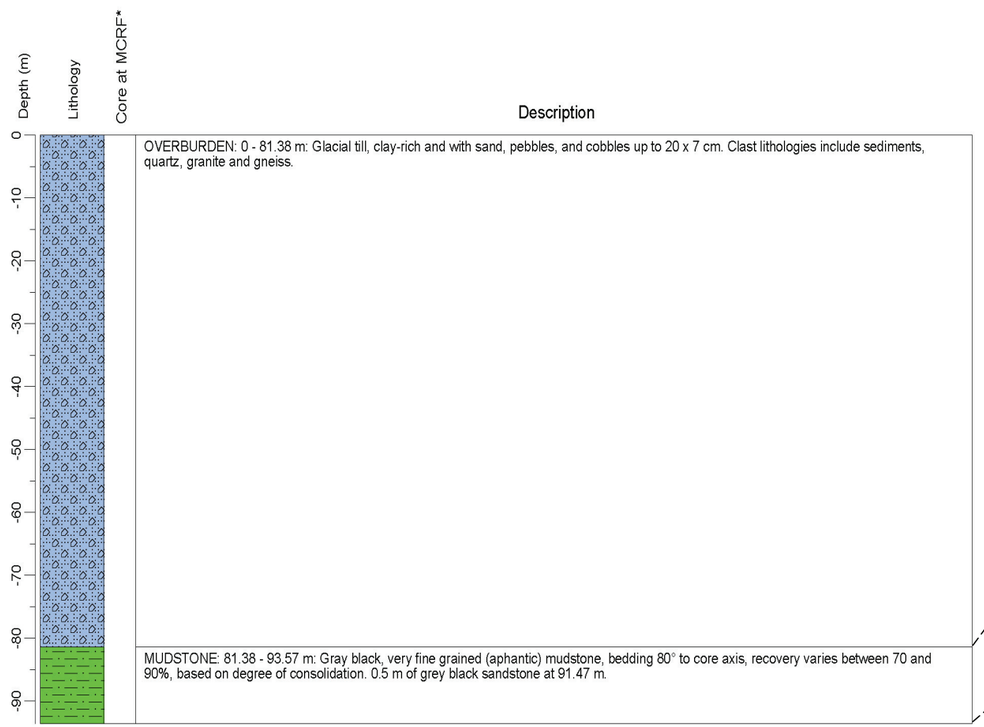
B)



Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-6D-1: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

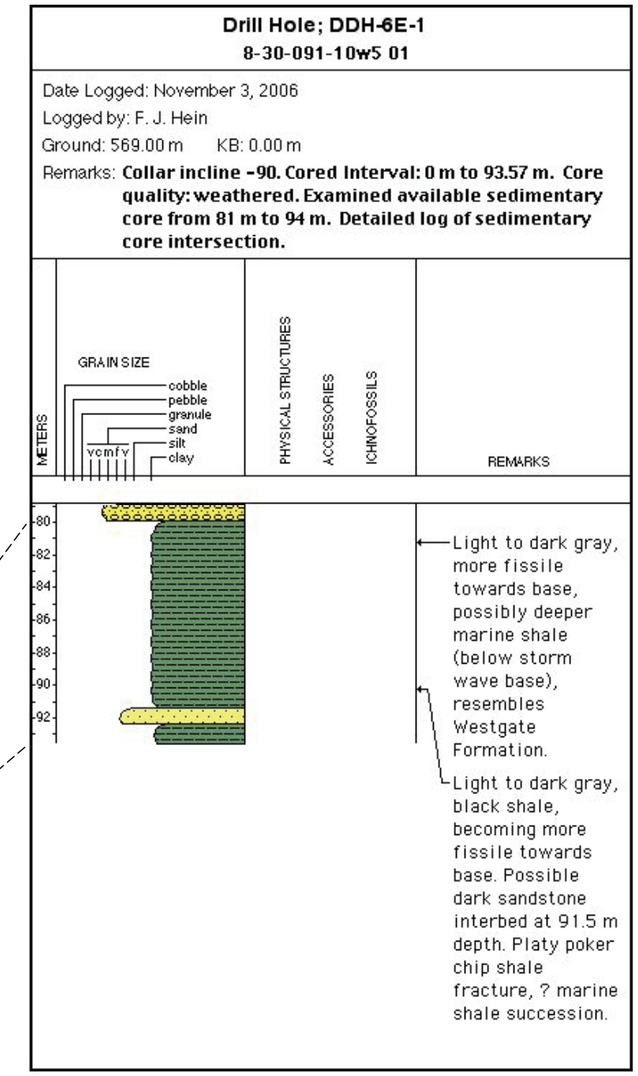
A)

Target:	**K6E**	**Company:**	**Ashton Mining of Canada Inc.**
Drill Hole:	DDH6E-01	Collar Azimuth:	°
Location:	585927E , 6309409N	Collar Incline:	-90 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	63.5 mm (HQ)
Elevation:	569 m asl	Geologist Logging:	Derrick Strickland
Start - End Date:	14/10/1997 - 15/10/1997	End of hole (EOH):	93.57 m



* Symbol denotes hand-sized sample of core is available at Mineral Core Research Facility at Alberta Geological Survey

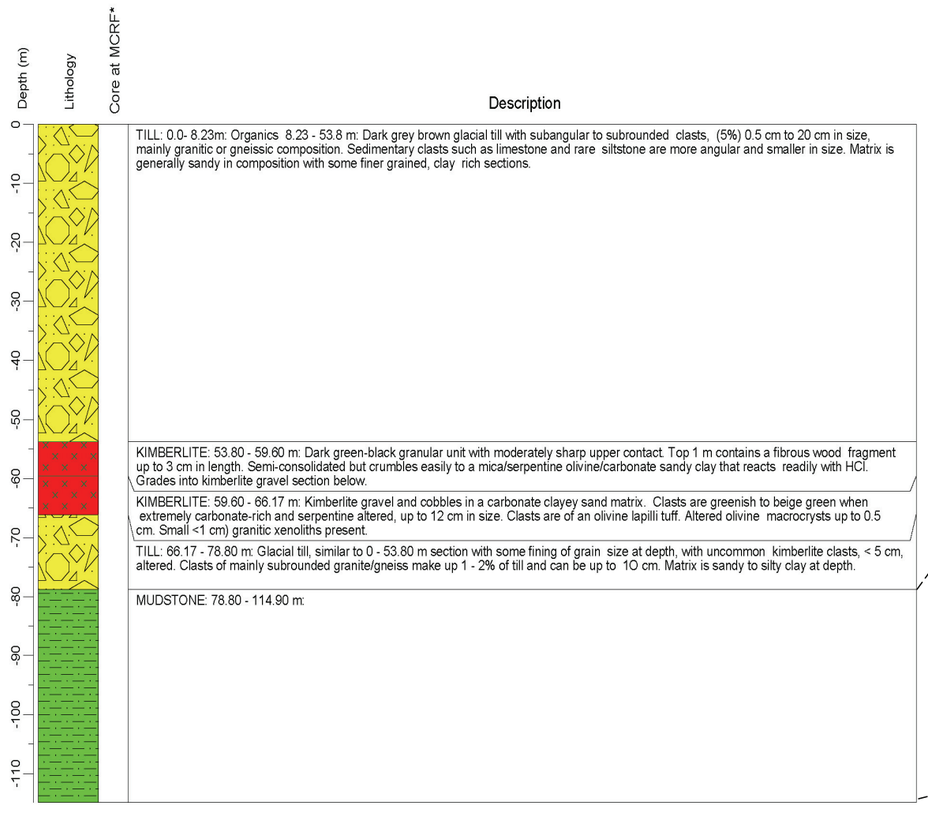
B)



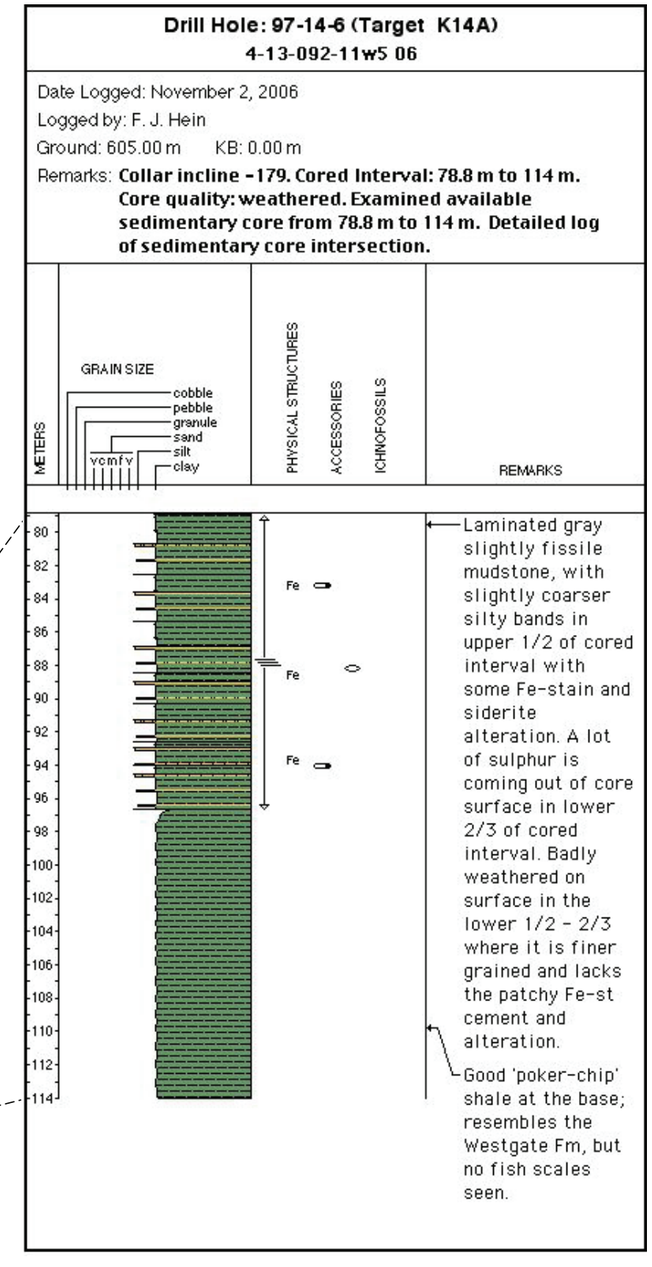
Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-6E-01: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	**K14**	**Company:**	**Ashton Mining of Canada Inc.**
Drill Hole:	DDH14-06	Collar Azimuth:	
Location:	583162E , 6315101N	Collar Incline:	-179°
Zone & Datum:	Z11, NAD 27	Core Diameter:	63.5 mm (HQ)
Elevation:	605 m asl	Geologist Logging:	Jeff Ward
Start - End Date:	24/10/1997 - 25/10/1997	End of hole (EOH):	114.90 m



B)

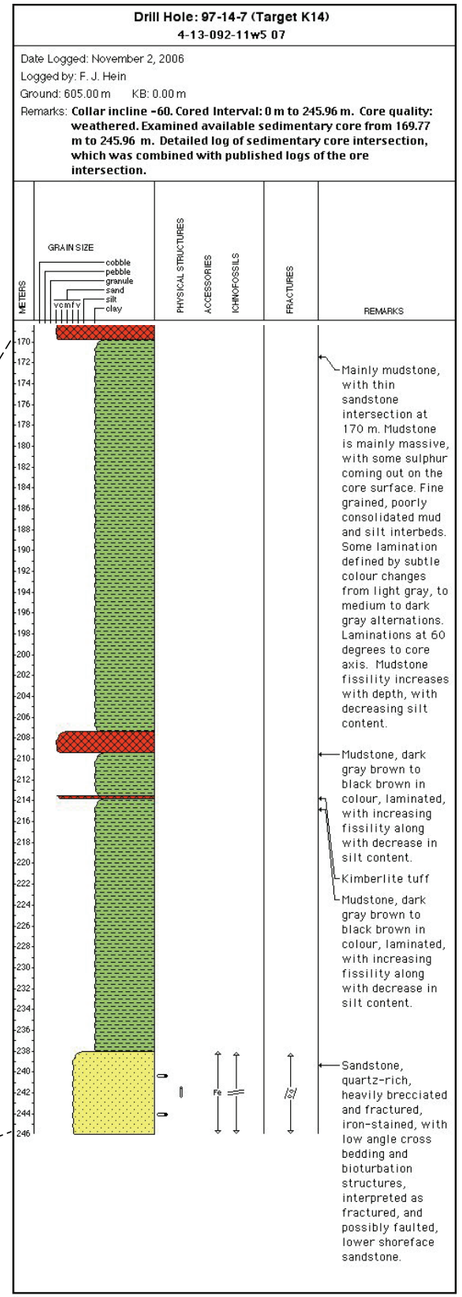


Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-14-06: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	**K14**	**Company:**	**Ashton Mining of Canada Inc.**
Drill Hole:	DDH14-07	Collar Azimuth:	°
Location:	583162E , 6315101N	Collar Incline:	-60 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	63.5 mm (HQ)
Elevation:	605 m asl	Geologist Logging:	J. Ward/D. Skelton
Start - End Date:	25/10/1997 - 28/10/1997	End of hole (EOH):	245.96 m

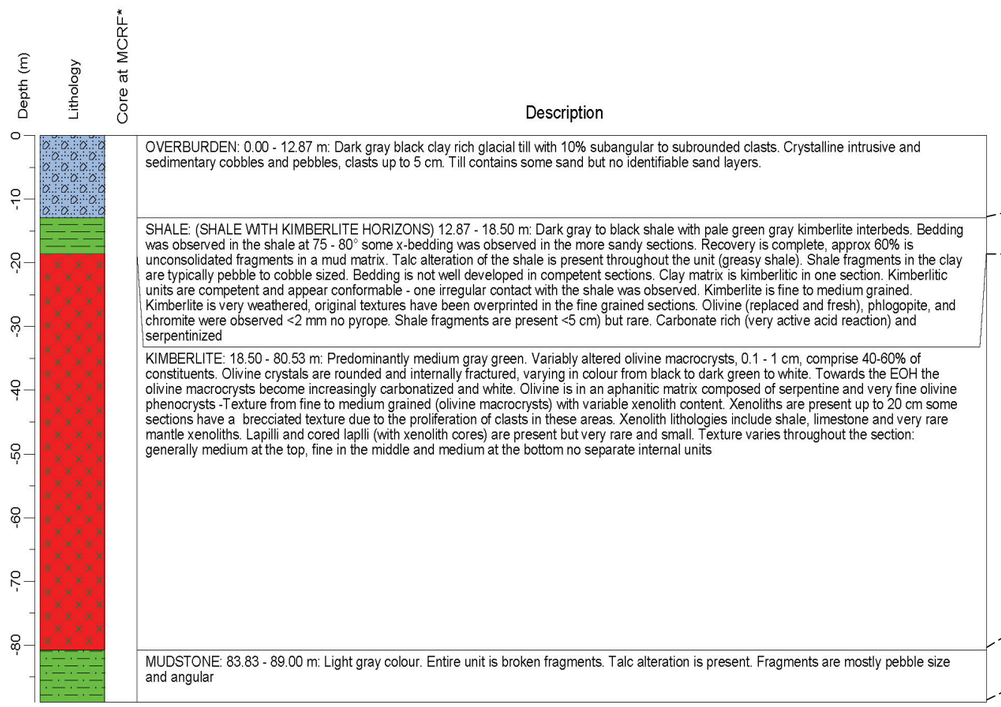
B)



Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-14-07: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	**K14B**	**Company:**	**Ashton Mining of Canada Inc.**
Drill Hole:	DDH14B-01	Collar Azimuth:	°
Location:	582820E , 6315277N	Collar Incline:	-90 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	85.0 mm
Elevation:	620 m asl	Geologist Logging:	Dave Skelton
Start - End Date:	22/10/1997 - 23/10/1997	End of hole (EOH):	89.00 m



OVERBURDEN: 0.00 - 12.87 m: Dark gray black clay rich glacial till with 10% subangular to subrounded clasts. Crystalline intrusive and sedimentary cobbles and pebbles, clasts up to 5 cm. Till contains some sand but no identifiable sand layers.

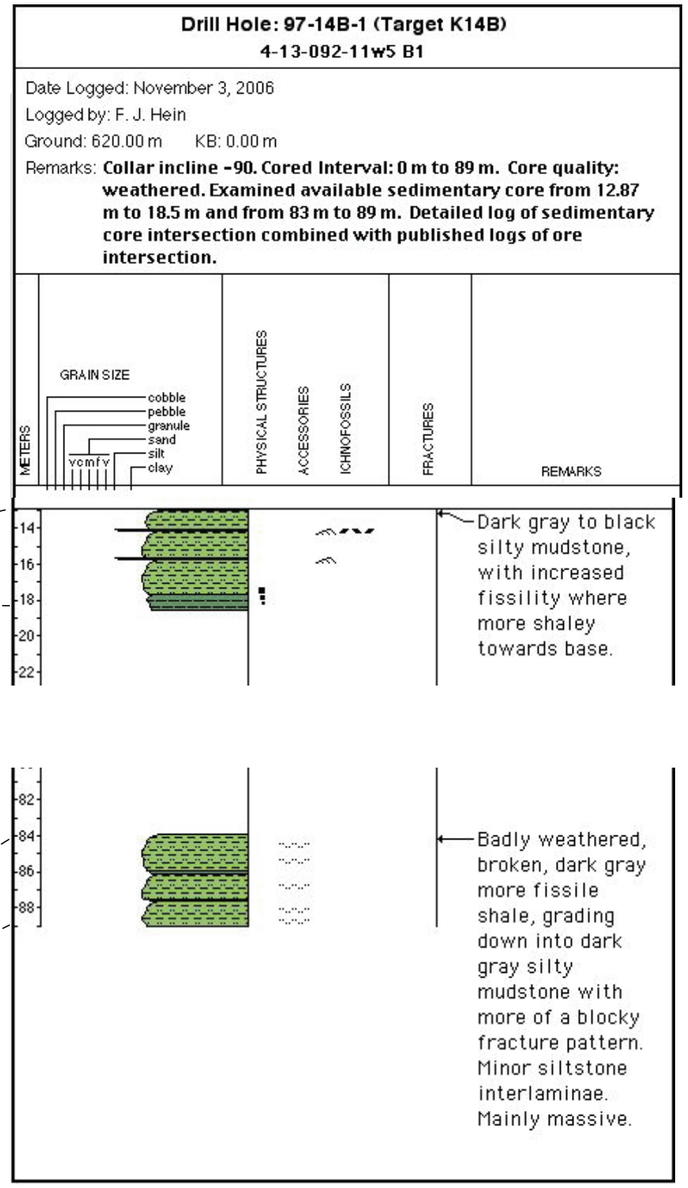
SHALE: (SHALE WITH KIMBERLITE HORIZONS) 12.87 - 18.50 m: Dark gray to black shale with pale green gray kimberlite interbeds. Bedding was observed in the shale at 75 - 80° some x-bedding was observed in the more sandy sections. Recovery is complete, approx 60% is unconsolidated fragments in a mud matrix. Talc alteration of the shale is present throughout the unit (greasy shale). Shale fragments in the clay are typically pebble to cobble sized. Bedding is not well developed in competent sections. Clay matrix is kimberlitic in one section. Kimberlitic units are competent and appear conformable - one irregular contact with the shale was observed. Kimberlite is fine to medium grained. Kimberlite is very weathered, original textures have been overprinted in the fine grained sections. Olivine (replaced and fresh), phlogopite, and chromite were observed <2 mm no pyrope. Shale fragments are present <5 cm) but rare. Carbonate rich (very active acid reaction) and serpentinized

KIMBERLITE: 18.50 - 80.53 m: Predominantly medium gray green. Variably altered olivine macrocrysts, 0.1 - 1 cm, comprise 40-60% of constituents. Olivine crystals are rounded and internally fractured, varying in colour from black to dark green to white. Towards the EOH the olivine macrocrysts become increasingly carbonatized and white. Olivine is in an aphanitic matrix composed of serpentine and very fine olivine phenocrysts -Texture from fine to medium grained (olivine macrocrysts) with variable xenolith content. Xenoliths are present up to 20 cm some sections have a brecciated texture due to the proliferation of clasts in these areas. Xenolith lithologies include shale, limestone and very rare mantle xenoliths. Lapilli and cored lapilli (with xenolith cores) are present but very rare and small. Texture varies throughout the section: generally medium at the top, fine in the middle and medium at the bottom no separate internal units

MUDSTONE: 83.83 - 89.00 m: Light gray colour. Entire unit is broken fragments. Talc alteration is present. Fragments are mostly pebble size and angular

* Symbol denotes hand-sized sample of core is available at Mineral Core Research Facility at Alberta Geological Survey

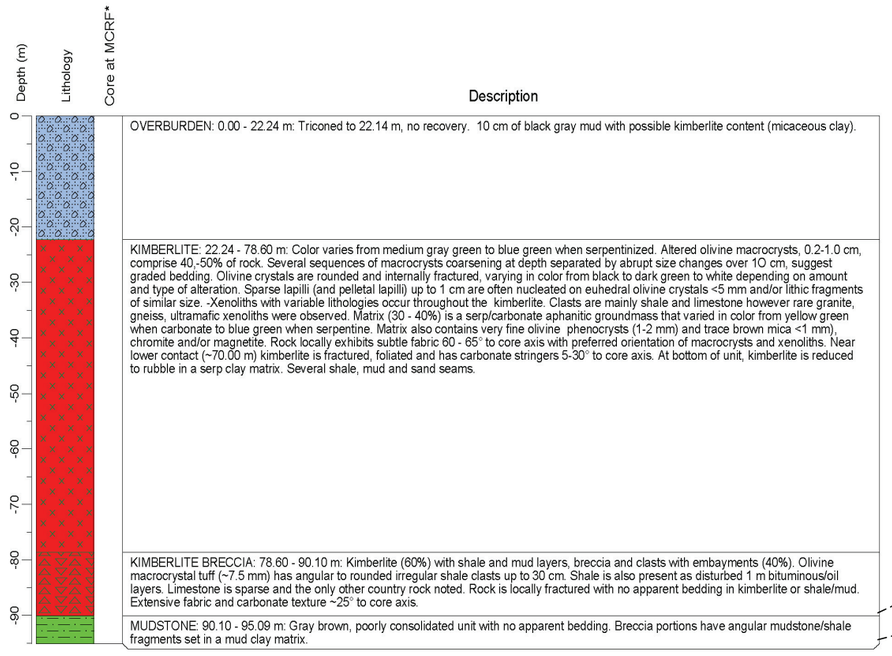
B)



Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-14B-01: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	**K14B**	**Company:**	**Ashton Mining of Canada Inc.**
Drill Hole:	DDH14B-04	Collar Azimuth:	°
Location:	582820E , 6315277N	Collar Incline:	-60 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	85.0 mm
Elevation:	620 m asl	Geologist Logging:	Jeff Ward
Start - End Date:	28/10/1997 - 30/10/1997	End of hole (EOH):	95.05 m



* Symbol denotes hand-sized sample of core is available at Mineral Core Research Facility at Alberta Geological Survey

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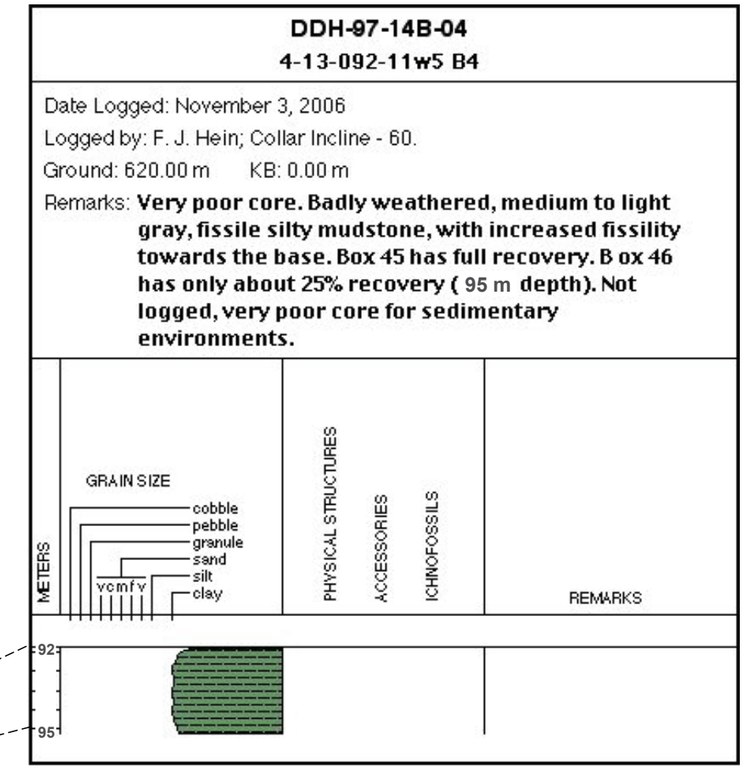
B)



Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-14B-04: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	**14C**	**Company:**	**Ashton Mining of Canada Inc.**
Drill Hole:	DDH14C-01	Collar Azimuth:	°
Location:	583029E , 6315357N	Collar Incline:	-90 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	85.0 mm
Elevation:	610 m asl	Geologist Logging:	Derrick Strickland
Start - End Date:	09/10/1997 - 11/10/1997	End of hole (EOH):	81.83 m

Depth (m)	Lithology	Core at MCRF*	Description
0 to -80			OVERBURDEN: 0.00 - 14.70 m: Brown-green, silty till, variably clast-rich and poor.
			KIMBERLITE: 14.70 - 60.60 m: Green, medium to coarse grained, equigranular volcaniclastic kimberlite, consisting of rounded olivine macrocrysts, light green-brown in colour 3 x 3 mm, (35 - 40% of the rock) and a microcryst population of <1 mm olivine which constitutes another 30%, all in a serpentine matrix. Much of the olivine has been serpentinized as well. Xenoliths of fine black shale up to 3.0 x 7.5 cm in size comprise 5 - 10% of the rock. Xenoliths of carbonate, <3 x 2 cm are also present, 3 - 5%. Lapilli and/or autoliths are present in amounts of 15-20%.
			MUDSTONE: (MUDSTONE AND SANDSTONE) 60.60 - 66.14m: Grey in colour, fine grained, not yet fully consolidated, has a muddy feel with bedding 30°- 40° TCA. 66.14-70.10 m: Sandstone: Grey-brown, fine-grained, unconsolidated. 70.10 - 75.28 m: Mudstone, as above. 75.28 - 75.79 m: Sandstone, as above. 75.79 - 78.72 m: Mudstone, as above.
			KIMBERLITE TUFF: 78.72 - 78.93 m: Grey in colour, medium to coarse grained, silica rich, 30 - 40% looks like the olivine has been altered to silica. Lapilli 5 - 10%, with largest being 1.2 x 1.2 cm altered to light green with a kernel of silicified olivine. Carbonate crystals are up to 1x1 mm, <1% of the rock. Shale xenoliths 10 - 15%, up to 0.5 x 0.5 cm, black. Contacts above and below are sharp, 70° TCA and show minor amounts of contact alteration. Upper contact fine grained for 1 cm and is darker gray than the rest of section.
			MUDSTONE: 78.93 - 81.83 m: Grey, fine grained, muddy, not fully consolidated, bedding at 30 - 40° TCA.

* Symbol denotes hand-sized sample of core is available at Mineral Core Research Facility at Alberta Geological Survey

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B)

Drill Hole: 97-14C-01 (Target K14C)

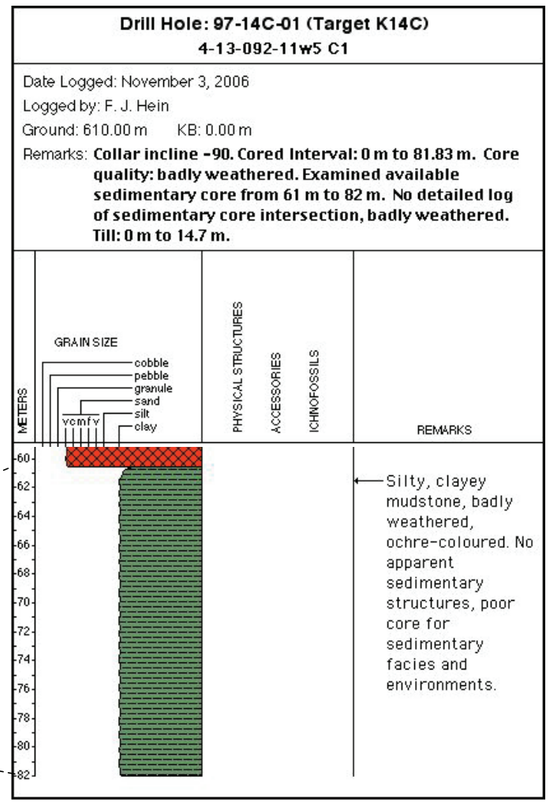
4-13-092-11w5 C1

Date Logged: November 3, 2006

Logged by: F. J. Hein

Ground: 610.00 m KB: 0.00 m

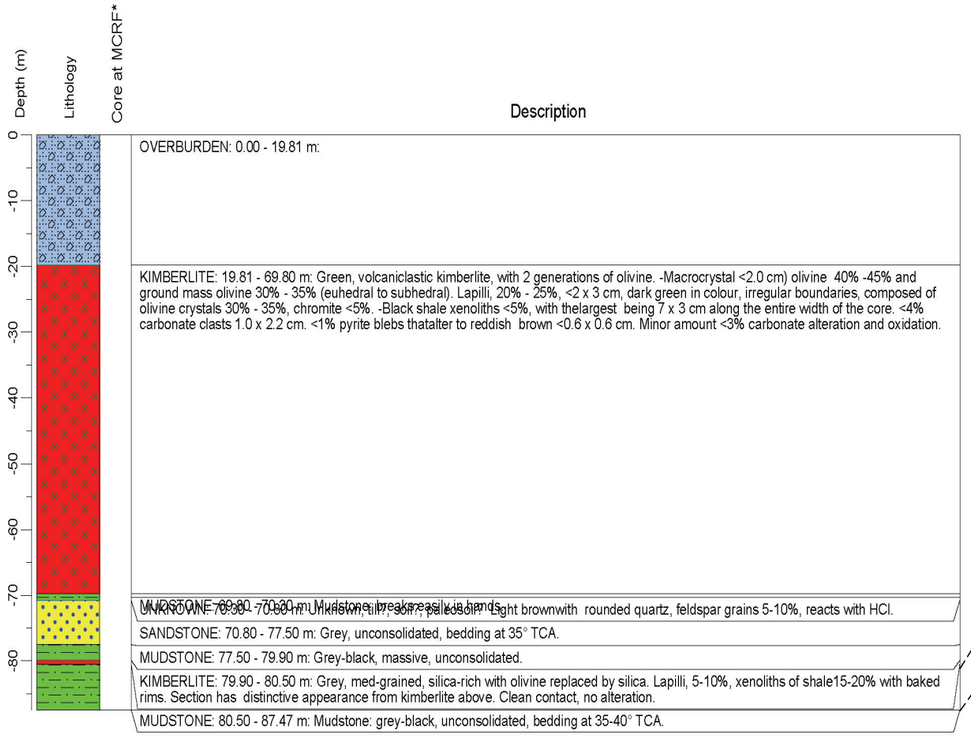
Remarks: **Collar incline -90. Cored Interval: 0 m to 81.83 m. Core quality: badly weathered. Examined available sedimentary core from 61 m to 82 m. No detailed log of sedimentary core intersection, badly weathered. Till: 0 m to 14.7 m.**



Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-14C-01: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	**K14C**	**Company:**	**Ashton Mining of Canada Inc.**
Drill Hole:	DDH14C-02	Collar Azimuth:	°
Location:	583029E , 6315357N	Collar Incline:	-70 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	85.0 mm
Elevation:	609 m asl	Geologist Logging:	Derrick Strickland
Start - End Date:	10/10/1997 - 13/10/1997	End of hole (EOH):	87.47 m



* Symbol denotes hand-sized sample of core is available at Mineral Core Research Facility at Alberta Geological Survey

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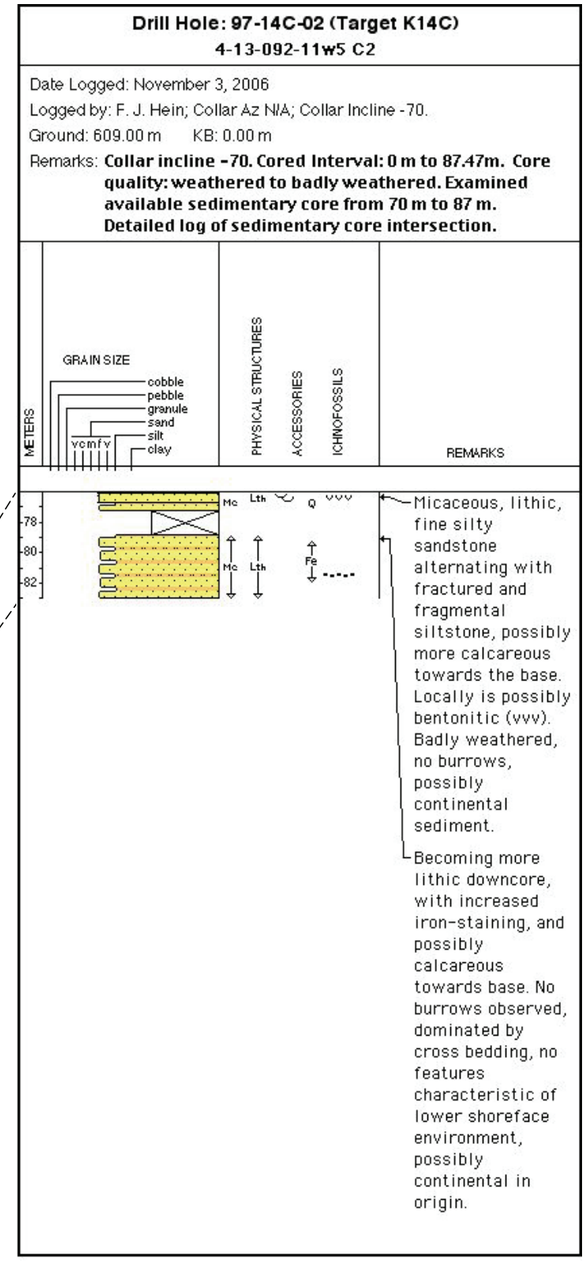
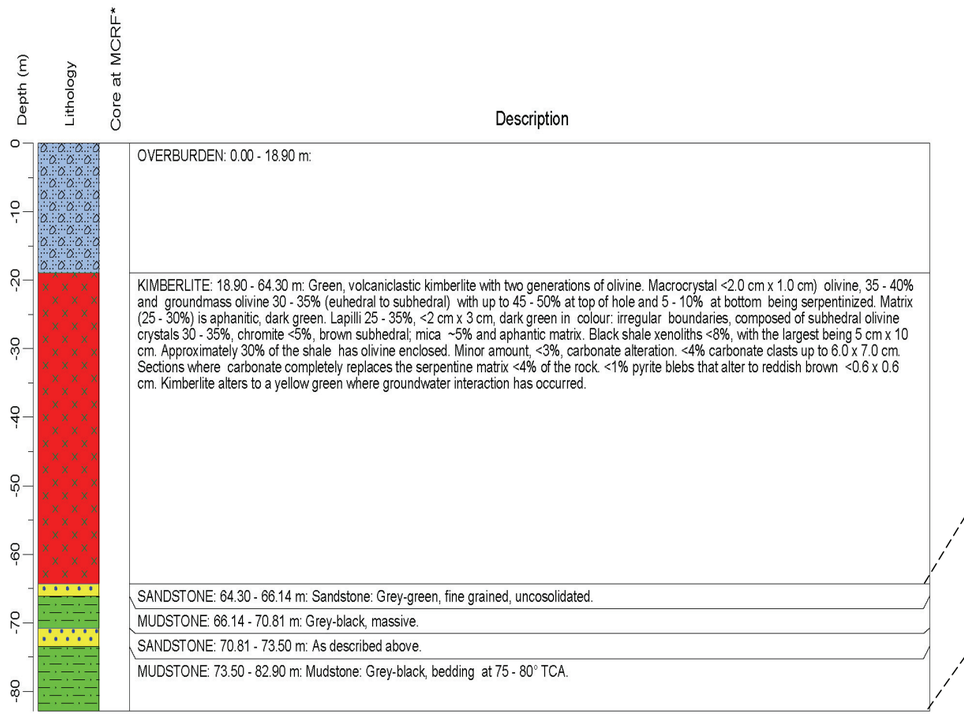
B)



Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-14C-02: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	**K14C**	**Company:**	**Ashton Mining of Canada Inc.**
Drill Hole:	DDH14C-03	Collar Azimuth:	°
Location:	583029E , 6315357N	Collar Incline:	-70 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	85.0 mm
Elevation:	609 m asl	Geologist Logging:	Derrick Strickland
Start - End Date:	13/10/1997 - 15/10/1997	End of hole (EOH):	82.90 m



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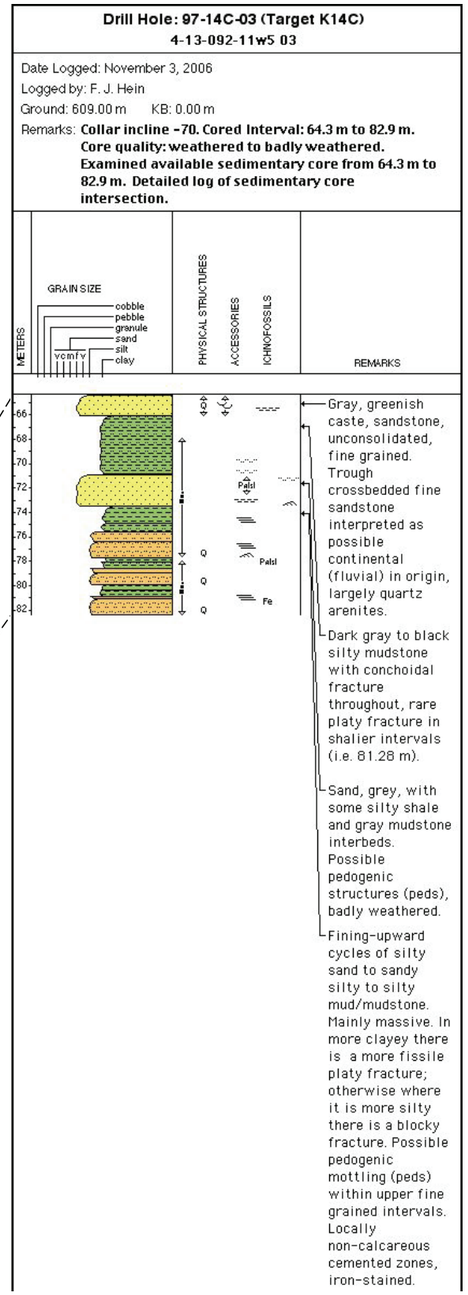
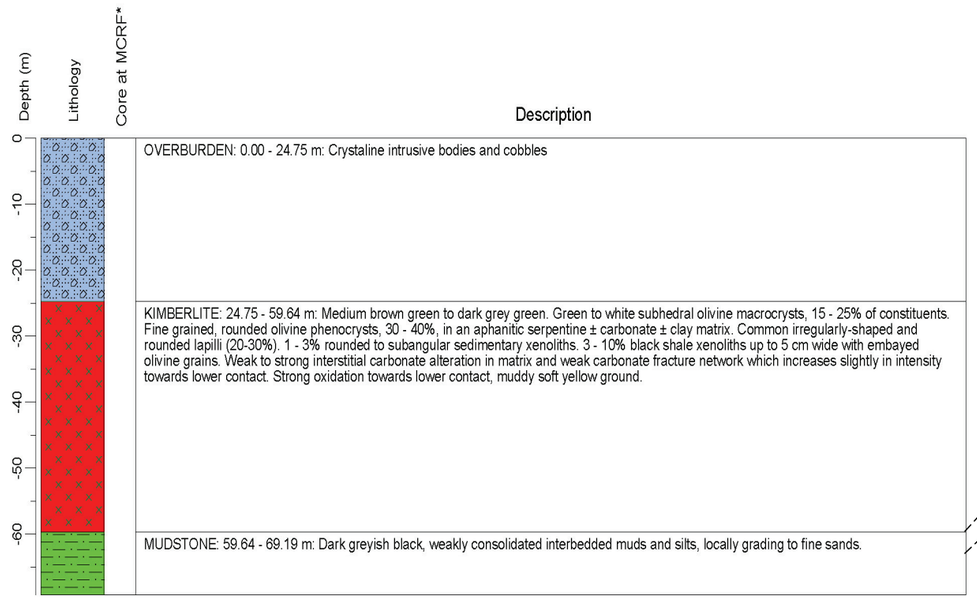


Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-14C-03: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

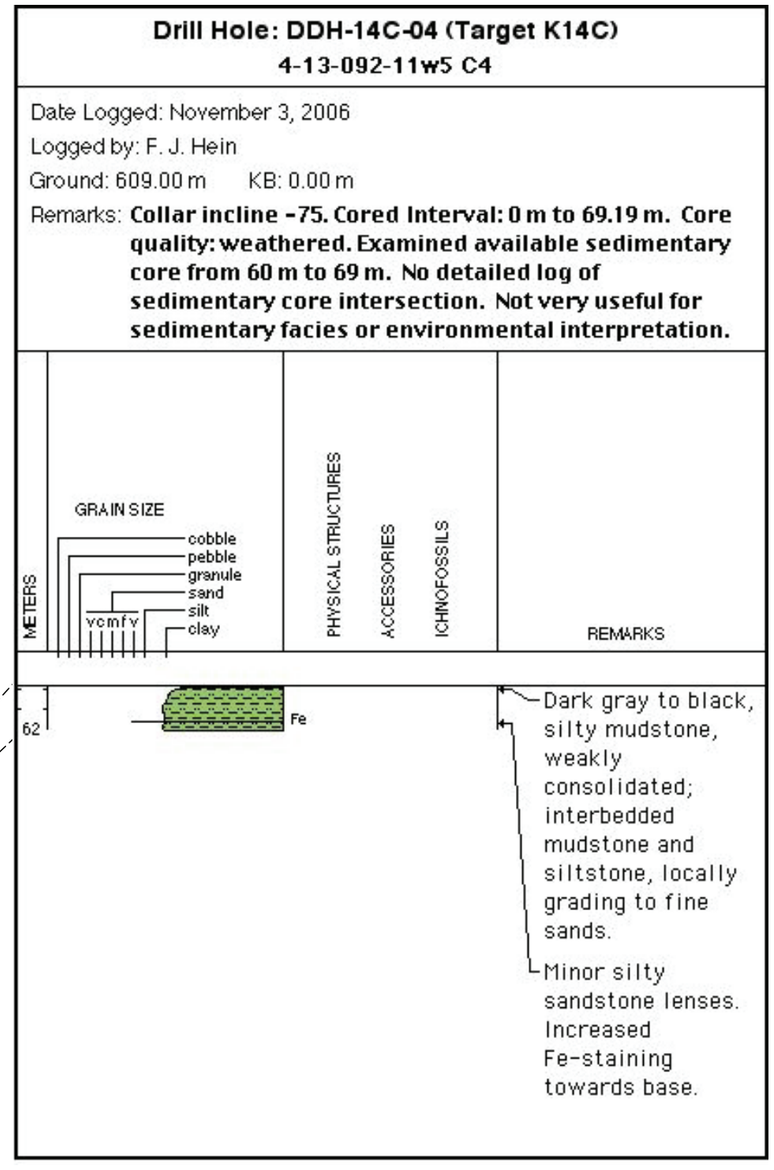
A)

Target:	**K14C**	**Company:**	**Ashton Mining of Canada Inc.**
Drill Hole:	DDH14C-04	Collar Azimuth:	°
Location:	583029E , 6315357N	Collar Incline:	-75 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	85.0 mm
Elevation:	609 m asl	Geologist Logging:	Andrew Berry
Start - End Date:	15/10/1997 - 17/10/1997	End of hole (EOH):	69.19 m



* Symbol denotes hand-sized sample of core is available at Mineral Core Research Facility at Alberta Geological Survey

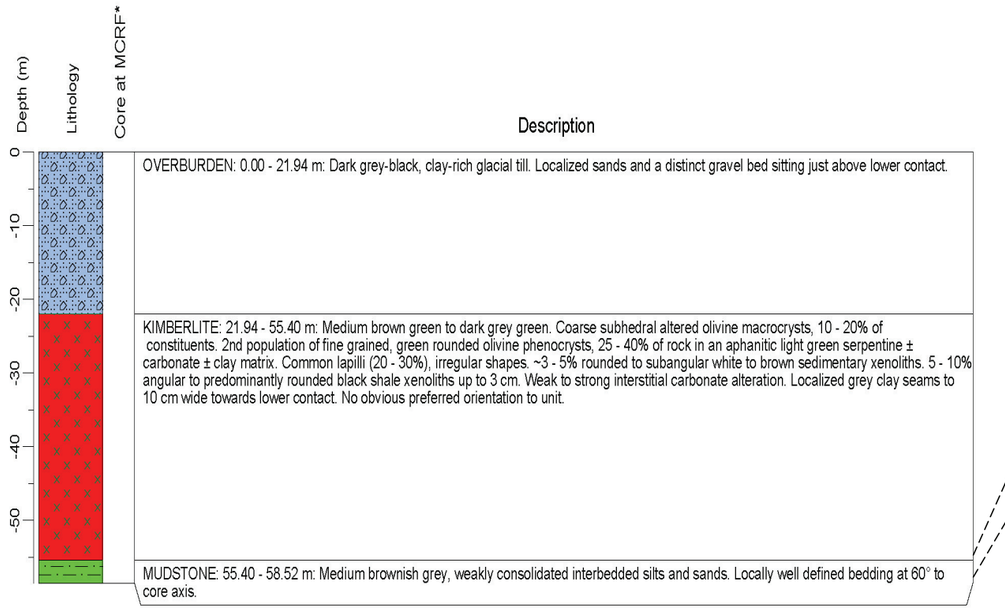
B)



Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-14C-04: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	**K14C**	**Company:**	**Ashton Mining of Canada Inc.**
Drill Hole:	DDH14C-05	Collar Azimuth:	°
Location:	583029E , 6315357N	Collar Incline:	-60 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	85.0 mm
Elevation:	609 m asl	Geologist Logging:	Andrew Berry
Start - End Date:	17/10/1997 - 18/10/1997	End of hole (EOH):	58.52 m



* Symbol denotes hand-sized sample of core is available at Mineral Core Research Facility at Alberta Geological Survey

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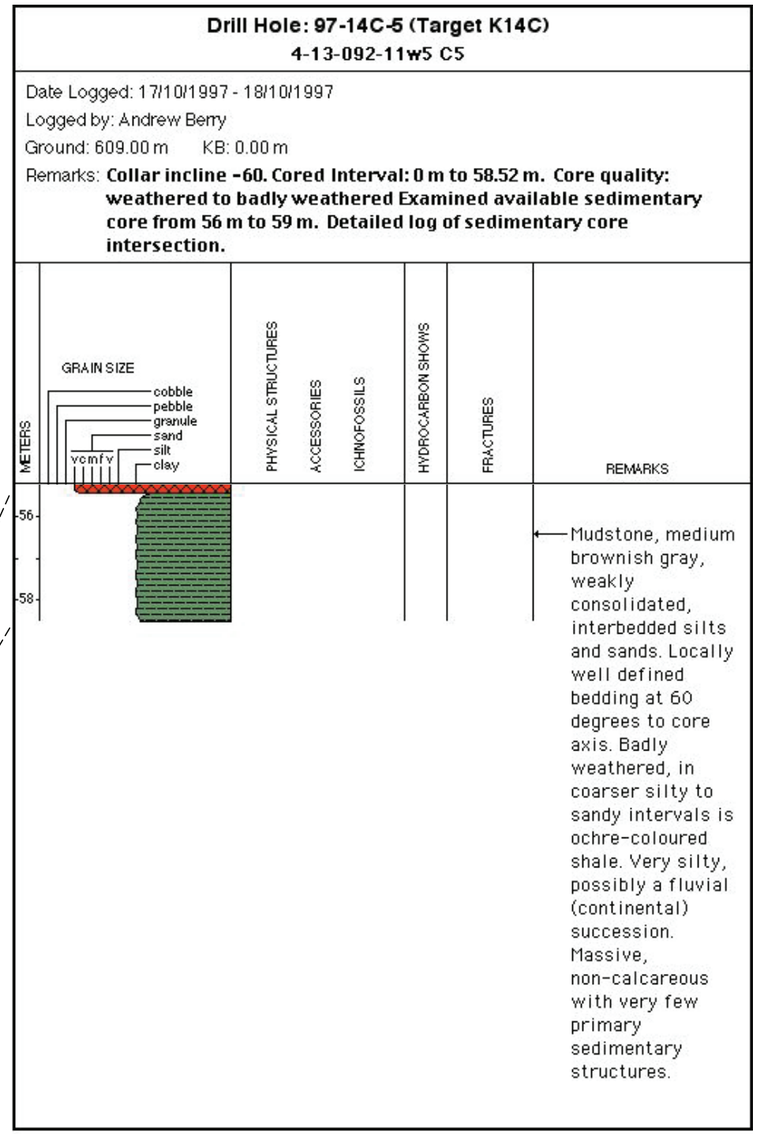
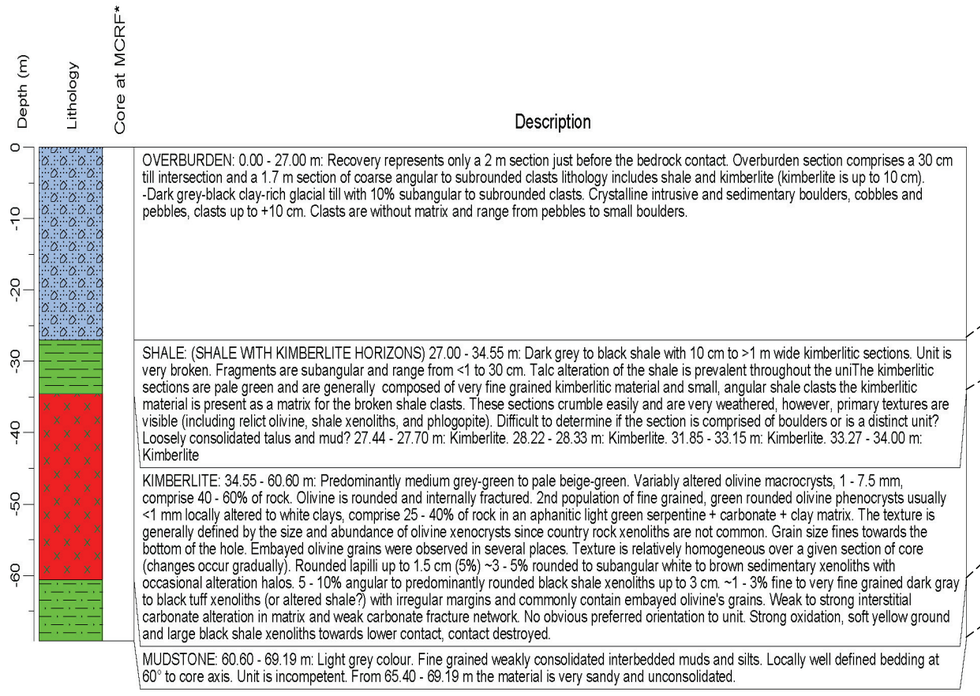


Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-14C-05: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	**K14C**	**Company:**	**Ashton Mining of Canada Inc.**
Drill Hole:	DDH14C-06	Collar Azimuth:	°
Location:	583029E , 6315357N	Collar Incline:	-90 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	85.0 mm
Elevation:	609 m asl	Geologist Logging:	Dave Skelton
Start - End Date:	18/10/1997 - 20/10/1997	End of hole (EOH):	69.19 m



* Symbol denotes hand-sized sample of core is available at Mineral Core Research Facility at Alberta Geological Survey

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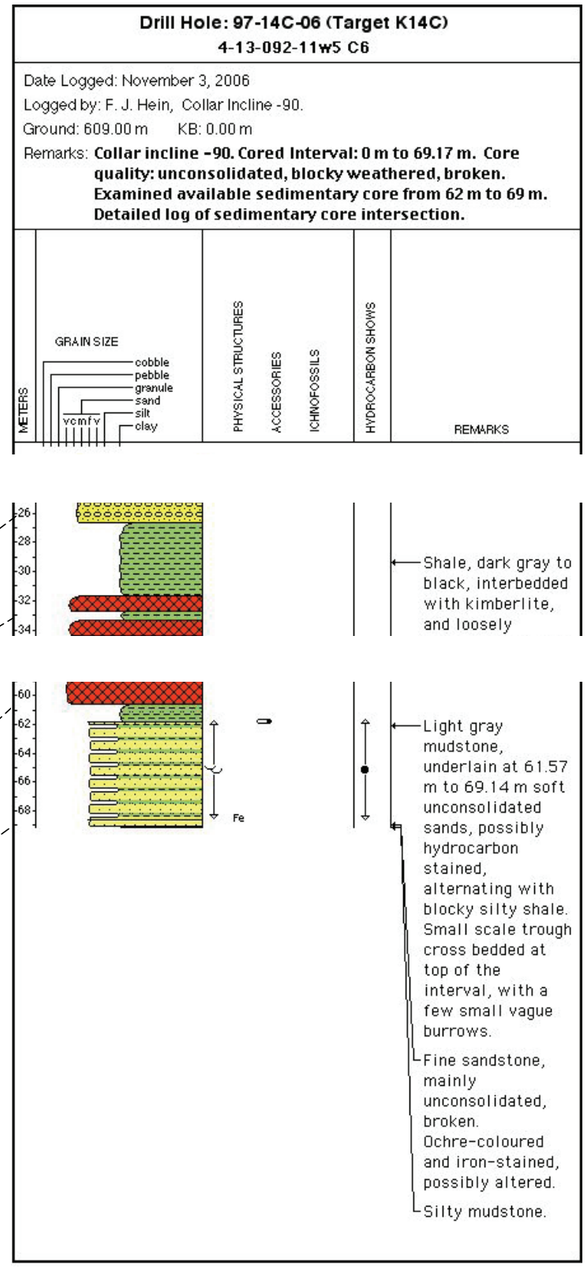


Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-14C-06: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	**K14C**	**Company:**	**Ashton Mining of Canada Inc.**
Drill Hole:	DDH14C-07	Collar Azimuth:	°
Location:	583029E , 6315357N	Collar Incline:	-70 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	85.0 mm
Elevation:	609 m asl	Geologist Logging:	Dave Skelton
Start - End Date:	20/10/1997 - 21/10/1997	End of hole (EOH):	76.80 m

Depth (m)	Lithology	Core at MCRF*	Description
0 to -24.38			OVERBURDEN: 0.00 - 24.38 m:
-24.38 to -32.61			SHALE: 24.38 - 32.61 m: Dark grey to black shale. Unit is comprised of two alternating shale horizons: continuous shale and shale pebbles/fragments in a clay matrix. Talc alteration of the shale is prevalent throughout the unit (greasy shale). Shale fragments in the clay are typically pebble to cobble sized. Clay is not kimberlitic. Bedding is not well developed in competent sectlons.
-32.61 to -67.50			KIMBERLITE: 32.61 - 67.50 m: Predominantly medium grey-green to pale beige-green. Variably altered olivine macrocrysts, 1 - 7.5 mm, comprise 40 - 60% of constituents. Olivines are rounded and internally fractured. Second population of fine grained, green, rounded olivine phenocrysts? Usually <1 mm locally altered, comprise 25 - 40% of fabric in anaphanitic light green serpentine + carbonate + clay matrix. Three distinct phases based on textural variations were observed: coarse olivine, fine olivine and a lapilli-rich section, transitions are gradual. Embayed olivine grains in shale were observed. Texture is relatively homogeneous over a given section of core (changes occur gradually) but is variable throughout the section. 5% rounded lapilli up to 2.0 cm (large lapilli are uncommon). <5% angular to predominantly rounded black shale xenoliths up to 3 cm -these are generally smaller and not common. Discontinuous weak to strong interstitial carbonate alteration in matrix and weak carbonate fracture network. No obvious preferred orientation to unit. Strong oxidation and large black shale xenoliths towards lower contact.
-67.50 to -76.80			MUDSTONE: 67.50 - 76.80 m: Light grey, fine grained, weakly consolidated interbedded muds, silts, and sand. Locally well defined bedding at 60° TCA.

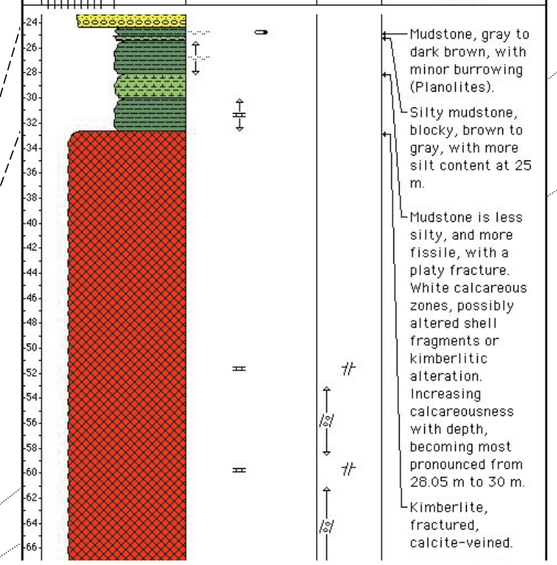
* Symbol denotes hand-sized sample of core is available at Mineral Core Research Facility at Alberta Geological Survey

B)

Ashton 97-14C-7
4-13-092-11w5 C7

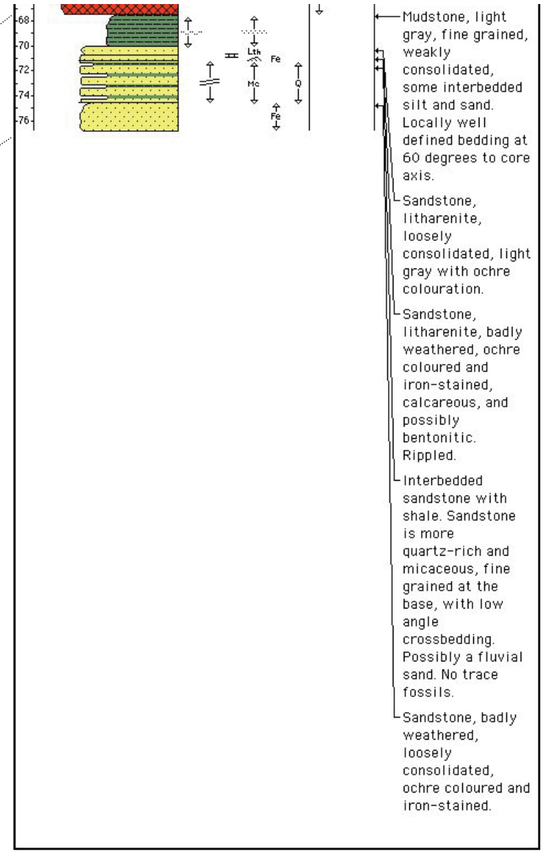
Date Logged: 20/10/1997 - 21/10/1997
Logged by: Dave Skelton; Collar Incline -70.
Ground: 0.00 m KB: 0.00 m
Remarks: **Collar incline -70. Cored Interval: 0 m to 76.8 m. Core quality: weathered to badly weathered. Examined available sedimentary core from 24 m to 33 m and from 68 m to 77 m. Detailed log of sedimentary core intersection, which was combined with published logs of the ore intersection.**

METERS | GRAIN SIZE (cobble, pebble, granule, sand, silt, clay; vc m f v) | PHYSICAL STRUCTURES | ACCESSORIES | ICHNOFOSSILS | FRACTURES | REMARKS



REMARKS:

- Mudstone, gray to dark brown, with minor burrowing (Planolites).
- Silty mudstone, blocky, brown to gray, with more silt content at 25 m.
- Mudstone is less silty, and more fissile, with a platy fracture. White calcareous zones, possibly altered shell fragments or kimberlitic alteration. Increasing calcareousness with depth, becoming most pronounced from 28.05 m to 30 m.
- Kimberlite, fractured, calcite-veined.



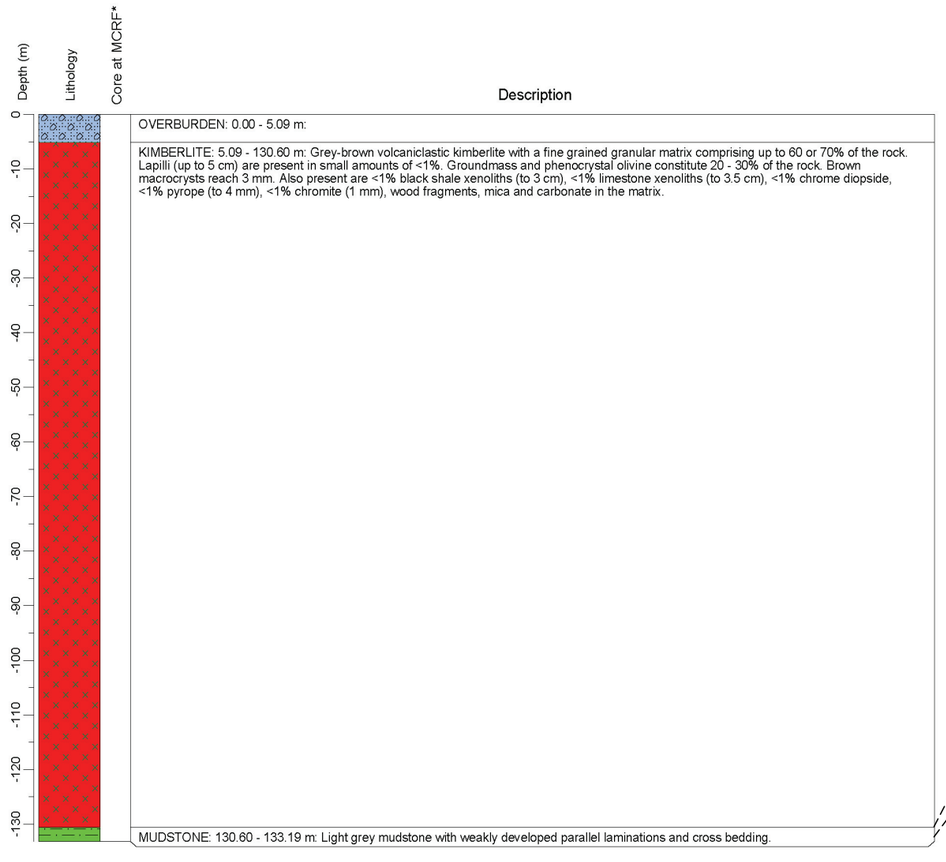
REMARKS:

- Mudstone, light gray, fine grained, weakly consolidated, some interbedded silt and sand. Locally well defined bedding at 60 degrees to core axis.
- Sandstone, litharenite, loosely consolidated, light gray with ochre colouration.
- Sandstone, litharenite, badly weathered, ochre coloured and iron-stained, calcareous, and possibly bentonitic. Rippled.
- Interbedded sandstone with shale. Sandstone is more quartz-rich and micaceous, fine grained at the base, with low angle crossbedding. Possibly a fluvial sand. No trace fossils.
- Sandstone, badly weathered, loosely consolidated, ochre coloured and iron-stained.

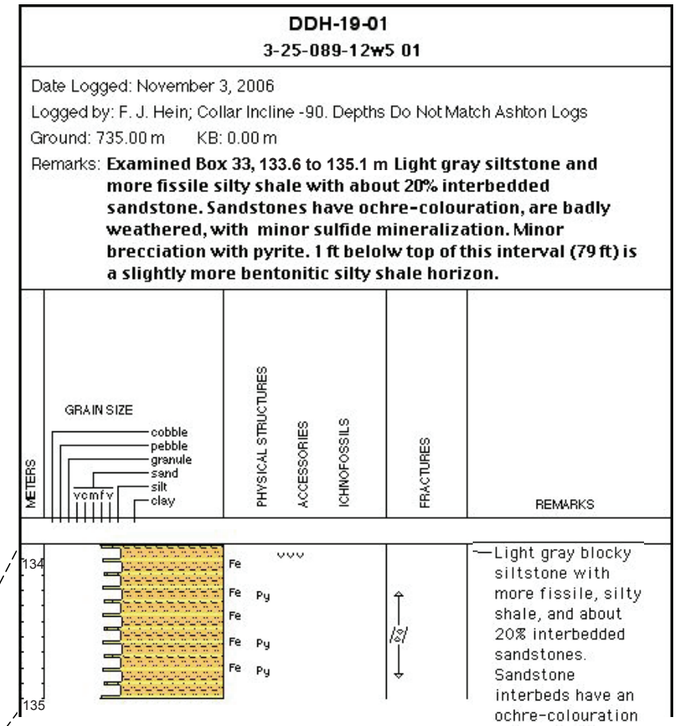
Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-14C-07: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	**K19**	**Company:**	**Ashton Mining Canada Inc.**
Drill Hole:	19-1	Collar Azimuth:	N/A °
Location:	575033E , 6289102N	Collar Incline:	-90 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	63.5 mm (HQ)
Elevation:	735 m asl	Geologist Logging:	R. Johnson
Start - End Date:	15/07/1997 - 20/07/1997	End of hole (EOH):	133.19 m



B)



Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-19-01: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

A)

Target:	**K91B**	**Company:**	**Ashton Mining of Canada Inc.**
Drill Hole:	DDH91B-01	Collar Azimuth:	°
Location:	581386E , 6316531N	Collar Incline:	-00 °
Zone & Datum:	Z11, NAD 27	Core Diameter:	63.5 mm (HQ)
Elevation:	667 m asl	Geologist Logging:	David Willis
Start - End Date:	22/10/1997 - 22/10/1997	End of hole (EOH):	93.57

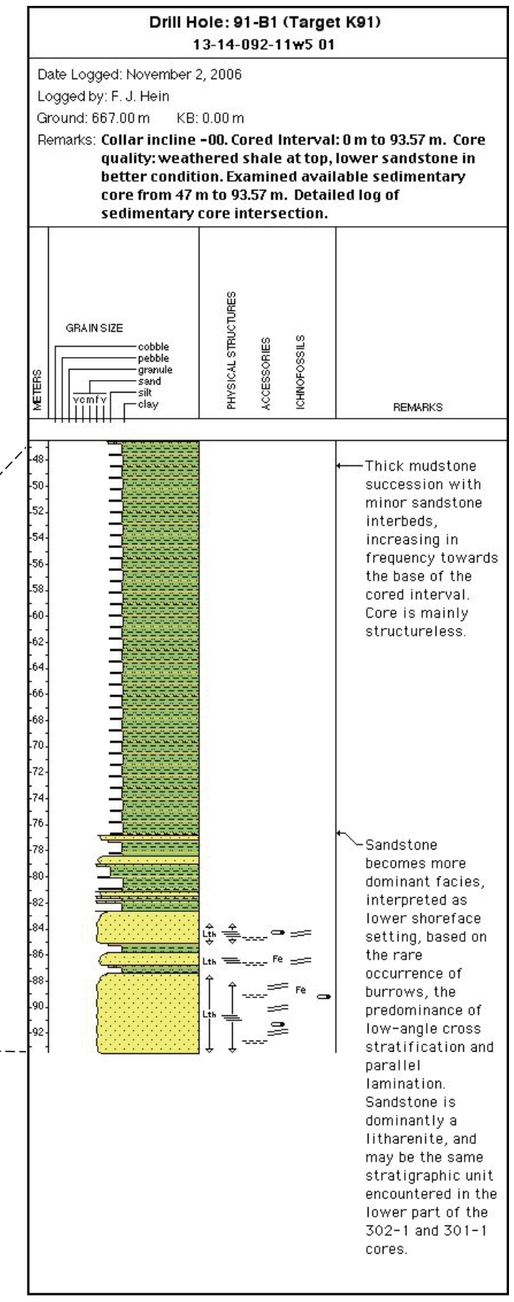
Depth (m)	Lithology	Core at MCRF*	Description
0 to -48.20			OVERBURDEN: 0.00 - 48.20 m: 8.23 - 11.28 m: Light brown sand and clay mixture. Fine grained sand. 11.28 - 14.32 m: Black till with abundant granite clasts. Clasts 1 to 4 cm in size. 14.32 - 32.61 m: Poor recovery of till. 1.20 m represents entire section (approximately 6%); High magnetic susceptibility up to 6.10. Average magnetic susceptibility 2.46.32.61 - 48.20 m: Black till with granite clasts. Clasts 1 to 2 cm in size.
-48.20 to -93.57			MUDSTONE: 48.20 - 93.57 m: Bedded mudstone grading from mud to sand. 48.20 - 85.90 m: Black mudstone with obvious bedding. 70° to 75° to core axis. 82.00 - 84.47 m: Transition zone from mud to sand.84.47 - 93.57 m: Gray sand with black banding. ~70° to 75° to core axis. Medium grained sand.

* Symbol denotes hand-sized sample of core is available at Mineral Core Research Facility at Alberta Geological Survey

B)

Drill Hole: 91-B1 (Target K91)
13-14-092-11w5 01

Date Logged: November 2, 2006
Logged by: F. J. Hein
Ground: 667.00 m KB: 0.00 m
Remarks: **Collar incline -00. Cored interval: 0 m to 93.57 m. Core quality: weathered shale at top, lower sandstone in better condition. Examined available sedimentary core from 47 m to 93.57 m. Detailed log of sedimentary core intersection.**



Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH97-91B-01: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

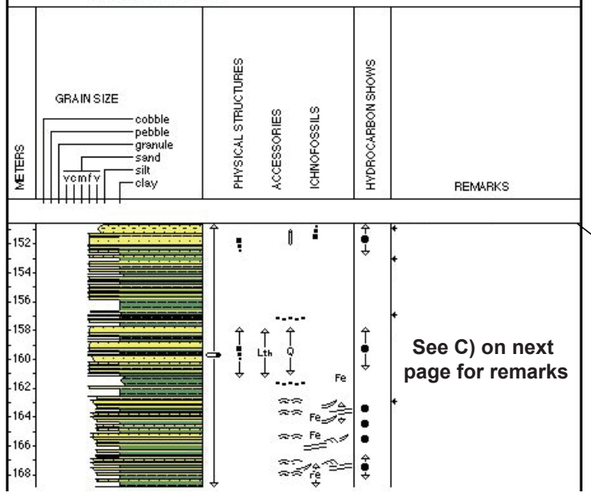
A)

Target:	BH302	Company:	Ashton Mining of Canada Inc.
Drill hole:	302-01	Collar Azimuth:	N/A
Location:	619871E, 6319547N	Collar Incline:	-90
Zone & Datum:	Z11, NAD 27	Core Diameter:	HQ/NQ
Elevation:	490 m above sea level (asl)	Geologist Logging:	L. Boyer and A. Henry
Start-End Date:	22/2/2003-25/2/2003	End of hole (EOH):	168.9 m

Interval	Rock Type	Description
0 to 105.2	TILL	Till
105 to 168.9	MUDST	Mudstone
168.9	EOH (m)	

BH 301-01 (same as BH 302-01)
1-27-092-07w5 01

Date Logged: November 2, 2006
Logged by: F. J. Hein; Collar Incline -90.
Ground: 149.35 m KB: 0.00 m
Remarks: **This core appears to be a re-entry on the BH 301-01 hole, with some repetition of depths, so repeat of stratigraphy. Logged separately, and will match overlap after drafting up the section. Need to do separately to correlate with palynology sampling. Bottom 3 boxes examined, numbered 23-25.**

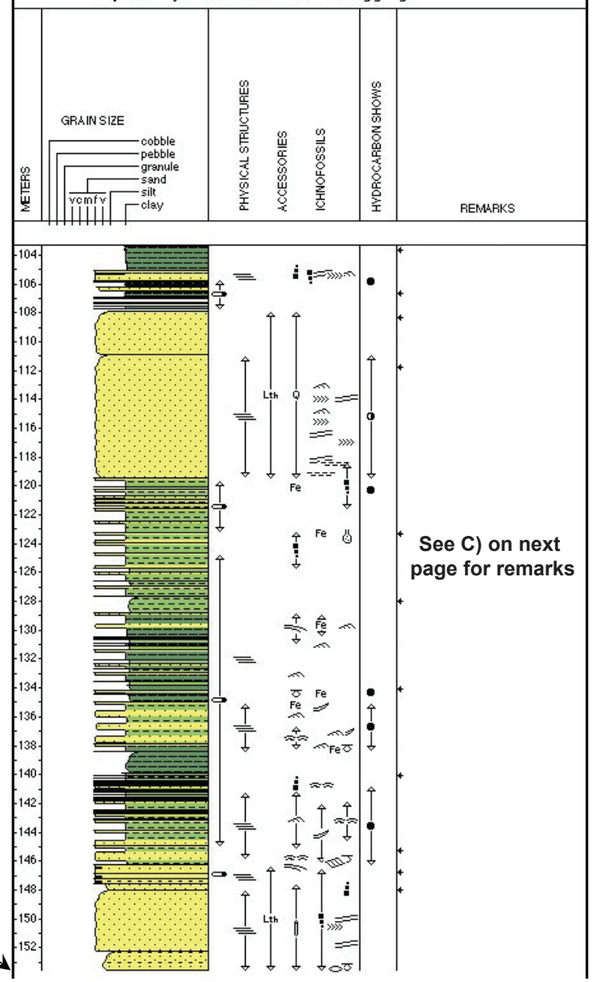


BH 301-01 is really the continuation of the BH302-01 drill hole

B)

BH 302-01
1-27-092-07w5 02

Date Logged: November 2, 2006
Logged by: F. J. Hein; Collar Incline -90.
Ground: 149.35 m KB: 0.00 m
Remarks: **Alternating mudstone with silty sand interbeds, bioturbated; minor Fe-st and concretions. Core is in good condition, better display of sedimentary structures. Top 15 boxes are missing.**
Core is numbered 302-1 for top; then probably re-entered & bottom 3 boxes are 301-01; ~ 10 ft overlap on depths, log separately and corrected after logging.



Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH-BH302-01: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study; C) drill log remarks (next page).

C)

BH 302-01

103.57 m
Fractured, burrowed sandy light gray mudstone, mainly massive., top ft or so is broken.

106.55 m
Fining up from sandy shale interbedded with sand, burrowed; to more organic medium to dark brown fissile shale, with heavy oil stained, bituminous sand interbeds. at top of unit, grades into mudstone, with bituminous burrow fills throughout.

108.26 m
Unconsolidated, very fine sand, qtz-litharenite. Very poor recovery at top.

111.68 m
Poorly consolidaqted sand at the top; poor recovery improving with depth. At the base at 120 m interbedded with shale, and moderate Fe-stained, overlain by mainly low angle to HCS cross str sands, minor ripples, very rare bioturbation; appears to be more quartz rich than underlying litharenites. Some hydrocarbon staining throughout. Upper shoreface.

123.30 m
Glossifungites surface; disconformity

127.95 m
Increase in separation of interbedded sands and shale vs. shale units; increase in burrowing within finer successions, and more Fe-st cemetation in upper 1/2 - 1/3 of cored interval. No obvious hydrocarbon staining in this part of the succession.

134.01 m
Slight increase in the percentage of sand, good graded laminae; flaser and tidal couplets; slight increase in percentage of burrowing within finer beds. Overall same tidal shelf succession. Minor Fe-stain/sid in some of coarser interbeds.

140.05 m
Tidal shelf, no obvious fining up until the top 1.5 m of this cored interval which appears to be finer shales. Same as below flaser ripples, ripples, tidal couplets, delicate interlamination, beds on a scale of cm or less. Very low to rare degree of bioturbation; mainly Planolites.

145.25 m
Excellent flaser ripples, climbing flaser ripples, some herringbone, tidal influenced shelf. Moderate to relative low degree of bioturbation. Mainly Planolites; rare Skolithos in thin coarser sand interlaminae. Minor hydrocarbon stain throughout.

146.69 m
Stacked HCS and swaley cross strat; relatively minor burrows compared to below.

147.96 m
Heavily bioturbated, Many prominent Skolithos burrows, slightly gn caste, litharenite, does not appear to be glauconitic. Coarsening up succession. Upper shoreface. Minor concretion at base of succession. Slightly fining up at 147.5 m.

BH 301-01 (same as BH 302-01)

150.83 m
Coarsening up shoreface succession, heavily bioturbated, as base of the 301-01 core. Same stratigraphy. Sturctgures better displayed in the 301-01 core. Qtz lith arenite, minor hydrocarbon staining.

152.92 m
Alternating pulses of sand and mudstone, mainly bioturbated; some flasers, graded laminations, tidal couplets, but more extensively burrowed, so more difficult to see sed structures. Lower shoreface.

156.80 m
Laminated sandy mudstone, alternating with more fissile and organic shales. minor laminations, rippling, graded laminations, and minor Fe stained throughout. More noticeable in lower 1/4 and top 1/4 of cored interval. Minor hydrocarbon staining patchy and in more coaraser beds. Again mainly lower shoreface environment.

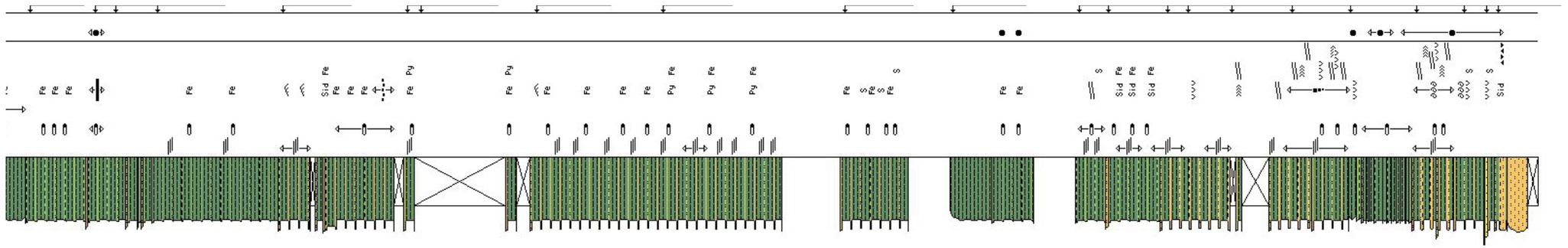
162.85 m
As above, but thinner cycles of sand alternating and coarsening up from sandy mudstone and shale, each cycle aboput 0.256 - 0.3 m thick. Minor rippling preserved, flasers and graded laminations, hydrocarbon stained. minor Fe st in lower 2/3 of cored interval.

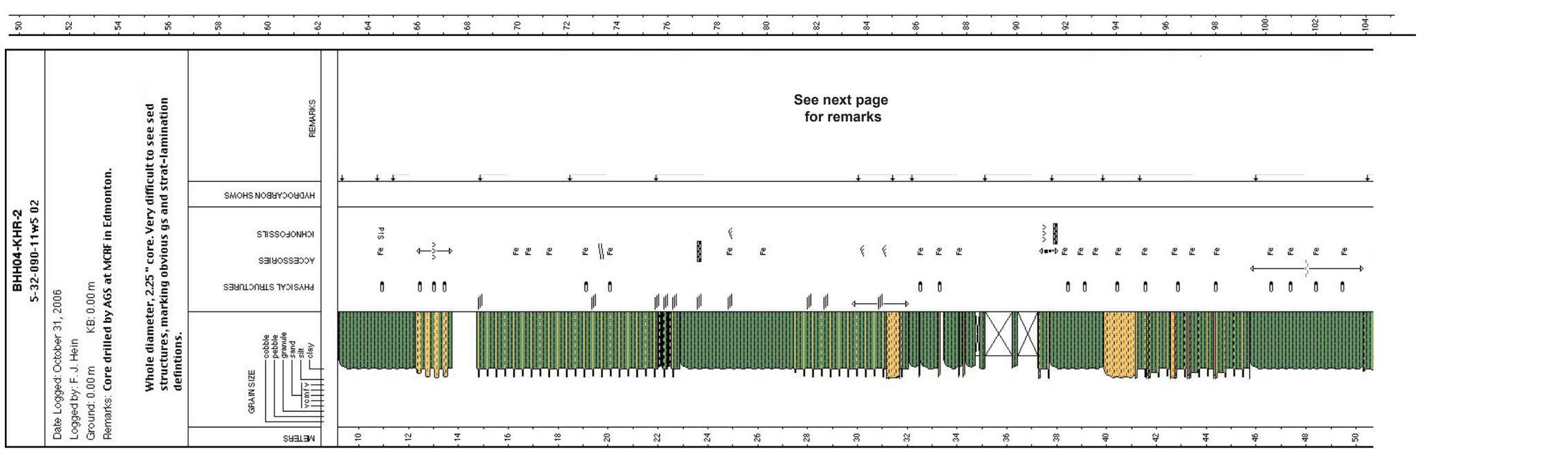
Appendix 1. Drill logs for Ashton Mining of Canada Inc. drill hole DDH-BH302-01: A) Ashton drill log; B) detailed drill log of the sedimentary core made available by Ashton for this study.

Target: **Stratigraphic Study hole drilled by Geological Survey of Canada and Alberta Geological Survey**
Drill hole: BHH04-KHR-2
Location: 577884E, 6300970N
Zone & Datum: Z11, NAD 27
Elevation: 490 m above sea level (asl)
Start-End Date: 09/12/2004-15/9/2004
Collar Azimuth: N/A
Collar Incline: -90
Core Diameter: HQ
End of hole (EOH): 105.16 m

Appendix 1. Detailed drill log, BHH04-KHR-2. Drill core remarks on next page.

See next page for remarks





BHH04-KHR-2

9.29 m
Massive, mainly light gy to tan mudstone, poor recovery at top; poor bedding definition.
10.68 m
Irregular, perhaps brecciated mudstone, with veinlets of unaffected mudstone (vertical or subvertical) separated by sideritized/limonitic or Fe-cemented mudstone, in angular and irregular zones. Does not appear to be obviously a pedogenic or bedding alteration.
11.33 m
Small white irregular blebs on core surface, ? altered weathered clasts, or altered burrow fills. Become more defined in lower 1/3 of core interval. Some of these seem to be 'coming out of the core' whereas others look like sand grains; possibly altered bentonite clasts (?). Slightly more massive, indurated siltstone towards base of core.
14.80 m
As above, with minor siltstone laminae. Some better preserved laminations in top 0.25 m of core. Occasional Fe-stained/limonitic alterations ? after white altered clasts, and the rare interbed of altered, coarser grained , sand burrow fills or wispy laminations/interbeds.
18.41 m
As above, with minor siltstone laminae. Scattered Fe-stained/limonitic alterations ? after white altered clasts, and the rare interbed of altered, coarser grained, sand burrow fills or wispy laminations/interbeds. Towards the base are what appear to be darker (? organic rich) finer beds, with a slight increase in fissility.
21.86 m
Faint parallel laminations preserved, within slightly darker gray, perhaps more organic, interbeds.
30.00 m
Laminations and minor wispy ripples better defined in lower 1/2 of core interval.
32.13 m
Minor coarser clayey silty interbeds, bioturbated, with some Fe-stained, ochre/ limonitic alteration.
35.09 m
Very poor recovery
37.76 m
Slightly more organic, fissile interbeds towards base; possible bentonitic interlaminations in overlying coarser unit.
39.78 m
Slightly coarser, and more massive, clayey siltstone towards base. Minor Fe-stain/burrow fills scattered throughout this core.
41.29 m
As above.
45.95 m
Mainly massive silty mudstone, with minor dispersed coarser burrow fills with Fe-staining; plant stem fragment at the top of this core interval.
50.41 m
Mainly structureless mudstone/silty mudstone, with some burrows throughout, slight oil stain and/or Fe-stain alteration as rims.
52.51 - 53 m
Patchy oil stain, bituminous, after burrows, and or with slight Fe-stain. Slightly more organic interlaminations.
53.51 m
Rare coarser siltstone interbedsl, especially towards base of this cored interval.
55.04 m
As above, slightly finer grained, minor Fe-st burrow fills, ? some pyritic; minor laminations preserved. Mainly structureless.
59.59 m
Slightly better preservation of laminations; dispersed Fe-stained, rimmed burrow fills, pyritic?, rare coarser interbed is also Fe-st/limonitic. Fine communited organic detritus. 64.09 m
Pyritic burrow fills, with Fe-stain alteration rims, minor laminations, but mainly structureless.
64.60 m
Lost core 64.41 - 67.7 m and 68.1 - 68.58 m
68.79 m
As above.
73.38 m
Laminations with minor rippling, slightly better displayed.
Pyritic burrow fills, with Fe-st/sideritic alteration rims. Otherwise structureless.
79.96 m
Slightly more fissile; perhaps finer grained than overlying interval. Minor Fe-stained and limonitic bands, ? after coarser interbeds or burrowed zones.Some sulphur coming out of core (ochre colouration).
83.91 m
Slightly more fissile interbeds, minor more organic interbeds, with some bitumen staining towards the base. Slightly finer grained at top.
88.48 m
Slightly less fissile, silty mudstone. Laminations better defined in scattered zones throughout this cored interval. Minor alteration rims around pyritic burrows, Fe-st or sideritic. More sulphur coming out of top part of core (ochre colour).
89.52 m
Massive, medium gry clayey siltstone, with conchoidal fracture. Anomaly ?.
91.70 m
Slilghtly coarser grained, siltier. Laminations better preserved, minor sulphur (ochre colour) coming out of core; Fe-st alteration rims around burrows.
92.44 m
White blebs; ? bentonitic below red marker (? anomaly).
94.02 m
Lost core.
96.19 m
Organic rich, silty mujdstone. Bedding and lamination is better defined. Bentonitic shale towards base. Finely communitued plant debris; Sulphur coming out of core, some around what appear to be stems. Fissile organic shale interbed above bentonitc shale. Bedding and laminations are better defined. Isolated white blebs, perhaps ? reworked bentonite into burrow fills higher upsection above bentonitic shale. Lower shoreface, possible hummocky cross-stratification.
98.33 m
Bituminous shales interbedded with bentonitic shale.
100.73 m
Bituminous, low angle cross bedded to parallel laminated clayey siltstone/silty mudstone, with dispersed and degraded shell fragments; dispersed white blebs ? altered, bentonitic burrow fills. Minor sulphur stain, quite organic looking. Lower shoreface.
102.47 m
White crystals aqnd sulfphur coming out of core, ? after altered bentonitic sands or silty sands.
103.27 m
Altered, bentonitic sand bed.
103.67 m
Vuggy, altered, indurated siltstone, broken core, top 1/2; below are more competent pieces of core; highly indurated. Older (? Albian) succession. Unconformity is marked by broken core and sideritization.

Appendix 2. Formation Tops Markers (Metres) from Selected Wells in the Buffalo Head Hills Area.

Formation Acronyms -->		"QUATRNRY C"	"SHAFTBR"	"BFSC"	"PEACERV"	"CADOTT"	"JOLIFU"	"MANN"	"HAR-MON"	"NOTIK"	"SPIRITRV"	"GETH"
Unique well identifier (UWI)	Kelly Bushing	Quaternary	Shaftesbury Formation	Base of Fish Scales	Peace River Group	Cadotte Formation	Joli Fou Formation	Mannville Group	Harmon Formation	Notikewan Formation	Spirit River Group	Gething Formation
00/16-20-088-12W5/0	704	230.4				299.1						
00/04-35-088-12W5/0	687.7	233.6				288.7						
00/06-05-088-13W5/0	678.2	36.8										
00/11-19-088-13W5/0	718.4	182.5										
00/08-21-088-13W5/0	723.4	322.2				311.1			330.1	341.3		
00/07-23-088-13W5/0	714.5	335.5							325			
02/08-24-088-13W5/0	708.9	223.8		238.2	297.8	299				326.5		
00/05-26-088-13W5/0	720.7	311				315.6			338.3	349.1		
00/08-30-088-13W5/0	720.8	301.6				313.2			335.8	345.8		
00/11-36-088-13W5/0	736.6	306.8										
00/16-36-088-13W5/0	735.9	311.6			319.1	323.4				359		
02/01-01-089-10W5/0	524.9	94.8				127						
00/12-24-089-10W5/0	527.6	86.8				129.8						
00/10-14-089-11W5/0	608.4	303				383.1			395.8	406.4		
00/12-15-089-11W5/0	637.7	220.6				239.1			254.1	269.4		
02/08-23-089-11W5/0	608.6	113.7				210.2			224.5	238.8		
00/02-33-089-11W5/0	652.2	315.1				358.9			372.6	385.3		
00/05-04-089-12W5/0	742.9	232.7				336			353.9	366		
00/08-06-089-12W5/0	755.4	234.1		282.8		338.3						
00/04-07-089-12W5/0	788.1	322.1		331.8		380.4			400.6			
00/10-12-089-12W5/0	684.6	274.8				288.7			305.2	319.9		
02/10-12-089-12W5/0	683.4	302.3				479.8			498.2	508.1		
00/09-13-089-12W5/0	694	325.9				466.7			480.6	493		
00/05-15-089-12W5/0	734.1	362.1				435.7			451.2	469.2		
00/10-17-089-12W5/0	729.3	325.7				328.3			341.8	354.5		
00/04-23-089-12W5/0	748.9	201.5				353.1						
00/01-24-089-12W5/0	703.5	327				304.3			321	334		
00/11-28-089-12W5/0	766.9	231.3										
00/16-29-089-12W5/0	746.3	224.4										
00/05-32-089-12W5/0	732.9	204.6										
00/01-33-089-12W5/0	774.4	343.9										
00/03-34-089-12W5/0	771.2	343.5				376.1			391.4	403.3		
00/01-36-089-12W5/0	710.4	339				312.7			330.6	341.6		
00/11-01-089-13W5/0	766	313.7				357.1			376.5	387.3		
00/10-11-089-13W5/0	736	304.1				328.4						
00/10-12-089-13W5/0	757.1	303.8										
00/13-14-089-13W5/0	712.7	230.1										
00/11-25-089-13W5/0	713.8	229.5			305.2	312.3						
00/10-35-089-13W5/0	716.4	317.4										
00/03-02-090-10W5/0	528	69.1				132.5				164		
00/04-01-090-11W5/0	594.5	192.4				195.4			214.8	232.1		
00/14-02-090-11W5/0	606.4	311.6				357.7			371.7	380.1		
00/07-03-090-11W5/0	609.9	317										
00/05-10-090-11W5/0	616.3	306.2				223.5			240.9	254.9		
00/06-11-090-11W5/0	593.2	310.5				299.8			319	329.3		
00/16-11-090-11W5/0	581.7	299				325.3			341.4	349.2		
00/07-12-090-11W5/0	570.9	322.2				337.1			355.3	367.2		
00/10-12-090-11W5/0	576.5	299.8				304.7			322.4	334.5		
00/06-16-090-11W5/0	632.7	296				408.1			418.5	432.5		
00/14-21-090-11W5/0	670.3	405.5										
00/14-22-090-11W5/0	627.3	341.9										
00/07-26-090-11W5/0	607.7	205										469.1
00/04-35-090-11W5/0	620	415.5										
00/11-06-090-12W5/0	718.5	304.9				322.1			343.6	355.2		
00/15-10-090-12W5/0	753.9	427.4				362.7			378.1	389.1		
00/06-12-090-12W5/0	714	299.7				318.7			334.4	347.7		
00/11-18-090-12W5/0	761.5	422.1				369.6			390.1	398.2		
00/14-19-090-12W5/0	767.6	307.3			364	372.9				404		
00/10-23-090-12W5/0	713.5	193.9		251.8		312.7						
00/04-29-090-12W5/0	755.3	320.3			356.4	359.4				387	384	
00/06-35-090-12W5/0	737.8	320				350.4			369.8	383.5		
00/02-02-090-13W5/0	719.5	306.1				321.1			343.3	353		
00/10-02-090-13W5/0	723.6	213.2							348.9			
00/03-06-090-13W5/0	699.7	310.5				297.3			317.1	325.9		
00/01-17-090-13W5/0	756.7	232.6										
00/06-25-090-13W5/0	801.8				395.5	399.1						
00/07-26-090-13W5/0	798	457.8				399.9			422.1	430.8		

Formation Acronyms -->		"QUATRNRY C"	"SHAFTBR"	"BFSC"	"PEACERV"	"CADOTT"	"JOLIFU"	"MANN"	"HAR-MON"	"NOTIK"	"SPIRITRV"	"GETH"
Unique well identifier (UWI)	**Kelly Bushing**	**Quaternary**	**Shaftesbury Formation**	**Base of Fish Scales**	**Peace River Group**	**Cadotte Formation**	**Joli Fou Formation**	**Mannville Group**	**Harmon Formation**	**Notikewan Formation**	**Spirit River Group**	**Gething Formation**
00/15-28-090-13W5/0	786.4	350.6			376.9	381.2			405.2	413.4		
00/13-30-090-13W5/0	821.8	244.8			405	409.5						
00/02-32-090-13W5/0	809.9	383				394.7			417.4	429.1		
00/04-36-090-13W5/0	796	323.8			390.5	394.2						
00/14-36-090-13W5/0	800					398.6			417.3	428.9		
03/10-02-091-10W5/0	529.4	112.1								167.3		
00/02-04-091-10W5/0	557	275.1				408.8			423.4	426.3		
00/11-04-091-10W5/0	560.7	325.1				414			429.1	436.2		
02/15-12-091-10W5/0	521.1	104			123	126.4				161		
02/11-14-091-10W5/0	536.4	103.4			127.9	133.6						
00/11-15-091-10W5/0	552.6	27.7		92.1		156.5						
00/01-16-091-10W5/0	561.6	347.1				411.4			421.7	436		
00/12-22-091-10W5/0	558.7	275				325.8			333.6	339.4		
02/12-25-091-10W5/0	527.5	5.3			123.4	127.3						
00/03-26-091-10W5/0	545.2	103			143	147.2				186.8		
00/03-01-091-11W5/0	643.4	80.5							248.4			
02/03-01-091-11W5/0	626.7	127										
00/12-03-091-11W5/0	742.5	313.2										
00/11-11-091-11W5/0	682.4	190		226.2								
00/08-16-091-11W5/0	775.1	1231.4		1261.6		1322			1337.5	1353.4		
00/16-21-091-11W5/0	759.6	100.1	126.5	300.1		369.2			388.9	406	403.7	
00/11-34-091-11W5/0	726.3	121.4		263.9		331.7			352.4	370.2		
00/03-06-091-12W5/0	813.2	20.6			407.3	410.8			432.5	442		
00/06-07-091-12W5/0	811.7	365				410.8			432.7	441.9		
00/08-07-091-12W5/0	819.8	361.7				422.5			442.7	452.5		
00/09-07-091-12W5/0	804.6	364.6				406.3			427.5	436.3		
00/11-07-091-12W5/0	802.9	364.9				402.1			425	436.7		
00/12-08-091-12W5/0	795.7	316				398.6			420.6	431.7		
00/15-09-091-12W5/0	798.1	325.7				405.5			427.8	440.3		
00/04-11-091-12W5/0	812	318.1				419.1			441.9	456.5		
00/01-15-091-12W5/0	805.3	314.2			406.5	411.9						
00/04-17-091-12W5/0	775.1	320.6				377.6			401.1	413.3		
00/05-17-091-12W5/0	784.8	81.7				388.4						
00/14-17-091-12W5/0	802.4					405.4						
00/02-18-091-12W5/0	776.9	355.1				377						
00/04-18-091-12W5/0	796	338.3				395.2			419.9	429.5		
00/10-18-091-12W5/0	780	369.1				382.9			407.1	418.6		
00/04-19-091-12W5/0	767.5	23.8				368.4			392.1	405		
00/06-19-091-12W5/0	777.2	322.8				376.8						
00/10-19-091-12W5/0	791.4	352.1			390.1	397.4						
00/07-20-091-12W5/0	816.2	363.2				417.6			443.3	453.9		
00/14-20-091-12W5/0	808.4	17.6				411.6			433.6	446.2		
02/15-21-091-12W5/0	793.3	80.6				398.6						
00/04-28-091-12W5/0	792.4	271.2				404.3			427.9	440.1		
00/13-28-091-12W5/0	801.7	335				409.9			434.2	450.4		
00/02-29-091-12W5/0	809					417			439.3	450.7		
00/09-29-091-12W5/0	803.6	81.6			405.8	409.7						
F1/12-29-091-12W5/0	803.2	110.2							433.2	446.9		
00/08-30-091-12W5/0	786.7	161.3			387.8	390.8						
00/10-30-091-12W5/0	781.9	14				386.4			412.8	426.5		
00/11-30-091-12W5/0	767.8	75										
00/13-30-091-12W5/0	779.1	319.1				378.9			408.5	422.5		
00/04-33-091-12W5/0	804.9	352.4										
00/06-34-091-12W5/0	767.7	130.4										
00/08-01-091-13W5/0	827.1	19.1				423.2			447.1	455.2		
00/14-01-091-13W5/0	825.1	694.6				420.1			442.1	451.5		
00/16-01-091-13W5/0	825.1	379.1				424.3			443.7	455.2		
00/10-02-091-13W5/0	807.6	324.9				400.1						
00/11-10-091-13W5/0	765.4	315							379			
00/08-12-091-13W5/0	810.3	369.8				407.7			431.1	440.1		
00/09-12-091-13W5/0	805.7	364.4				407.1			428.6	437.1		
00/11-12-091-13W5/0	803.5	330.4				401.7			425.5	434.4		
00/02-13-091-13W5/0	786.8	381.2				387.7			410.1	421		
00/04-13-091-13W5/0	794.4	326.9				394.8			418.9	429.8		
00/08-13-091-13W5/0	787.5	13.4				389.9			414.9	424.9		
00/16-13-091-13W5/0	771.1	46.3				373.3			396.3	406.7		
00/11-17-091-13W5/0	748	328			334.3	337.1						
00/04-20-091-13W5/0	747.1	194.5										

Formation Acronyms -->		"QUATRNRY C"	"SHAFTBR"	"BFSC"	"PEACERV"	"CADOTT"	"JOLIFU"	"MANN"	"HAR-MON"	"NOTIK"	"SPIRITRV"	"GETH"
Unique well identifier (UWI)	**Kelly Bushing**	**Quaternary**	**Shaftesbury Formation**	**Base of Fish Scales**	**Peace River Group**	**Cadotte Formation**	**Joli Fou Formation**	**Mannville Group**	**Harmon Formation**	**Notikewan Formation**	**Spirit River Group**	**Gething Formation**
00/02-24-091-13W5/0	758.4	327.8				362.1			386.6	396.9		
00/15-24-091-13W5/0	760	434.9				363.2			388.3	399.6		
00/02-25-091-13W5/0	760.6	377.7							390.8	403		
00/16-25-091-13W5/0	788.5	450.7				389			420.5	432.2		
00/10-27-091-13W5/0	773.9	200				368.4						
00/15-35-091-13W5/0	810.5	331.4										
00/13-10-092-10W5/0	550.4	109.8			152.1	163.4				203.5		
00/12-13-092-10W5/0	540	4.3			142	147.5						
00/04-18-092-10W5/0	590.5	272.4				350.4			361.9	373.3		
00/14-21-092-10W5/0	561.3	5.1			160.1	166			189.9			
02/14-21-092-10W5/0	560.8	51.5				167			190.4			
00/15-21-092-10W5/0	557.5	11.2				168.1			189.1	209.5		
03/13-24-092-10W5/0	543.6	78.2			141.9	145.6				193		
00/04-29-092-10W5/0	570.4	24				176.1			200.8	218.7		
00/15-30-092-10W5/0	580.7					185.2			212.7	231.5		
03/04-34-092-10W5/0	556.3	105.4			156.6	162						
00/09-35-092-10W5/0	544.7					151.2			172.8	192.3		
00/03-36-092-10W5/0	546	5.1			145.3	148.9			173.6	195.9		
00/09-02-092-11W5/0	643.5	104.9		180.4		247.5				287.4		
00/06-07-092-11W5/0	793.4	205.5										
00/15-23-092-11W5/0	626.2	137				230.4				276.3		
00/05-26-092-11W5/0	648.5	6.3		58.8		256.8			283.8	300.7		
00/15-27-092-11W5/0	645	206.5				252.1						
02/16-30-092-11W5/0	752	4.9				355.8						
02/16-30-092-11W5/2	752	37.4				355.9						
00/09-03-092-12W5/0	772.5	343				373			404.2	419.1		
02/09-03-092-12W5/0	779	249.7		310.2		378.1			408.6	425.6		
00/01-05-092-12W5/0	778.1	1233.3										
00/02-05-092-12W5/0	790.7				383.9	387.5						
00/04-06-092-12W5/0	820.8	444.4				681.2						
00/06-06-092-12W5/0	819					425.7			455.3	469.3		
00/08-27-092-12W5/0	780.9	16.8			375.1	383.7						
00/06-29-092-12W5/0	778.2	190.9										
00/12-36-092-12W5/0	782	102.1			380	386				434.8		
00/13-01-092-13W5/0	778.5	203.7										
00/02-02-092-13W5/0	818.4	215.4										
00/07-02-092-13W5/0	815.3	437.4				410.3			444.6	457.6		
00/10-03-092-13W5/0	814.3	161.2			401.4	408.7						
00/10-07-092-13W5/0	746.8	228.7				347.1						
00/11-08-092-13W5/0	776.4	314.7			366.7	372.8						
00/06-11-092-13W5/0	818.1	255.2								463.1		
00/14-14-092-13W5/0	764.2	349.8				360.9			402.2	418.4		
00/16-16-092-13W5/0	772.4					374.6			409	423.6		
00/14-34-092-13W5/0	761.8	321.3			367	370.2						
00/10-02-093-10W5/0	543	96.3			149.8	153.4						
00/11-04-093-10W5/0	560.2	24.8			166.2	170.7				213.6		
00/02-05-093-10W5/0	564.9	40.7			168	175.3						
02/14-08-093-10W5/0	574.3	104.9				180						
00/15-10-093-10W5/0	554.5	24.4		98.3		164.1			189	211.2		
00/09-12-093-10W5/0	538.9	4.1	41.8	85.2	137.2	144.5						
00/11-13-093-10W5/0	540.8	100.7			134.1	148.1			172.6	194.2		
00/11-14-093-10W5/0	545.8	101.6			140	156.1				200.2		
00/03-15-093-10W5/0	552.9	94.9			147.5	167			188.7			
00/05-22-093-10W5/0	559.2	24.4			157.8	166.8						
00/06-23-093-10W5/0	545.3	5.2			144.2	152.2			175.6	196.3		
00/04-25-093-10W5/0	543.3	56.9		82.4		151.1	167.2	187.8	176.5	198.5		
00/04-27-093-10W5/0	554.5	113.9			143.6	162.5						
00/12-28-093-10W5/0	568.3	8.2	34.3		173.1	179.3				224.3		
00/09-30-093-10W5/0	588	92.9			186.4	198.1						
00/16-04-093-11W5/0	716.8	3	171.5		308.7	328.7						
02/02-05-093-11W5/0	739.4	120.1	142.8		328.9	344.6						
00/15-09-093-11W5/0	737.3	3	129.4			341.6						
00/04-10-093-11W5/0	722.4					345.2			377.9	399.5		
00/13-10-093-11W5/0	724.8	133.8				331.8						
00/03-11-093-11W5/0	664.7	5.4			260.8	269						
00/10-32-093-11W5/0	779.2	91.3	131.6			390.9			419.1	449.7		
00/09-04-093-12W5/0	782.9	23.5			368.9	383.6						
00/10-14-093-12W5/0	793.6	105.3				400.6			434.9			
00/06-05-093-13W5/0	702.9	249			312.7	317.7			345.5	354.1		

Formation Acronyms -->		"QUATRNRY C"	"SHAFTBR"	"BFSC"	"PEACERV"	"CADOTT"	"JOLIFU"	"MANN"	"HAR-MON"	"NOTIK"	"SPIRITRV"	"GETH"
Unique well identifier (UWI)	**Kelly Bushing**	**Quaternary**	**Shaftesbury Formation**	**Base of Fish Scales**	**Peace River Group**	**Cadotte Formation**	**Joli Fou Formation**	**Mannville Group**	**Harmon Formation**	**Notikewan Formation**	**Spirit River Group**	**Gething Formation**
00/06-16-093-13W5/0	707.6	104.1			320.1	325.9						
00/07-17-093-13W5/0	683.5	101.3			298.7	304.3				336		
00/10-22-093-13W5/0	725.1	327.6								374		