Table A1. Key sections of the Lisburne Group and related units, northern Alaska

[See Table A2 for additional data. Lisburne Group in parauthochthon found in subsurface below North Slope and in northeastern Brooks range east of ~150°W and north of ~69°N. Allochthonous Lisburne exposed throughout western, central, and southeastern Brooks Range; named plates mostly W of 155.5°W. Allochthon data mainly from outcrop, but includes some drill hole data from Endicott Mountains allochthon in Red Dog district and Lisburne 1 well. *, occurrence of this allochthon at this locality too small to be shown on Figure 1. For extent and structural stacking order of allochthons and plates, see Mayfield et al. (1988), Young (2004), and Dumoulin et al. (2004). Structural terminology after Young (2004) unless otherwise specified. Allochthons: EMA, Endicott Mountains; IRA, Ipnavik River; KRA, Kelly River; NRA, Nuka Ridge; PCA, Picnic Creek. Quadrangles shown on Figure 1: BM, Baird Mountains; CL, Chandler Lake; DM, De Long Mountains; HP, Howard Pass; KR, Killik River; MM, Misheguk Mountain; PH, Point Hope. Unit name in bold indicates locality is type section. Mamet foraminiferal zones from Armstrong and Mamet (1977). Age abbreviations: e, early; l, late; m, middle; C, Chesterian; K, Kinderhookian; M, Meramecian; Mo, Morrowan; O, Osagean. App., appendix; DDH, diamond drill hole]

Name and (or) Locality No., Figures 1, 3	Structural Setting	Area and (or) Quadrangle	Units	Depositional Setting (of Lisburne Group unless specified)	Age Control	References	Remarks
Main Lisburne Platform							
1	Parautochthon or EMA	North Lisburne Peninsula (PH)	Lisburne Group: Kogruk Formation, Nasorak Formation	Shallow water.	Conodonts: probable l M to e C for Nasorak-Kogruk transition.	94 TM 78 (Moore et al., 2002).	
19	North Slope parautochthon	Northeast Brooks Range	Lisburne Group: Wahoo Limestone, Alapah Limestone Endicott Group: Kayak Shale	Shallow water.	Foraminifers: Mamet zones 20, 21 (Wahoo); 16i, 16s, 18 (Alapah).	69A-1 (Armstrong and Mamet, 1977).	Many additional sections in Armstrong and Mamet (1977) and references therein.
Prudhoe Bay (PB)		Subsurface	Lisburne Group: Wahoo Limestone, Alapah Limestone Endicott Group: Kayak Shale, Kekiktuk Conglomerate	Shallow water.	Foraminifers: Mamet zones 20, 21 (Wahoo); 17, 18 (Alapah).	Armstrong and Mamet (1974).	Additional data on subsurface Lisburne in Bird and Jordan (1977).
Northwest Platform Margin							
2	Parautochthon or EMA	South Lisburne Peninsula (PH)	Lisburne Group: **Nasorak Formation** Endicott Group: Kapaloak sequence (“undivided Mississippian sedimentary rocks” of Campbell, 1967).	Shallow water (Kogruk); Nasorak includes deeper water facies.	Megafossils: Late Mississippian (Nasorak); O (Kapaloak).	Section B (Campbell, 1967).	Kapaloak name introduced by Moore et al. (1984).
3			Lisburne Group: Tupik Formation (phosphatic unit of this paper), Kogruk Formation, **Nasorak Formation**.	Shallow water (Kogruk); Nasorak and Tupik (phosphatic unit) are deeper water facies.	Megafossils: C (Kogruk); Early and Late Mississippian (Nasorak).	Section A (Campbell, 1967); 08AD20 (this paper).	See also: Armstrong et al. (1971); Armstrong and Mamet (1977).
Southwest Platform Margin							
7	EMA (Wolverine Creek plate)*	Rok window (DM)	Lisburne Group: Kogruk Formation, Utukok Formation; phosphatic unit of this paper in sections in Mt. Raven window of this plate. Endicott Group: Kayak Shale	Mainly shallow water; locally deeper water, including uppermost part of Kogruk (phosphatic unit).	Conodonts: very e C (top of Kogruk); m-l O (lower Kogruk); O (upper Utukok).	Loc. 14, fig. 2 (Dumoulin et al., 2004); loc. 73 (Dumoulin et al., 2006).	See loc. 42 (Dumoulin et al., 2006) for phosphatic unit in this plate.
Ivotuk Hills (IH)	EMA (Ivotuk plate)	KR (outcrop section)	Lisburne Group: Ivotuk Hills sequence (upper part is phosphatic unit of this paper).	Mainly shallow- to moderate water, but deeper water for upper strata (including phosphatic unit).	Conodonts: l C (uppermost beds); e C (phosphatic unit); e O, l M (lower part).	Outcrop section (Dumoulin and Harris, 1993); loc. 6 (Dumoulin et al., 2011).	Additional information from nearby Lisburne 1 well (Dumoulin and Bird, 2002; loc. 7, Dumoulin et al., 2011).
Skimo Creek (SC)	EMA (Skimo thrust sheet of Dumoulin et al., 2008b)	CL	Lisburne Group: Alapah Limestone (includes phosphatic and mudrock units of this paper), Wachsmuth Limestone.	Mainly shallow water; deeper water for phosphatic and mudrock units.	Conodonts, foraminifers: M to Mo (Alapah); C to e Mo (mudrock unit); e C (phosphatic unit; O (Wachsmuth).	Armstrong and Mamet (1977), Dumoulin et al. (2008b); loc. 11 (Dumoulin et al., 2011).	Additional information from nearby Confusion Creek (loc. 10, Dumoulin et al. 2011).
18 (Shainin Lake)	EMA (?Tiglukpuk thrust sheet of Dumoulin et al., 2008b)		Lisburne Group: **Alapah Limestone** (includes phosphatic unit of this paper), **Wachsmuth Limestone.** Endicott Group: **Kayak Shale**	Mainly shallow water; deeper water for phosphatic unit; top of section here is Holocene erosion surface.	Conodonts, foraminifers: l M to C (Alapah); O to e M (Wachsmuth); K (Kayak).	Armstrong and Mamet (1977), Dumoulin et al. (1997); loc. 12 (Dumoulin et al., 2011).	Conodonts, foraminifers, and cephalopods indicate l M to e C for phosphatic unit.
West Kuna Basin							
Red Dog (RD)	EMA (Red Dog plate)	DM	Etivluk Group: Siksikpuk Formation Lisburne Group: Kuna Formation (Ikalukrok and Kivalina units).	Deep water.	Conodonts, radiolarians: probably Mo (lower Etivluk); probably C (upper Ikalukrok); m O (Kivalina-Ikalukrok transition).	Composite section from DDHs 50, 640, and 664, locs. 136, 139, and 142 (Dumoulin et al., 2006).	Much additional lithologic and fossil data from Red Dog plate in Dumoulin et al. (2004, 2006).
6	EMA (Key Creek plate)		Lisburne Group: Kuna Formation Endicott Group: Kayak Shale	Deep water.	Conodonts: m O (lower Kuna).	Loc. 2, App. (Dumoulin et al., 2004); loc. 103 (Dumoulin et al., 2006).	Kuna-Kayak transition well exposed here.
8			Etivluk Group: Siksikpuk Formation Lisburne Group: Kuna Formation	Deep water.	Conodonts and radiolarians: probably Mo (lower Etivluk); e C (upper Kuna).	Loc. 6, App. (Dumoulin et al., 2004); loc. 107 (Dumoulin et al., 2006).	Kuna-Etivluk transition well exposed here.
4	PCA (Wulik plate)		Etivluk Group Lisburne Group (no named subunits) Endicott Group: Kayak Shale	Deep water.	Conodonts: m O, l M, e C (Lisburne).	Loc. 3, App. (Dumoulin, et al., 2004); locs. 34-35, 38 (Dumoulin et al., 2006).	
Central Kuna Basin							
15	EMA (Aniuk River plate)*	HP	Lisburne Group: Kuna Formation, Rough Mountain Creek unit. Endicott Group: Kayak Shale	Deep water (Kuna); shallow water (Rough Mountain Creek).	Conodonts: l K (Rough Mountain Creek); m-l K (Kayak).	Loc. 12 (Dumoulin and Harris, 1997).	

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Name and (or) Locality No., Figures 1, 3	Structural Setting	Area and (or) Quadrangle	Units	Depositional Setting (of Lisburne Group unless specified)	Age Control	References	Remarks
Central Kuna Basin (cont.)							
14	EMA (Key Creek plate)	HP	Etivluk Group Lisburne Group: **Kuna Formation**	Deep water.	Conodonts: e m O, l m O (Kuna).	Loc. 9 (Dumoulin et al., 1993); loc. 146 (Dover et al., 2004).	
16	PCA (Picnic plate)	KR	Endicott Group: **Kurupa Sandstone**	Kurupa is deep water (siliciclastic turbidites).	Plants: probably Early Mississippian (Kurupa).	Mull et al. (1987).	
17			Etivluk Group: Imnaitchiak Chert Lisburne Group: **Akmalik Chert**	Deep water.	Conodonts and radiolarians: e O, m O, probably l M (Akmalik).	Unit named in Mull et al. (1987); age data from Blome et al. (1998).	
Abby Creek (AC)		HP	Etivluk Group Lisburne Group: Akmalik Chert	Deep water.	Conodonts and radiolarians: probably Morrowan (lower Etivluk); probably C (Akmalik-Etivluk transition); m O (Akmalik).	Abby Creek barite section in Kelley et al. (1993).	
12	IRA (Ipnavik plate)		Lisburne Group: Rim Butte unit	Deep water.	Conodonts: l K-earliest O, m O, l O (Rim Butte).	Loc. 27 (Dover et al. 2004).	Redeposited older conodonts (Famennian and Kinderhookian) in m O conodont sample.
13			Etivluk Group Lisburne Group: Rim Butte unit	Deep water.	Conodonts: l M (Rim Butte).	Loc. 25 (Dumoulin et al., 1993).	
Kelly Platform							
5	KRA (Amphitheatre plate)	DM	Lisburne Group: Kogruk Formation (includes phosphatic unit of this paper), micritic limestone unit in nearby section.	Mainly shallow water; uppermost Kogruk (phosphatic unit) and micritic limestone unit are deeper water.	Conodonts: e Chesterian (phosphatic unit).	Loc. 15, App. (Dumoulin et al., 2004); loc. 94 (Dumoulin et al., 2006); loc. 2 (Dumoulin et al., 2011).	Micritic limestone unit at nearby loc. 95 (Dumoulin et al., 2006).
9	KRA (Eli plate)	BM	Lisburne Group: Kogruk Formation, Utukok Formation	Mainly shallow water; upper Kogruk is deeper water.	Conodonts and corals: m-l O, M (Kogruk); K, m O (Utukok).	Maiyumerak Mountains section of Dumoulin and Harris (1992).	Deeper water upper Kogruk at loc. N (Dumoulin and Harris, 1992).
10	KRA (Kelly plate)	MM	Lisburne Group: **Tupik Formation** (phosphatic unit of this paper), **Kogruk Formation, Utukok Formation**	Mainly shallow water; Tupik (phosphatic unit) is deeper water.	Conodonts: likely Late Mississippian (phosphatic unit).	Sable and Dutro (1961); loc. 06AD21, table 2, (Dumoulin et al., 2011).	
Nuka Allochthon							
11	NRA	MM	Etivluk Group **Nuka Formation**	Shallow water; Nuka sections elsewhere range from deep marine (Solie and Mull, 1991) to nonmarine? (Young, 2004).	Conodonts: l C-e Mo (Nuka).	Unit named by Tailleur and Sable (1963) and revised by Tailleur et al. (1973); age data used herein from locs. 55-58 (Mayfield et al., 1984).	

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Table A2. Features of the Lisburne Group in Alaska, including paleogeographic position, structural and stratigraphic terminology, lithologies, and potential petroleum source and reservoir rocks

[Lisburne Group in parauthochthon found in subsurface below North Slope and in northeastern Brooks range east of ~150°W and north of ~69°N. Allochthonous Lisburne exposed throughout western, central, and southeastern Brooks Range; named plates mostly W of 155.5°W. Allochthon data mainly from outcrop, but includes some drill hole data from Endicott Mountains allochthon in Red Dog district and Lisburne 1 well. For extent and structural stacking order of allochthons and plates, see Mayfield et al. (1988), Young (2004), and Dumoulin et al. (2004). Structural terminology after Young (2004) unless otherwise specified. Quadrangles shown on Figure 1: A, Arctic; BM, Baird Mountains; Co, Coleen; Ch, Christian; CL, Chandler Lake; DM, De Long Mountains; HP, Howard Pass; KR, Killik River; MM, Misheguk Mountain; N, Noatak; TM, Table Mountain; W, Wiseman. CAI, conodont color alteration index; DDH, diamond drill hole; ms sec, measured section; NA, not applicable]

Allochthon	Plate (area) [Key sections, Table A1, Figs. 1, 3]	Lisburne Group subunits, thickness	Lisburne Group lithofacies (references)	Potential petroleum source rocks: maximum thickness, TOC, other data	Known or potential reservoir rocks and (or) oil data
Main Lisburne Platform					
North Slope parautochthon	NA (subsurface) [PB]	Wahoo Limestone, Alapah Limestone recognized locally; elsewhere, various informal subunit names used; <300 to >2000 m.	Dominantly shallow-water limestone and dolostone with minor but notable clastic content (sandstone, siltstone, shale) that increases northward (Bird and Jordan, 1977; Jameson, 1994; Dumoulin and Bird, 2001; McGee, 2004). Localized, paired, small-displacement vertical faults and disrupted intra-Lisburne reflections observed on seismic records southeast of Prudhoe Bay are interpreted as collapsed karst features.	Gray and green shale "marker" beds as much as 20 m thick are laterally persistent and widespread (Jameson, 1994); one sample from Prudhoe Bay field area reportedly has 14% TOC (Masterson, 2001).	Lisburne pool at Prudhoe Bay (Jameson, 1994). Wells west, south, and east of Prudhoe contain 40 to 120 m net thickness of dolostone with oil shows and 5 to >25% porosity (Bird and Jordan, 1977).
	NA (NE Brooks Range) [19]	Wahoo Limestone, 100 to >330 m; Alapah Limestone, 250 to >900 m.	Shallow-water limestone and dolostone (Mamet and Armstrong, 1972; Armstrong and Mamet, 1975; Watts et al., 1994).	Shale interbeds in the NE Brooks Range are noticeably less abundant than in the subsurface for reasons unknown (Jameson, 1994).	Dolostone intervals ~1 to 30 m thick have maximum porosities of 10-15% and locally contain rare dead oil (Bird et al., 1987).
Parautochthon or Endicott Mountains	Plates unnamed (North Lisburne Peninsula: Cape Lisb. to Noyalik Peak) [1]	Kogruk Formation, ~220 m; Nasorak Formation, ~250 m.	Mainly shallow-water limestone and dolostone; local karst breccia at top of Kogruk (Moore et al., 2002). Structural interpretations: Mayfield et al. (1988); Moore et al. (2002); Young (2004).		Nasorak Formation locally contains dead oil in vugs and veins (Moore et al., 2002).
	Plates unnamed (NE Brooks Range)	Alapah Limestone, ~475 m; Wachsmuth Limestone, >340 m.	Mainly shallow-water limestone and dolostone; thin shale beds at base of shallowing-upward cycles may have formed in outer ramp settings (McGee, 2004). Structural interpretations: Brosgé et al. (2001); W. Wallace, written commun. (2012).	Local shales <0.25 to 0.5 m thick. Shales have 0.09 to 9.75% TOC, n=17 (McGee, 2004).	
Ikpikpuk-Umiat Basin					
North Slope parautochthon	NA (subsurface)	Informal names; includes phosphatic unit of this paper; >1000 m.	Mainly shallow-water limestone; lower part of Lisburne in Inigok well (dolostone unit) contains deeper water interval 120-130 m thick of interbedded dark dolostone, black mudstone, and cherty spiculite; a similar, coeval interval 35 to 45 m thick in Ikpikpuk well (part of lower limestone unit) also contains granular phosphorite (Dumoulin and Bird, 2001; Dumoulin et al., 2011).	~75 m (Inigok well), >20 m (Ikpikpuk well) 9.6% TOC in cuttings near base of Lisburne in Inigok well may be contamination; most TOC values <1% (Magoon and Bird, 1988; Magoon et al., 1988).	
Northwest Platform Margin					
North Slope parautochthon	NA (subsurface; offshore, Chukchi Sea: Popcorn, Diamond, Crackerjack wells)	Permian transitional sequence, Wahoo Limestone, and Alapah Limestone (>1154 m).	Known from incomplete penetrations in 3 wells in rifted Hanna Trough (Sherwood et al., 2002). Subequal, mostly shallow-water limestone and siliciclastics (sandstone, siltstone, shale) that vary laterally and vertically in abundance and grain size; grades upward into Permian noncalcareous, spiculitic mudstone. Dolostone generally absent; evaporite minerals occur in Pennsylvanian limestones.		Limestone porosity generally < 5–10%; high porosity (~25%) observed in Permian spiculitic siltstones (Sherwood et al., 2002).

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Allochthon	Plate (area) [Key sections, Table A1, Figs. 1, 3]	Lisburne Group subunits, thickness	Lisburne Group lithofacies (references)	Potential petroleum source rocks: maximum thickness, TOC, other data	Known or potential reservoir rocks and (or) oil data
Northwest Platform Margin (cont.)					
North Slope parautochthon	NA (subsurface; onshore: Tunalik well)	Informal names; >1000 m.	Incomplete penetration encountered mainly deep-water, mud-rich, spiculitic limestone, with a unique 230 m-thick intercalation of Permian volcanic rocks (Dumoulin and Bird, 2001).	Average TOC (n=66) of 0.4% with maximum of 1.57% (Magoon and Bird, 1988).	
Parautochthon or Endicott Mountains	Plates unnamed (South Lisburne Peninsula: Cape Lewis to Chariot site) [2, 3]	Tupik Formation, ~100 to 160 m; Kogruk Formation, >1000 m; Nasorak Formation, ~670 m.	Kogruk is shallow-water limestone and dolostone; Tupik (chert, mudstone, phosphatic calcareous radiolarite) and Nasorak (limestone turbidites, shale) are deeper water facies (Campbell, 1967; Armstrong et al., 1971; Armstrong and Mamet, 1977; this paper).	~90 m of dark-gray, carbonaceous shale in lower part of Nasorak south of Cape Lewis (unit 2 of Armstrong et al., 1971). Black, calcareous shale of Nasorak near Chariot site (n=3) has TOC of 0.76-0.9 (this paper).	Black, calcareous shale of Nasorak near Chariot site (n=3) has solid bitumen Ro of 2.13-2.71 (this paper).
Southwest Platform Margin					
Endicott Mountains	Wolverine Creek (N, DL) [7]	Kogruk Formation (70 to 100 m), Utukok Formation (120 m), phosphatic unit of this paper (≤ 15 m) recognized locally.	Mostly shallow-water limestone, dolostone, and lesser mudrocks; intervals of deep-water black shale, chert, and carbonate, 5-30 m thick, occur locally at base and (or) in upper part of Kogruk; upper interval (phosphatic unit) includes phosphatic dolostone (Dumoulin et al., 2004, 2006, 2011).	30 m (4 localities). Black shale at Anxiety Ridge has 2.4% TOC (Slack et al., 2004c).	Kogruk dolostone has intervals 2 to >10 m thick with dead oil in vugs, fossil molds, and fractures.
	Ivotuk (HP, KR) [IH]	No formal formation names; includes phosphatic unit of this paper; 300 to 350 m (outcrop), >550 m (subsurface).	Mainly shallow- to moderate-water dolostone and lesser limestone, with 20- to 95-m-thick upper interval of deep-water, organic-rich black shale, chert, dolostone, and phosphorite; phosphatic unit generally ≤ 20 m thick (Dumoulin and Harris, 1993; Dumoulin and Bird, 2002; Dover et al., 2004; Dumoulin et al., 2004, 2006, 2011).	<20 to >50 m (3 outcrop measured sections and 5 thrust repeats of Lisburne in Lisburne 1 well) 6 shale and 4 phosphorite samples have 2-20% TOC, including 3 shale samples with ≥14.7% TOC (Dumoulin et al., 2011).	Dolostone unit, 80 to 120 m thick, has local dead oil and porosity as high as 10-13% (S. Hewitt, A. Kane, written communs., 1979).
	Plates unnamed; Skimo and Tiglukpuk thrust sheets of Dumoulin et al. (2008b) in Skimo Creek area (CL, KR, north of Toyuk thrust fault) [SC, 18]	Alapah Limestone, Wachsmuth Limestone recognized locally; includes phosphatic and mudrock units of this paper; >1300 m.	Mostly shallow-water limestone and dolostone, with deep-water interval ≤30 m thick of black shale, mudstone, phosphorite, and carbonate rocks in upper part of Lisburne (phosphatic unit); uppermost Lisburne (mudrock unit) locally consists of ≤40 m of deep-water, variably calcareous mudrocks, siltstone, and lesser glauconitic limestone (Armstrong and Mamet, 1978; Dumoulin et al., 1997; Whalen et al., 2005, 2006; Dumoulin et al., 2008b, 2011; White, 2007).	~15 m in phosphatic unit, 20 m in mudrock unit (3 ms sec). Phosphatic unit: 1.2-15% TOC in 12 shale and 20 phosphorite samples; 11 of 12 shales have ≥4.2% TOC (Brosgé et al., 1981; Dumoulin et al., 2011). Mudrock unit: 1.7-1.9% TOC, n=3 (this paper). Shales in lower Lisburne: 1.1-1.8% TOC, n=4 (Dumoulin et al., 2008b).	Dolostone intervals 10 to >40 m thick with dead oil (locally in geopetal structures) and porosities as high as 11% (Krynine et al., 1950)
Southeast Platform Margin					
Endicott Mountains	(A, C?)	Kuna Formation; 30 to 60 m.	Deep-water black shale and sooty limestone (Brosgé et al., 2001). Similar strata, including phosphatic limestone, may occur in Coleen quadrangle (Brosgé and Reiser, 1969).		

Table A2. Features of the Lisburne Group in Alaska, including paleogeographic position, structural and stratigraphic terminology, lithologies, and potential petroleum source and reservoir rocks

[Lisburne Group in parauthochthon found in subsurface below North Slope and in northeastern Brooks range east of ~150°W and north of ~69°N. Allochthonous Lisburne exposed throughout western, central, and southeastern Brooks Range; named plates mostly W of 155.5°W. Allochthon data mainly from outcrop, but includes some drill hole data from Endicott Mountains allochthon in Red Dog district and Lisburne 1 well. For extent and structural stacking order of allochthons and plates, see Mayfield et al. (1988), Young (2004), and Dumoulin et al. (2004). Structural terminology after Young (2004) unless otherwise specified. Quadrangles shown on Figure 1: A, Arctic; BM, Baird Mountains; Co, Coleen; Ch, Christian; CL, Chandler Lake; DM, De Long Mountains; HP, Howard Pass; KR, Killik River; MM, Misheguk Mountain; N, Noatak; TM, Table Mountain; W, Wiseman. CAI, conodont color alteration index; DDH, diamond drill hole; ms sec, measured section; NA, not applicable]

Allochthon	Plate (area) [Key sections, Table A1, Figs. 1, 3]	Lisburne Group subunits, thickness	Lisburne Group lithofacies (references)	Potential petroleum source rocks: maximum thickness, TOC, other data	Known or potential reservoir rocks and (or) oil data
Southeast Platform Margin (cont.)					
Higher allochthons	(A, Ch? TM?)	Akmalik Chert (~75 m); parts of map units ŦMs and ℙMp (15-150 m)	Deep-water black radiolarian chert, lesser slate, minor limestone and barite (Brosgé et al., 2001). Similar strata may occur in Christian and Table Mountain quadrangles (Brosgé and Reiser, 2000; C.G. Mull, written commun., 2012).		
West Kuna Basin (DL, MM)					
Endicott Mountains	Red Dog (DL) [RD]	Kuna Formation (Ikalukrok unit, <30 to >240 m; Kivalina unit, ≤122 m)	Ikalukrok is deep-water black shale and mudstone with intervals of carbonate (including calcarenite turbidites and calcareous radiolarite) and rare volcanic rocks; hosts massive sulfide and barite deposits in Red Dog district. Kivalina is deep-water, rhythmically interbedded variably calcareous shale and limestone (mostly carbonate turbidites) with minor volcanic rocks (Dumoulin et al., 2004, 2006; Kelley and Jennings, 2004).	15 to 100 m (outcrop, 4 measured sections); 20->130 m (26 DDH). 80% of 16 Ikalukrok shale samples from 6 outcrops and 70% of 136 samples from 13 mineralized drill holes have 2-11% TOC (Slack et al., 2004b, c, d). 37 of 40 mudrock samples from 100 m thick Ikalukrok section have 2-8% TOC (this paper).	Vein of solid dead oil seen in Kuna chert at Oak prospect. Five shallow wells (< 1,000 m) drilled to test shale-gas potential of the Kivalina as energy source for Red Dog Mine; volumes of gas recovered are considered uneconomic (AOGCC, 2012; Lidji, 2012).
Endicott Mountains	Key Creek (DL, MM) [6, 8]	Kuna Formation (60 to 110 m), Kogruk Formation (100 to 150 m), Utukok Formation (≥40 to 150 m).	Kuna is deep-water black shale and mudstone with lesser organic-rich dolostone and rare volcanic rocks. Kogruk and Utukok are mainly shallow-water limestone, dolostone, and subordinate mudrocks; upper 14 m of Kogruk are deeper water black shale, siliceous spiculite, and dolostone (Dumoulin et al, 2004, 2006).	~40 m (1 measured section) 5 of 7 shale samples from 6 localities have 2-5.3% TOC (Slack et al., 2004c).	Kogruk dolostone has porous zones 1 to >3 m thick with dead oil in fractures and vugs; local cavernous porosity in DDH 1104.
Picnic Creek	Wulik (DL, MM) [4]	No formal formation names, 100 to 280 m.	Mainly deep-water carbonate rocks (including spiculite, radiolarite, and turbidites), chert, and mudrocks (Dumoulin et al., 2004, 2006).	≤65 m (2 measured sections). 3 samples from 1 locality have 1.2-3.4% TOC (Slack et al., 2004c).	Fractures in carbonate rocks in DL B-1 quadrangle locally contain dead oil.
	Amaruk (DL)	No formal formation names, 150 to 280 m.	Mainly deep-water chert and carbonate turbidites (Dumoulin et al., 2004, 2006).	<10 m (1 locality).	
Ipnavik River	Nachralik Pass (MM)	No formal formation names, <100 m.	Deep-water spiculitic chert and lesser dolomitic/calcareous radiolarite (Dumoulin et al., 2004, 2006).	Mudrock rare or absent.	
Central Kuna Basin (HP, KR)					
Endicott Mountains	Drenchwater (HP)	Kuna Formation (>300 m).	Deep-water mudrocks, chert, rare limestone (including possible turbidites), and thick sequence of igneous rocks; hosts Drenchwater massive sulfide deposit (Werdon, 1999; Dumoulin et al., 2004).	>5-10 m (2 localities) 3 of 4 shale samples from 2 localities have 2-5% TOC (Slack et al., 2004c, this paper).	
	Aniuk River and Key Creek (HP, KR) [14, 15]	Kuna Formation (≤70 m), Rough Mountain Creek unit (15 to 17 m).	Kuna is deep-water black shale, mudstone, chert, and lesser organic-rich dolostone; Rough Mountain Creek unit is shallow-water limestone and lesser mudrocks (Dumoulin et al., 1993, 1994, 2004; Dumoulin and Harris, 1997; Dover et al., 2004).	5 to 50 m (7 measured sections) 67% of 49 shale samples from 26 localities have 2-11% TOC (Slack et al., 2004c, this paper).	Kuna Formation contains dead oil in fractures in HP C-3 quadrangle; CAI here ~1.5-2.

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Allochthon	Plate (area) [Key sections, Table A1, Figs. 1, 3]	Lisburne Group subunits, thickness	Lisburne Group lithofacies (references)	Potential petroleum source rocks: maximum thickness, TOC, other data	Known or potential reservoir rocks and (or) oil data
Central Kuna Basin (HP, KR) (cont.)					
Picnic Creek	Picnic (HP) [AC, 16, 17]	Akmalik Chert, a few tens of m to ≥100 m.	Deep-water black siliceous mudstone and chert, with local stratiform barite bodies associated with organic-rich shale and calcareous radiolarite; in NW, locally abundant turbidites made of dolomitized pelmatozoan packstone (Dumoulin et al., 1993, 1994, 2004, 2006; Dover et al., 2004; Johnson, 2008).	<5 to 10 m (1 ms sec, 15 localities) Shale associated with Stack barite occurrence has 22.4% TOC (Slack et al., 2004c).	Barite and dark limestone are locally petroliferous and contain dead oil in vugs and patches.
Ipnavik River	Ipnavik (HP) [12. 13]	Rim Butte unit; ≥70 to 85 m but repeated in multiple thrust imbricates.	Deep-water limestone turbidites interbedded with dark, siliceous, spiculitic mudstone and chert with rare interbeds of dolomitic radiolarite (Dumoulin et al., 1993, 1994, 2004, 2006; Dover et al., 2004).	<10 m (3 measured sections) Dark mudstone contains 0.1-0.8% TOC, n=3 (Slack et al., 2004c)	
East Kuna Basin (CL, W)					
Endicott Mountains	Plates unnamed (CL, south of Toyuk thrust)	Kuna Formation, Alapah Limestone, Wachsmuth Limestone, 240 to 500 m.	Shallow-water limestone and dolostone overlain by <100 to 200 m of deep-water chert, black shale, phosphatic limestone, and spiculitic limestone (Armstrong and Mamet, 1978; Nelson and Csejtey, 1990; Dumoulin et al., 1997, 2011).	~15 to 65 m (2 measured sections, Armstrong and Mamet, 1978; 3 locs. in Dumoulin et al., 2011) 7.2% TOC in Kuna Formation at Ekokpuk Creek (Brosgé et al., 1981).	Lower part of Lisburne has 15 to ≥50 m of vuggy dolostone with intercrystalline porosity (Armstrong and Mamet, 1978).
Kelly Platform (N, DL, BM, MM)					
Kelly River	Amphitheatre (DL) [5]	Kogruk Formation (includes phosphatic unit of this paper), ≥640 m; micritic limestone unit, 100 to 200 m.	Kogruk mostly shallow-water limestone and dolostone; uppermost Kogruk (phosphatic unit) is <15 m of deep-water black shale, lesser, locally phosphatic, limestone, and phosphorite nodules; deeper water micritic limestone unit (Mls) contains black shale and spiculitic chert (Dumoulin et al., 2004, 2006, 2011).	<15 m (upper Kogruk), 50 m (Mls) (2 localities). Black shale and phosphorite in uppermost Kogruk has 0.8-3.0% TOC, n=4 (Dumoulin et al., 2011).	Dead oil (in fractures?)
	Wulik Peaks-Kelly (DL, MM) [10]	Kogruk Formation (includes phosphatic unit of this paper), 200 to 600 m; Utukok Formation, >150 to 200 m.	Mostly shallow-water limestone and dolostone; uppermost Kogruk (phosphatic unit) is ≤10 m of deep-water black shale with local radiolarian-rich phosphorite nodules and (or) phosphatic limestone layers (Dumoulin et al., 2004, 2006, 2011).	≤10 m (3 localities) Black shale and phosphorite in uppermost Kogruk has 2.8-7.7% TOC, n=3 (Dumoulin et al., 2011).	Kogruk limestone locally contains dead oil in vugs and fractures. Pyrobitumen noted in fractures in Utukok Fm.
	Eli (BM, DL, MM, N) [9]	Kogruk Formation, 160 to 300 m; Utukok Formation, ≥180 m.	Mostly shallow-water limestone and dolostone; uppermost Kogruk is 50 m of deep-water, thinly interbedded dark spiculitic limestone, chert, and shale (Dumoulin and Harris, 1992; Dumoulin et al., 2004, 2006).	<10 to 15 m (2 localities). Carbonaceous shale in uppermost Kogruk.	

Supplementary Data for Dumoulin et al., Lisburne Group

Detrital Zircon U-Pb Geochronology: Analytical Methods and Data Table A3

Analytical Methods

Separation of Samples

Samples were separated at the laboratories of Apatite to Zircon, Inc., in Viola, Idaho. The samples were crushed using a jaw crusher and sieved through 300 µm nylon mesh. Instead of a conventional Wilfley or Gemini table, lithium polytungstate and a centrifuge were used to produce heavy mineral concentrate separations to ensure that zircon grains were not inadvertently washed away during the separation process. Diiodomethane and standard magnetic separation processes were used to separate zircon grains from the heavy mineral concentrate. The separation procedure produced thousands of zircons from a sample that initially weighed about 1 kg.

Following separation, zircons standards and unknowns were mounted in 1-cm^2 epoxy wafers and ground down to expose internal grain surfaces before final polishing. Grains and the locations for laser spots on these grains were selected using a high power optical microscope with transmitted light. This method was used instead of cathodoluminescence 2-D imaging because it allows the recognition of features such as inclusions and cracks below the surface of individual grains that could otherwise result in spurious isotopic counts. One hundred grains were selected, some of which were chosen to represent the variation of sizes, colors, and morphologies of the zircons present in the sample. A larger fraction of grains were selected by random process. This methodology captures the ages of the broad range of zircon types present as well as providing a measure of their relative abundances.

Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA ICPMS)

U-Pb analyses were conducted on a New Wave YAG 213 nm laser ablation (LA) system in line with a Finnigan Element2 magnetic sector, inductively coupled plasma, mass spectrometer (ICP-MS) at the Washington State University Geoanalytical Laboratory in Pullman, Washington, U.S.A. (e.g., Chang et al., 2006). All analyses, including standards and unknowns, were performed using a 20 µm spot. Following approximately 6 seconds of background data collection, laser ablation commenced and signal data were collected by scanning repeatedly across the masses (in amu): 202, 204, 206, 207, 208, 232, 235, and 238. Ablated material was transported to the plasma line using He; Ar was the plasma gas.

Each analysis consisted of 250 scans that took approximately 30 seconds to complete. The analyses consisted of a 6-second integration on peaks with the laser turned off (for background measurements) followed by a 25-second integration with the laser firing. Four standard spots were analyzed prior to and following each group of ~25-30 unknown sample spots to correct for machine fluctuations and to determine fractionation factors. Common Pb correction was made by using the measured ^{204}Pb content and assuming an initial Pb composition from Stacey and Kramers (1975). Uncertainties shown in Table A3 are calculated as asymmetric errors that were generated from the standards employed in the analysis and fractionation factors, as well as those caused by machine error. The most precise age from the concordant-scan-weighted ratio $^{207}Pb/^{235}U$, $^{206}Pb/^{238}U$ or $^{207}Pb/^{206}Pb$ was selected as the preferred age in Table A2.

Filtering of U-Pb data

Table A3 reports the number of scans that yielded concordant U-Pb ages for each grain analyzed with the number of concordant scans ranging from zero to as many as 156. For this study, we accepted only those analyses consisting of more than 10 concordant scans as representing dependable ages and have omitted grains having fewer concordant scans from the graphical plots and discussion in this paper. Nonetheless, at least five of the remaining grains yield ages that are significantly younger than the late Meramecian-early Chesterian (Late Mississippian) stratigraphic age of the sample. Examination of the data reveals that each of these grains contain relatively large amounts of uranium and thorium (as much as 3600 and 3000 ppm, respectively) and that the youngest grains form a trend of decreasing age with increasing uranium and thorium content toward an unreasonably young age and high uranium content. High content of uranium and thorium are known to produce radiation damage in the crystal lattice of zircon (metamictization) and consequent lead loss (e.g., White and Ireland, 2012). Considering that sample DDH 796 is likely to have been exposed to the fluids related to the Red Dog mineralization event and that short trends of decreasing U-Pb age with increasing uranium and thorium content are evident in cross plots even for grains older than the stratigraphic age of the rocks, it appears that the U-Pb ages of grains with the highest contents of uranium in this sample may mark grains whose ages have been significantly decreased from their original ages. To avoid this complication, we have not included the U-Pb ages of grains having uranium contents greater than 1000 ppm (16 grains) in the plots of Figure 5.

Comparison with other data sets

Figure 5b compares the Ikalukrok data with data taken from published sources. The published data was taken directly from the original data sets that were included in the publications, which in some cases produced differences in the numbers of analyses compared with those reported in the cited publications.

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Table A3. U-Pb ZIRCON GEOCHRONOLOGIC ANALYSES BY LASER-ABLATION ICP MASS SPECTROMETRY

Spot[A]	Uranium and Thorium			Measured Isotopic Ratios (Concordant scans only)							Apparent ages (Ma) (Concordant scans only)									Preferred Age (Ma)				Concordance	
Analysis Name	U (ppm)	Th (ppm)	U/Th	207Pb/ 235U	2 sigma	206Pb/ 238U	2 sigma	207Pb/ 206Pb	2 sigma	Error Corr.	207Pb/ 235U	2 -sigma	2 +sigma	206Pb/ 238U	2 -sigma	2 +sigma	207Pb/ 206Pb	2 -sigma	2 +sigma	Preferred Age	2 -sigma	2 +sigma	Preferred Age From:	Concordant Scans	Total Scans
Sample DDH-796, Ikalukrok Unit, Red Dog Mining District																									
80703_1	92	47	1.96	1.82866	0.07885	0.17430	0.00499	0.07609	0.00336	0.23	1055.80	28.50	28.11	1035.78	27.40	27.34	1097.42	89.61	87.08	1035.78	27.40	27.34	206Pb/238U	131	178
80703_2	399	443	0.90	0.79339	0.02746	0.09508	0.00265	0.06052	0.00213	0.30	593.09	15.61	15.49	585.51	15.62	15.60	622.19	76.72	74.91	593.09	15.61	15.49	207Pb/235U	130	177
80703_3	931	283	3.29	0.99525	0.09470	0.10673	0.00764	0.06763	0.00664	0.32	701.40	48.77	47.63	653.73	44.60	44.44	857.26	210.85	197.53	653.73	44.60	44.44	206Pb/238U	17	178
80703_4	180	389	0.46	0.72531	0.03121	0.08909	0.00271	0.05905	0.00263	0.24	553.80	18.45	18.29	550.15	16.05	16.03	568.84	98.51	95.55	550.15	16.05	16.03	206Pb/238U	122	178
80703_5	508	456	1.11	0.42910	0.01671	0.05830	0.00175	0.05338	0.00222	0.22	362.54	11.90	11.84	365.30	10.66	10.65	344.92	95.34	92.61	365.30	10.66	10.65	206Pb/238U	136	176
80703_6	377	407	0.93	0.90001	0.03046	0.10662	0.00306	0.06122	0.00207	0.35	651.74	16.34	16.21	653.11	17.81	17.79	646.97	73.62	71.94	651.74	16.34	16.21	207Pb/235U	148	174
80703_7	716	494	1.45	0.77834	0.02680	0.09358	0.00256	0.06032	0.00209	0.31	584.54	15.36	15.25	576.67	15.10	15.09	615.22	75.67	73.90	576.67	15.10	15.09	206Pb/238U	133	175
80703_8	135	60	2.26	6.01198	0.35014	0.34916	0.01591	0.12488	0.00704	0.41	1977.58	51.35	50.08	1930.58	76.23	75.78	2027.10	101.55	98.16	1977.58	51.35	50.08	207Pb/235U	42	176
80703_9	192	130	1.48	4.46562	0.15731	0.30565	0.00972	0.10596	0.00374	0.38	1724.61	29.44	29.02	1719.28	48.06	47.88	1731.08	65.51	64.11	1724.61	29.44	29.02	207Pb/235U	150	174
80703_10	530	410	1.29	0.52743	0.02212	0.06909	0.00226	0.05536	0.00232	0.34	430.10	14.76	14.65	430.69	13.63	13.62	426.99	94.88	92.16	430.69	13.63	13.62	206Pb/238U	124	175
80703_11	2377	1649	1.44	0.18820	0.00988	0.02593	0.00111	0.05263	0.00278	0.37	175.09	8.46	8.42	165.04	7.00	7.00	313.04	122.29	117.84	[B]165.04	7.00	7.00	206Pb/238U	84	176
80703_12	261	63	4.15	0.81558	0.03298	0.09660	0.00304	0.06123	0.00254	0.29	605.58	18.53	18.36	594.47	17.85	17.83	647.38	90.56	88.04	594.47	17.85	17.83	206Pb/238U	124	173
80703_13	456	206	2.21	2.29716	0.08097	0.20443	0.00720	0.08150	0.00301	0.39	1211.41	25.09	24.78	1199.09	38.57	38.45	1233.44	73.38	71.66	1211.41	25.09	24.78	207Pb/235U	150	175
80703_14	1675	326	5.13	0.52070	0.02006	0.06575	0.00239	0.05743	0.00227	0.39	425.62	13.44	13.35	410.53	14.45	14.43	508.20	87.94	85.59	[B]425.62	13.44	13.35	207Pb/235U	129	176
80703_15	696	74	9.46	1.31939	0.04997	0.13735	0.00493	0.06967	0.00252	0.47	854.25	21.99	21.76	829.68	27.96	27.90	918.57	75.23	73.46	854.25	21.99	21.76	207Pb/235U	132	174
80703_16	159	76	2.09	1.08450	0.06106	0.11686	0.00425	0.06731	0.00388	0.25	745.83	29.97	29.53	712.44	24.57	24.52	847.37	122.26	117.66	712.44	24.57	24.52	206Pb/238U	81	169
80703_17	565	159	3.55	1.66396	0.06838	0.15932	0.00600	0.07575	0.00294	0.48	994.89	26.23	25.90	952.98	33.38	33.30	1088.45	78.74	76.78	994.89	26.23	25.90	207Pb/235U	97	173
80703_18	666	232	2.87	0.65290	0.02054	0.08157	0.00224	0.05805	0.00194	0.26	510.26	12.66	12.58	505.48	13.36	13.35	531.74	73.90	72.22	510.26	12.66	12.58	207Pb/235U	146	174
80703_19	1152	714	1.61	0.67745	0.02623	0.08290	0.00270	0.05927	0.00226	0.38	525.23	15.94	15.82	513.42	16.06	16.04	576.94	83.84	81.69	[B]525.23	15.94	15.82	207Pb/235U	139	171
80703_20	556	305	1.82	1.28293	0.04636	0.13631	0.00434	0.06826	0.00245	0.38	838.16	20.72	20.51	823.78	24.63	24.59	876.44	75.29	73.52	838.16	20.72	20.51	207Pb/235U	129	172
80703_21	488	232	2.10	0.90918	0.03606	0.10592	0.00345	0.06225	0.00240	0.39	656.62	19.27	19.09	649.01	20.12	20.09	682.84	83.55	81.40	656.62	19.27	19.09	207Pb/235U	132	170
80703_22	267	248	1.08	0.57331	0.02534	0.07298	0.00219	0.05698	0.00261	0.22	460.15	16.42	16.29	454.08	13.17	13.15	490.57	102.59	99.40	454.08	13.17	13.15	206Pb/238U	134	172
80703_23	364	71	5.11	0.79699	0.03312	0.09567	0.00315	0.06042	0.00251	0.34	595.13	18.80	18.63	588.97	18.55	18.53	618.68	91.05	88.51	595.13	18.80	18.63	207Pb/235U	109	172
80703_24	1000	592	1.69	0.45473	0.01658	0.06009	0.00183	0.05488	0.00211	0.28	380.58	11.60	11.54	376.18	11.14	11.13	407.48	87.03	84.74	376.18	11.14	11.13	206Pb/238U	136	172
80703_25	342	84	4.05	4.87507	0.17210	0.31734	0.01014	0.11142	0.00374	0.45	1797.96	29.96	29.53	1776.75	49.70	49.51	1822.65	61.55	60.30	1797.96	29.96	29.53	207Pb/235U	135	176
80703_26	333	199	1.67	2.45882	0.08712	0.21024	0.00628	0.08482	0.00290	0.40	1260.02	25.74	25.42	1230.08	33.51	33.42	1311.51	67.01	65.57	1260.02	25.74	25.42	207Pb/235U	139	174
80703_27	1741	882	1.97	0.63139	0.02298	0.07709	0.00261	0.05941	0.00215	0.41	496.96	14.35	14.25	478.70	15.62	15.60	581.97	79.52	77.58	[B]496.96	14.35	14.25	207Pb/235U	122	175
80703_28	433	228	1.90	0.62877	0.02816	0.07862	0.00256	0.05801	0.00256	0.34	495.33	17.63	17.48	487.86	15.28	15.26	530.04	98.06	95.14	487.86	15.28	15.26	206Pb/238U	128	170
80703_29	206	96	2.15	2.94674	0.10737	0.23895	0.00756	0.08944	0.00322	0.39	1394.01	27.81	27.44	1381.22	39.37	39.25	1413.64	69.62	68.05	1394.01	27.81	27.44	207Pb/235U	133	170
80703_30	92	130	0.71	0.50876	0.03869	0.06775	0.00266	0.05446	0.00427	0.17	417.62	26.21	25.88	422.60	16.07	16.05	390.21	181.10	171.46	422.60	16.07	16.05	206Pb/238U	96	174
80703_31	320	110	2.91	0.49766	0.02459	0.06487	0.00227	0.05564	0.00288	0.23	410.11	16.74	16.60	405.19	13.75	13.74	437.90	117.51	113.36	405.19	13.75	13.74	206Pb/238U	122	177
80703_32	639	55	11.58	1.46086	0.04647	0.15188	0.00432	0.06976	0.00219	0.38	914.36	19.26	19.08	911.48	24.21	24.16	921.33	65.09	63.76	914.36	19.26	19.08	207Pb/235U	155	174
80703_33	723	360	2.01	0.80701	0.02959	0.09799	0.00295	0.05973	0.00217	0.36	600.78	16.69	16.56	602.60	17.33	17.31	593.92	79.70	77.75	600.78	16.69	16.56	207Pb/235U	142	177
80703_34	150	118	1.27	3.83558	0.14219	0.27610	0.00854	0.10076	0.00382	0.32	1600.25	30.08	29.64	1571.67	43.23	43.08	1638.07	71.19	69.54	1600.25	30.08	29.64	207Pb/235U	126	173
80703_35	1236	953	1.30	0.36025	0.01321	0.04895	0.00154	0.05338	0.00191	0.40	312.40	9.89	9.84	308.06	9.46	9.45	344.94	81.79	79.77	[B]308.06	9.46	9.45	206Pb/238U	128	175
80703_36	947	168	5.65	0.64987	0.02338	0.08153	0.00254	0.05781	0.00212	0.34	508.40	14.44	14.34	505.26	15.14	15.13	522.56	81.50	79.47	508.40	14.44	14.34	207Pb/235U	136	178
80703_37	34	55	0.62	2.80414	0.17730	0.22461	0.00910	0.09055	0.00590	0.24	1356.64	47.88	46.78	1306.17	48.01	47.84	1437.10	126.94	121.83	1356.64	47.88	46.78	207Pb/235U	83	176
80703_38	619	53	11.61	1.41194	0.04764	0.14887	0.00442	0.06879	0.00224	0.41	893.98	20.15	19.96	894.64	24.82	24.77	892.34	67.97	66.52	893.98	20.15	19.96	207Pb/235U	156	175
80703_39	1320	273	4.84	0.49396	0.01954	0.06410	0.00217	0.05589	0.00211	0.43	407.61	13.33	13.24	400.50	13.14	13.13	448.05	84.88	82.69	[B]407.61	13.33	13.24	207Pb/235U	113	176
80703_40	371	214	1.74	4.53725	0.15304	0.30161	0.00920	0.10911	0.00381	0.33	1737.83	28.26	27.87	1699.28	45.64	45.48	1784.54	64.29	62.94	1737.83	28.26	27.87	207Pb/235U	115	176
80703_41	981	616	1.59	1.44650	0.04504	0.14893	0.00422	0.07044	0.00238	0.25	908.42	18.78	18.61	894.97	23.72	23.67	941.26	69.90	68.37	908.42	18.78	18.61	207Pb/235U	139	175
80703_42	171	128	1.34	1.45854	0.05588	0.15289	0.00458	0.06919	0.00267	0.32	913.41	23.21	22.95	917.16	25.61	25.56	904.35	80.45	78.43	913.41	23.21	22.95	207Pb/235U	125	175
80703_43	253	267	0.95	1.47533	0.05568	0.15152	0.00495	0.07062	0.00279	0.31	920.32	22.97	22.71	909.50	27.76	27.70	946.33	82.09	79.98	920.32	22.97	22.71	207Pb/235U	143	177
80703_44	852	878	0.97	0.40402	0.01703	0.05448	0.00198	0.05379	0.00222	0.41	344.56	12.36	12.28	341.96	12.10	12.09	362.15	94.28	91.60	341.96	12.10	12.09	206Pb/238U	146	178
80703_45	568	55	10.26	1.45772	0.04382	0.15183	0.00422	0.06963	0.00210	0.37	913.07	18.19	18.02	911.21	23.64	23.60	917.55	62.50	61.28	913.07	18.19	18.02	207Pb/235U	156	178
80703_46	187	145	1.29	0.65015	0.03152	0.08182	0.00261	0.05763	0.00281	0.27	508.57	19.49	19.30	506.96	15.57	15.55	515.80	109.02	105.42	506.96	15.57	15.55	206Pb/238U	123	178
80703_47	139	81	1.72	0.84126	0.04294	0.10032	0.00310	0.06082	0.00321	0.19	619.84	23.82	23.54	616.29	18.19	18.17	632.84	115.84	111.75	616.29	18.19	18.17	206Pb/238U	140	178
80703_48	109	48	2.26	2.51426	0.11551	0.21484	0.00786	0.08488	0.00401	0.32	1276.16	33.65	33.10	1254.54	41.76	41.62	1312.76	93.01	90.26	1276.16	33.65	33.10	207Pb/235U	108	174

80703_49	682	443	1.54	0.50772	0.01831	0.06623	0.00206	0.05560	0.00204	0.34	416.92	12.37	12.30	413.38	12.48	12.47	436.53	82.60	80.53	416.92	12.37	12.30	207Pb/235U	133	176
80703_50	327	58	5.66	0.59086	0.02958	0.07539	0.00283	0.05684	0.00287	0.33	471.42	18.97	18.79	468.56	16.96	16.94	485.37	113.30	109.42	468.56	16.96	16.94	206Pb/238U	151	178
80703_51	71	28	2.48	1.49324	0.08124	0.15214	0.00557	0.07119	0.00392	0.28	927.64	33.36	32.82	912.93	31.21	31.13	962.75	114.53	110.46	912.93	31.21	31.13	206Pb/238U	132	178
80703_52	511	54	9.52	0.81116	0.02953	0.09836	0.00296	0.05981	0.00221	0.32	603.10	16.62	16.49	604.78	17.38	17.36	596.81	81.12	79.10	603.10	16.62	16.49	207Pb/235U	154	178
80703_53	1137	314	3.62	2.00010	0.20980	0.17170	0.01717	0.08449	0.00876	0.48	1115.55	72.28	69.79	1021.47	94.84	94.15	1303.75	208.29	194.97	[B]1115.55	72.28	69.79	207Pb/235U	17	178
80703_54	168	161	1.05	0.69340	0.03283	0.08727	0.00323	0.05762	0.00277	0.33	534.84	19.78	19.59	539.39	19.15	19.13	515.50	107.34	103.85	539.39	19.15	19.13	206Pb/238U	133	178
80703_55	339	180	1.88	0.42843	0.02006	0.05773	0.00219	0.05383	0.00255	0.35	362.06	14.31	14.21	361.78	13.35	13.34	363.89	108.47	104.94	361.78	13.35	13.34	206Pb/238U	142	178
80703_56	180	45	3.98	2.00665	0.08168	0.18822	0.00691	0.07732	0.00336	0.31	1117.76	27.77	27.40	1111.71	37.54	37.43	1129.55	87.76	85.33	1117.76	27.77	27.40	207Pb/235U	160	178
80703_57	56	103	0.55	4.77379	0.18392	0.31143	0.01083	0.11117	0.00449	0.33	1780.30	32.61	32.09	1747.75	53.35	53.13	1818.68	74.19	72.38	1780.30	32.61	32.09	207Pb/235U	144	178
80703_58	235	48	4.85	1.45812	0.05478	0.15013	0.00460	0.07044	0.00264	0.34	913.23	22.76	22.50	901.67	25.79	25.74	941.27	77.66	75.77	913.23	22.76	22.50	207Pb/235U	145	177
80703_59	411	112	3.67	1.81325	0.05955	0.17285	0.00511	0.07608	0.00263	0.29	1050.25	21.61	21.38	1027.79	28.09	28.03	1097.26	70.02	68.46	1050.25	21.61	21.38	207Pb/235U	146	178
80703_60	425	294	1.44	1.51159	0.05788	0.15778	0.00529	0.06949	0.00250	0.45	935.08	23.54	23.27	944.40	29.47	29.40	913.19	75.08	73.31	935.08	23.54	23.27	207Pb/235U	150	176
80703_61	203	159	1.28	4.50147	0.15927	0.30426	0.01018	0.10730	0.00398	0.34	1731.24	29.61	29.19	1712.38	50.43	50.24	1754.12	68.69	67.14	1731.24	29.61	29.19	207Pb/235U	142	176
80703_62	362	277	1.31	3.67842	0.11794	0.26861	0.00791	0.09932	0.00319	0.37	1566.70	25.76	25.44	1533.76	40.26	40.13	1611.36	60.39	59.20	1566.70	25.76	25.44	207Pb/235U	153	177
80703_63	377	56	6.77	1.66533	0.05575	0.16422	0.00492	0.07355	0.00239	0.40	995.41	21.35	21.13	980.16	27.27	27.21	1029.16	66.35	64.96	995.41	21.35	21.13	207Pb/235U	145	175
80703_64	458	387	1.18	0.83892	0.02981	0.10043	0.00318	0.06058	0.00217	0.36	618.55	16.53	16.39	616.96	18.65	18.63	624.37	78.17	76.29	618.55	16.53	16.39	207Pb/235U	145	176
80703_65	246	152	1.62	0.93686	0.04004	0.10835	0.00337	0.06271	0.00272	0.28	671.24	21.10	20.88	663.13	19.61	19.58	698.55	93.76	91.06	663.13	19.61	19.58	206Pb/238U	146	176
80703_66	57	49	1.17	20.02829	0.61056	0.60989	0.01709	0.23817	0.00730	0.35	3092.72	29.70	29.27	3069.58	68.62	68.25	3107.79	49.27	48.42	3092.72	29.70	29.27	207Pb/235U	149	176
80703_67	1420	509	2.79	2.18393	0.09640	0.19245	0.00799	0.08230	0.00366	0.42	1175.93	30.98	30.51	1134.62	43.29	43.14	1252.78	88.33	85.85	[B]1175.93	30.98	30.51	207Pb/235U	66	178
80703_68	494	369	1.34	0.66455	0.02667	0.08344	0.00257	0.05776	0.00231	0.32	517.39	16.33	16.20	516.63	15.33	15.31	520.78	88.83	86.43	516.63	15.33	15.31	206Pb/238U	139	178
80703_69	1850	877	2.11	0.45587	0.02083	0.05741	0.00227	0.05759	0.00261	0.40	381.39	14.58	14.48	359.84	13.87	13.85	514.36	100.96	97.87	[B]381.39	14.58	14.48	207Pb/235U	99	178
80703_70	152	494	0.31	0.84891	0.03882	0.10032	0.00331	0.06137	0.00288	0.26	624.05	21.43	21.21	616.30	19.39	19.36	652.25	102.24	99.04	616.30	19.39	19.36	206Pb/238U	130	178
80703_71	141	58	2.43	2.95337	0.10152	0.24004	0.00696	0.08923	0.00319	0.28	1395.71	26.24	25.91	1386.92	36.24	36.14	1409.17	69.10	67.56	1395.71	26.24	25.91	207Pb/235U	131	174
80703_72	3597	3013	1.19	0.14543	0.00928	0.02015	0.00101	0.05236	0.00326	0.40	137.87	8.24	8.21	128.58	6.38	6.38	300.95	145.10	138.88	[B]128.58	6.38	6.38	206Pb/238U	44	174
80703_73	230	132	1.74	2.92003	0.23726	0.22395	0.01569	0.09457	0.00799	0.37	1387.11	62.40	60.54	1302.72	82.92	82.39	1519.43	163.72	155.29	1387.11	62.40	60.54	207Pb/235U	18	178
80703_74	1531	399	3.84	3.43763	0.16068	0.25329	0.01054	0.09843	0.00423	0.50	1513.04	37.10	36.44	1455.41	54.31	54.08	1594.66	81.37	79.22	[B]1513.04	37.10	36.44	207Pb/235U	51	174
80703_75	88	97	0.91	3.94871	0.15357	0.28011	0.00876	0.10224	0.00393	0.35	1623.73	31.76	31.27	1591.92	44.18	44.03	1665.20	71.97	70.28	1623.73	31.76	31.27	207Pb/235U	139	178
80703_76	115	82	1.41	0.77962	0.04462	0.09459	0.00333	0.05978	0.00346	0.24	585.27	25.62	25.30	582.61	19.62	19.59	595.59	128.03	123.07	582.61	19.62	19.59	206Pb/238U	112	170
80703_77	228	185	1.23	3.46019	0.18500	0.25205	0.01223	0.09957	0.00490	0.51	1518.19	42.56	41.69	1449.03	63.10	62.79	1616.00	93.08	90.28	1518.19	42.56	41.69	207Pb/235U	78	171
80703_78	212	174	1.22	3.74810	0.12543	0.27247	0.00815	0.09977	0.00328	0.38	1581.71	27.00	26.65	1553.32	41.35	41.21	1619.77	61.79	60.54	1581.71	27.00	26.65	207Pb/235U	133	171
80703_79	169	64	2.63	1.84955	0.06886	0.17825	0.00566	0.07526	0.00298	0.26	1063.27	24.69	24.39	1057.41	30.99	30.91	1075.32	80.47	78.43	1063.27	24.69	24.39	207Pb/235U	139	171
80703_80	404	68	5.97	2.78945	0.20065	0.22136	0.01331	0.09139	0.00632	0.45	1352.72	54.49	53.06	1289.07	70.45	70.07	1454.81	134.46	128.74	1352.72	54.49	53.06	207Pb/235U	23	170
80703_81	247	88	2.80	1.95727	0.06475	0.18551	0.00554	0.07652	0.00256	0.35	1100.95	22.36	22.11	1097.03	30.15	30.08	1108.71	67.62	66.17	1100.95	22.36	22.11	207Pb/235U	159	169
80703_82	203	220	0.92	0.50739	0.02419	0.06556	0.00217	0.05613	0.00276	0.24	416.69	16.36	16.23	409.37	13.14	13.13	457.45	111.06	107.34	409.37	13.14	13.13	206Pb/238U	108	175
80703_83	1012	928	1.09	0.33063	0.01290	0.04492	0.00147	0.05339	0.00223	0.25	290.05	9.87	9.82	283.23	9.06	9.05	345.31	95.98	93.21	[B]283.23	9.06	9.05	206Pb/238U	124	176
80703_84	554	375	1.48	0.48602	0.01776	0.06407	0.00205	0.05501	0.00216	0.26	402.19	12.17	12.10	400.35	12.40	12.39	412.80	88.92	86.53	402.19	12.17	12.10	207Pb/235U	128	176
80703_85	163	147	1.11	0.72985	0.03488	0.08843	0.00274	0.05986	0.00294	0.21	556.47	20.58	20.37	546.26	16.27	16.25	598.45	108.19	104.63	546.26	16.27	16.25	206Pb/238U	124	176
80703_86	425	176	2.41	0.51254	0.02147	0.06736	0.00222	0.05519	0.00237	0.30	420.16	14.47	14.36	420.23	13.44	13.43	419.75	97.18	94.33	420.23	13.44	13.43	206Pb/238U	124	177
80703_87	268	354	0.76	0.49559	0.02246	0.06568	0.00217	0.05473	0.00256	0.26	408.71	15.30	15.19	410.06	13.13	13.12	401.11	106.41	103.00	410.06	13.13	13.12	206Pb/238U	130	177
80703_88	465	179	2.60	1.27046	0.04479	0.13371	0.00432	0.06891	0.00247	0.36	832.60	20.13	19.93	809.00	24.56	24.52	896.11	74.90	73.14	832.60	20.13	19.93	207Pb/235U	142	178
80703_89	1420	954	1.49	0.34306	0.01333	0.04705	0.00155	0.05288	0.00194	0.43	299.49	10.10	10.05	296.40	9.55	9.54	323.61	84.60	82.44	[B]296.40	9.55	9.54	206Pb/238U	132	178
80703_90	572	462	1.24	0.65964	0.02441	0.08264	0.00257	0.05789	0.00219	0.31	514.39	14.99	14.88	511.85	15.30	15.28	525.70	84.07	81.91	514.39	14.99	14.88	207Pb/235U	151	178
80703_91	1026	342	3.00	1.85217	0.05712	0.17815	0.00512	0.07540	0.00250	0.25	1064.20	20.44	20.24	1056.86	28.05	27.99	1079.29	67.17	65.74	[B]1064.20	20.44	20.24	207Pb/235U	163	178
80703_92	397	114	3.49	1.42910	0.05280	0.14760	0.00461	0.07022	0.00263	0.32	901.17	22.19	21.95	887.51	25.90	25.85	934.82	77.79	75.90	901.17	22.19	21.95	207Pb/235U	138	178
80703_93	2046	2543	0.80	0.32635	0.01238	0.04446	0.00146	0.05324	0.00202	0.36	286.78	9.50	9.45	280.42	9.03	9.02	338.93	87.06	84.77	[B]280.42	9.03	9.02	206Pb/238U	121	178
80703_94	2415	10	233.68	0.86256	0.04401	0.09672	0.00446	0.06468	0.00318	0.46	631.52	24.14	23.85	595.17	26.22	26.17	763.91	105.27	101.86	[B]631.52	24.14	23.85	207Pb/235U	48	178
80703_95	764	9	84.43	0.63782	0.02330	0.08109	0.00265	0.05705	0.00222	0.28	500.96	14.50	14.40	502.60	15.83	15.81	493.44	87.15	84.84	500.96	14.50	14.40	207Pb/235U	140	175
80703_96	363	253	1.43	0.72890	0.03207	0.08737	0.00293	0.06051	0.00273	0.28	555.91	18.92	18.75	539.97	17.40	17.37	621.72	98.81	95.83	539.97	17.40	17.37	206Pb/238U	119	176
80703_97	651	741	0.88	0.45022	0.01666	0.06027	0.00198	0.05418	0.00209	0.31	377.44	11.70	11.63	377.24	12.05	12.04	378.65	88.09	85.75	377.44	11.70	11.63	207Pb/235U	141	177
80703_98	237	147	1.61	1.28539	0.05003	0.13516	0.00406	0.06897	0.00277	0.26	839.25	22.35	22.11	817.23	23.06	23.02	897.97	84.02	81.81	839.25	22.35	22.11	207Pb/235U	121	177
80703_99	287	66	4.37	1.68219	0.05883	0.16591	0.00506	0.07354	0.00266	0.30	1001.81	22.40	22.15	989.51	28.01	27.95	1028.83	74.00	72.27	1001.81	22.40	22.15	207Pb/235U	149	174

[A] Analyses yielding no concordant scans are not reported.

[B] Analyses having uranium contents above 1000 ppm are not included in the plots of Figure 5

Table A4. Whole-rock geochemical data for black mudrocks of the Lisburne Group*

[*Data sources: [a], Slack et al. (2004c); [b], Dumoulin et al. (2011); [c], this study. Results for samples having >10 wt% CO_2 or >10 wt% P_2O_5 are excluded. Analytical methods are described in Dumoulin et al. (2011). n.a., not analyzed]

Kuna Formation (and related units) regional outcrops

Sample number	SiO_2	Al_2O_3	$Fe_2O_3^T$	MnO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	LOI
	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%
90JS04M[a]	83.22	4.95	1.32	0.002	0.31	0.35	0.15	1.21	0.190	0.50	8.01
91AD1B3.0[a]	64.19	5.56	1.33	0.006	1.59	7.89	0.11	1.49	0.253	3.89	12.31
91AD1-7.2[a]	67.64	3.89	1.30	0.006	1.15	7.99	0.08	1.08	0.184	0.64	14.85
91JS04G[a]	71.84	3.43	1.22	0.006	1.82	6.26	0.08	0.99	0.177	1.58	11.37
91JS18A[a]	59.85	14.47	3.89	0.023	1.44	5.33	0.35	2.71	0.710	0.15	10.95
91JS19B[a]	73.72	3.11	0.81	0.002	0.18	5.93	0.08	0.93	0.094	4.68	9.35
91JS34B[a]	66.21	14.89	1.25	0.002	0.69	0.06	0.13	2.44	0.627	0.04	12.84
91JS38E[a]	71.89	13.09	1.14	0.002	0.86	0.02	0.92	3.91	0.483	0.06	6.85
92AD9B[a]	79.85	4.99	1.37	0.002	0.31	1.12	0.08	1.18	0.167	1.20	9.13
92AD9C[a]	74.79	4.58	1.24	0.013	1.85	3.47	0.08	1.09	0.155	0.48	11.60
92AD35A-1[a]	87.84	3.12	1.07	0.002	0.19	0.10	0.08	0.75	0.115	0.11	6.02
92AD35A-1.5[a]	79.53	6.42	1.43	0.002	0.43	0.54	0.16	1.58	0.257	0.62	8.90
92AD35A-12[a]	72.58	12.35	0.92	0.002	0.66	0.07	0.18	3.53	0.470	0.04	8.92
92AD35C-43A[a]	77.52	9.03	1.02	0.006	0.66	0.79	0.45	2.15	0.326	0.50	7.74
92AD60A[a]	73.23	6.66	3.62	0.004	0.39	1.52	0.09	1.44	0.353	0.54	12.46
92AD60D[a]	83.19	6.32	2.01	0.006	0.36	0.17	0.09	1.09	0.281	0.22	5.79
92AD60F[a]	85.63	2.74	0.59	0.004	0.15	1.21	0.09	0.59	0.098	0.63	8.53
92AD74C[a]	58.33	6.46	1.84	0.090	0.80	9.19	0.42	1.37	0.300	5.59	14.15
92AKD837R[a]	80.10	3.36	0.75	0.010	1.16	2.60	0.02	0.33	0.100	0.75	n.a.
93JS06A[a]	87.60	0.46	0.52	<0.01	0.43	4.59	0.04	0.07	0.030	0.05	n.a.
93JS06C[a]	80.50	4.19	1.00	<0.01	0.27	3.09	0.07	0.66	0.150	0.07	n.a.
93JS07C[a]	61.90	2.86	0.70	<0.01	0.71	12.00	0.05	0.72	0.120	3.15	n.a.
93JS07J[a]	64.27	3.16	0.86	0.008	0.71	10.73	0.05	0.67	0.129	2.69	15.84
93JS13E[a]	64.58	15.02	2.59	0.002	0.76	0.07	0.20	2.86	0.624	0.14	11.69
94JS07A[a]	69.80	5.87	2.38	0.010	0.33	5.53	0.06	0.95	0.220	3.68	n.a.
94JS09L[a]	85.60	2.12	0.71	<0.01	0.08	1.91	0.03	0.39	0.100	1.68	n.a.
94JS17S[a]	86.40	5.24	0.68	<0.01	0.12	0.03	0.04	0.86	0.270	0.09	n.a.
94JS17T[a]	79.30	3.87	2.29	<0.01	0.12	0.74	0.04	0.70	0.230	1.38	n.a.
98AKD28[a]	83.52	4.42	2.17	<0.01	0.34	0.45	0.08	0.93	0.250	0.15	6.92
98AKD29[a]	90.08	1.99	1.03	<0.01	0.79	1.31	0.08	0.35	0.085	0.06	4.27
98AKD30[a]	75.90	4.91	2.20	0.010	0.60	1.02	0.15	1.29	0.250	0.17	8.01
99 AD24B[a]	81.93	6.68	1.62	0.002	0.48	0.30	0.22	1.91	0.352	0.17	6.50
JS-00-6A[a]	79.46	8.05	1.33	0.006	0.61	0.44	0.32	1.98	0.407	0.10	6.38
JS-00-6B[a]	83.95	7.78	0.42	0.002	0.46	0.04	0.07	1.82	0.393	0.03	5.11
JS-00-9[a]	80.29	9.62	0.55	0.002	0.86	0.07	0.28	2.35	0.464	0.04	4.97
JS-00-14[a]	76.34	8.31	0.50	0.002	0.53	0.09	0.09	2.11	0.465	0.03	9.91
JS-00-15A[a]	77.47	10.64	1.39	0.004	0.67	0.50	0.50	2.31	0.545	0.07	6.12
JS-00-17[a]	83.79	6.55	0.78	0.002	0.40	0.03	0.31	1.72	0.329	0.05	5.77
JS-00-20[a]	84.39	6.76	0.54	0.002	0.53	0.06	0.29	1.93	0.263	0.04	5.57
JS-00-22[a]	80.76	8.47	1.20	0.002	0.71	0.02	0.36	2.17	0.452	0.06	5.92
JS-00-23B[a]	81.91	8.14	1.36	0.020	0.37	0.16	0.26	2.20	0.383	0.07	5.63
JS-00-27[a]	82.20	8.51	0.83	0.002	0.57	0.06	0.36	2.11	0.357	0.03	5.34
JS-03-1A[a]	78.18	8.89	1.01	0.003	0.87	0.02	0.49	2.23	0.513	0.06	7.46
JS-03-1B[a]	65.71	3.92	1.06	0.381	2.60	8.68	0.62	0.58	0.197	2.91	12.06
JS-03-1C[a]	74.31	10.45	2.28	0.012	0.82	0.08	0.93	2.51	0.600	0.04	6.75

JS-03-1D[a]	75.18	9.55	2.62	0.009	0.72	0.04	0.38	2.38	0.504	0.04	7.88
JS-03-1E[a]	77.12	10.62	1.75	0.004	0.75	0.01	0.33	2.71	0.550	0.03	5.90
JS-03-1F[a]	75.96	10.66	2.56	0.005	0.67	0.02	0.31	2.68	0.521	0.05	6.24
JS-03-1G[a]	75.98	10.94	1.78	0.005	0.63	0.01	0.38	2.63	0.492	0.03	6.76
JS-03-1H[a]	77.85	9.76	2.30	0.004	0.56	0.02	0.23	2.37	0.456	0.03	5.91
JS-05-96[c]	75.82	3.32	1.00	0.008	0.40	4.72	0.27	0.63	0.108	3.36	9.47

Kuna Formation KE-20 outcrop

Sample number	SiO_2 wt%	Al_2O_3 wt%	$Fe_2O_3^T$ wt%	MnO wt%	MgO wt%	CaO wt%	Na_2O wt%	K_2O wt%	TiO_2 wt%	P_2O_5 wt%	LOI wt%
KE98-20-309[c]	74.66	9.55	1.48	0.008	0.32	2.06	0.15	1.65	0.446	0.06	8.21
KE98-20-303[c]	76.14	10.14	2.19	<0.001	0.34	0.12	0.30	1.63	0.492	0.06	7.16
KE98-20-268[c]	79.72	7.21	0.75	0.002	0.30	0.04	0.07	1.30	0.328	0.05	8.91
KE98-20-262[c]	84.10	5.79	0.99	<0.001	0.21	0.07	0.06	0.86	0.255	0.03	7.76
KE98-20-256[c]	82.24	7.01	2.38	0.002	0.27	0.03	0.06	1.15	0.277	0.03	6.89
KE98-20-250[c]	81.25	7.92	0.58	<0.001	0.35	0.03	0.08	1.44	0.376	0.08	8.23
KE98-20-244[c]	80.43	8.81	0.68	0.002	0.38	0.05	0.07	1.56	0.425	0.05	7.74
KE98-20-238[c]	82.91	6.56	1.02	<0.001	0.27	0.03	0.06	1.16	0.320	0.07	7.70
KE98-20-232[c]	85.34	5.54	0.73	<0.001	0.23	0.02	0.05	0.94	0.262	0.04	7.20
KE98-20-220[c]	80.17	7.84	0.62	0.002	0.29	0.02	0.06	1.30	0.362	0.04	8.70
KE98-20-214[c]	83.31	6.23	0.44	<0.001	0.25	0.03	0.05	1.02	0.285	0.04	8.81
KE98-20-208[c]	81.13	7.05	0.88	<0.001	0.29	0.04	0.07	1.22	0.336	0.04	9.33
KE98-20-202[c]	83.74	5.69	0.71	<0.001	0.22	0.02	0.04	0.90	0.261	0.04	8.86
KE98-20-196[c]	78.94	6.96	2.58	0.001	0.27	0.04	0.07	1.14	0.320	0.08	9.72
KE98-20-190[c]	74.10	8.43	4.47	0.001	0.33	0.04	0.08	1.45	0.375	0.07	10.82
KE98-20-184[c]	76.77	8.18	1.10	<0.001	0.33	0.02	0.07	1.41	0.348	0.05	11.87
KE98-20-178[c]	80.13	6.73	1.44	<0.001	0.26	0.03	0.06	1.13	0.284	0.05	10.28
KE98-20-172[c]	73.02	9.67	3.32	0.003	0.39	0.11	0.09	1.70	0.398	0.12	10.87
KE98-20-168[c]	78.05	6.42	1.37	0.002	0.28	0.15	0.07	1.05	0.269	0.09	12.62
KE98-20-162[c]	78.57	6.82	0.98	0.002	0.28	0.13	0.06	1.14	0.289	0.05	11.34
KE98-20-156[c]	82.95	6.15	1.96	<0.001	0.22	0.05	0.05	0.99	0.255	0.08	7.38
KE98-20-150[c]	86.26	3.46	1.97	<0.001	0.13	0.15	0.04	0.57	0.135	0.10	7.39
KE98-20-132[c]	74.55	10.31	1.93	0.018	0.35	2.46	0.13	1.68	0.489	0.06	8.42
KE98-20-126[c]	78.76	9.71	1.93	0.002	0.30	0.05	0.12	1.64	0.500	0.06	5.71
KE98-20-114[c]	80.54	9.29	1.65	0.002	0.31	0.05	0.11	1.54	0.463	0.05	6.06
KE98-20-108[c]	76.98	9.14	2.36	0.002	0.27	0.08	0.09	1.27	0.345	0.07	9.53
KE98-20-96[c]	77.40	9.65	2.07	0.002	0.32	0.11	0.13	1.60	0.427	0.08	7.75
KE98-20-87[c]	77.46	10.80	0.98	0.002	0.38	0.19	0.16	1.87	0.539	0.04	6.33
KE98-20-81[c]	75.66	11.17	0.64	0.002	0.37	0.03	0.14	1.78	0.537	0.04	9.16
KE98-20-75[c]	74.86	10.65	0.44	0.002	0.36	0.09	0.16	1.67	0.462	0.03	10.12
KE98-20-69[c]	75.41	9.81	1.77	<0.001	0.31	0.08	0.15	1.52	0.439	0.07	8.95
KE98-20-63[c]	87.52	4.80	1.69	<0.001	0.17	0.12	0.07	0.86	0.226	0.12	4.57
KE98-20-51[c]	74.53	11.82	1.36	0.002	0.39	0.05	0.15	1.97	0.543	0.04	8.53
KE98-20-42[c]	79.46	11.19	1.20	0.002	0.36	0.20	0.15	1.89	0.569	0.07	5.35
KE98-20-36[c]	77.59	10.45	2.13	0.002	0.34	0.08	0.13	1.78	0.544	0.18	6.12
KE98-20-30[c]	76.84	8.31	1.99	0.002	0.30	0.06	0.10	1.40	0.370	0.05	10.75
KE98-20-24[c]	80.52	7.87	2.59	0.002	0.26	0.04	0.10	1.32	0.357	0.04	7.28
KE98-20-18[c]	81.47	8.41	1.57	0.002	0.28	0.06	0.11	1.48	0.379	0.03	6.38
KE98-20-12[c]	76.15	9.19	3.22	0.003	0.31	0.13	0.13	1.53	0.421	0.08	7.39
KE98-20-6[c]	73.94	10.87	1.04	0.002	0.39	0.04	0.17	1.84	0.506	0.06	10.30
KE98-20-0[c]	82.67	6.45	2.07	<0.001	0.22	0.03	0.10	1.10	0.297	0.03	7.50

Kuna Formation drill cores

Sample number	SiO_2	Al_2O_3	$Fe_2O_3^T$	MnO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	LOI
	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%
50-326[c]	76.41	4.86	2.84	0.050	0.92	2.48	0.10	0.93	0.268	0.65	9.22
50-333[c]	76.33	5.18	2.22	0.039	0.91	2.82	0.09	0.97	0.290	0.62	9.14
50-378[c]	84.37	3.31	1.92	0.010	0.51	0.65	0.05	0.58	0.168	0.03	8.45
50-402.5[c]	77.08	4.90	2.38	0.042	1.78	2.70	0.08	0.89	0.263	0.05	8.49
50-425.5[c]	79.51	7.43	2.74	0.010	0.25	0.32	0.09	1.24	0.361	0.16	6.89
50-420[c]	84.34	4.12	2.05	0.033	0.60	0.80	0.07	0.55	0.179	0.03	6.14
1105-1155.3[a]	74.02	6.45	3.44	0.031	2.18	2.80	0.29	1.65	0.410	0.06	7.81
1105-1171.5[a]	72.84	8.43	3.69	0.021	1.22	1.10	0.29	2.27	0.508	0.07	8.52
1105-1190.7[a]	74.38	7.33	2.68	0.020	1.62	1.87	0.28	1.96	0.422	0.10	8.18
1105-1211.5[a]	71.18	8.31	3.58	0.024	1.83	2.08	0.35	2.15	0.453	0.10	8.78

Phosphatic unit (EMA, Skimo thrust sheet)

Sample number	SiO_2	Al_2O_3	$Fe_2O_3^T$	MnO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	LOI
	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%
11SKBO-4-(2)[c]	79.95	1.21	0.59	0.006	0.23	5.61	0.10	0.32	0.063	2.40	8.49
11SKBO-3-(2)[c]	55.67	3.00	1.20	0.007	0.29	14.50	0.23	0.92	0.162	10.00	12.05
11SKBO-2.7-(2)[c]	71.64	1.83	0.81	0.006	0.50	7.79	0.13	0.50	0.092	2.27	13.43
11SKBO-1.2-(2)[c]	58.74	3.44	1.23	0.008	0.67	10.24	0.18	1.05	0.186	1.60	18.49
11SKBO-0.95-(2)[c]	67.59	2.76	1.13	0.004	0.26	6.75	0.13	0.78	0.154	3.95	14.93
11SKBO-14-(2)[c]	59.97	5.31	2.28	0.014	1.27	9.40	0.32	1.52	0.313	3.50	14.44
11SKBO-8.2-(2)[c]	50.53	4.13	1.47	0.011	0.82	13.28	0.20	1.38	0.212	0.70	21.50
11SKBO-7.3-(2)[c]	64.41	3.30	1.17	0.010	0.50	8.37	0.18	1.08	0.173	0.65	18.46
11SKBO-5.5-(2)[c]	55.95	5.80	2.61	0.014	1.03	7.62	0.26	1.85	0.293	0.56	20.25
11SKBO-4.8-(2)[c]	50.71	5.11	1.33	0.007	0.65	14.49	0.22	1.28	0.201	1.77	22.42
11SKBO-3.8-(2)[c]	47.78	7.23	2.63	0.013	1.77	12.47	0.31	2.03	0.382	0.48	22.81
CCP-1.35[b]	65.55	3.76	1.43	0.005	0.57	8.69	0.30	1.05	0.202	3.76	14.49
05AD6E[b]	49.25	4.99	2.09	0.006	0.53	10.77	0.21	1.74	0.279	7.91	22.44

Phosphatic unit (EMA, Ivotuk plate; **KRA)

Sample number	SiO_2	Al_2O_3	$Fe_2O_3^T$	MnO	MgO	CaO	Na_2O	K_2O	TiO_2	P_2O_5	LOI
	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%	wt%
92AD31A[b]	41.63	8.39	2.62	0.099	2.39	8.17	0.39	2.09	0.439	3.31	29.02
92AD31H[b]	39.35	7.44	2.37	0.033	1.21	12.63	0.40	1.77	0.387	7.69	25.33
92AD32B[b]	65.97	5.20	1.65	0.069	3.24	7.61	0.09	1.14	0.258	1.33	12.24
03AD27A[b]**	67.12	9.27	2.07	0.010	1.37	4.83	0.42	2.46	0.513	3.04	8.12
03AD38C[b]**	61.61	4.68	1.46	0.101	2.43	6.66	0.43	2.06	0.206	0.92	18.22
JS-00-2[b]**	49.42	8.12	2.12	0.038	1.28	14.37	0.18	2.72	0.457	9.51	11.43
JS-05-82C[b]	49.59	5.98	2.12	0.010	1.21	4.22	0.65	1.57	0.316	2.42	27.22

Table A4. Whole-rock geochemical data for black mudrocks of the Lisburne Group* [cont.]

[*Data sources: [a], Slack et al. (2004c); [b], Dumoulin et al. (2011); [c], this study. Results for samples having >10 wt% CO_2 or >10 wt% P_2O_5 are excluded. Analytical methods are described in Dumoulin et al. (2011). n.a., not analyzed]

Kuna Formation (and related units) regional outcrops [cont.]

Sample number	Total	F	TOC	CO_2	Total S	SO_4	Li	Be	Sc	Zr	Hf	Nb
	wt%	wt%	wt%	wt%	wt%	wt%	ppm	ppm	ppm	ppm	ppm	ppm
90JS04M[a]	100.21	0.10	4.65	0.26	0.42	0.15	13	<1	8.0	47	1.1	2.1
91AD1B3.0[a]	98.62	0.82	5.01	5.30	0.55	<0.05	30	2	9.0	89	2.2	3.7
91AD1-7.2[a]	98.81	0.38	6.02	5.05	0.88	0.48	19	1	10.0	58	1.5	2.5
91JS04G[a]	98.77	0.33	3.98	5.05	0.59	0.12	19	1	9.0	66	1.5	2.4
91JS18A[a]	99.87	0.38	1.53	4.60	0.46	0.18	31	2	16.0	145	4.2	9.9
91JS19B[a]	98.89	0.70	5.54	1.28	0.74	0.15	13	<1	9.0	46	1.0	1.9
91JS34B[a]	99.18	0.11	5.73	1.28	0.09	0.07	43	2	15.0	108	2.9	7.8
91JS38E[a]	99.23	0.10	3.05	0.18	0.24	<0.05	18	1	11.0	79	2.2	5.9
92AD9B[a]	99.40	0.16	5.39	0.29	0.47	0.12	23	<1	8.0	46	1.0	1.5
92AD9C[a]	99.35	0.12	4.84	4.35	0.74	0.15	24	<1	7.0	44	0.9	1.7
92AD35A-1[a]	99.40	0.07	3.20	1.28	0.40	0.27	19	<1	4.0	33	0.6	<1
92AD35A-1.5[a]	99.87	0.15	5.01	0.33	0.48	0.30	17	<1	10.0	66	1.6	3.3
92AD35A-12[a]	99.72	0.10	4.15	0.40	0.44	0.36	18	1	11.0	86	2.3	6.0
92AD35C-43A[a]	100.19	0.18	3.28	0.40	0.43	0.45	29	2	8.0	95	2.0	9.5
92AD60A[a]	100.31	0.12	2.81	0.18	1.94	2.19	22	1	10.0	100	2.3	4.1
92AD60D[a]	99.53	0.14	1.76	0.95	1.45	0.42	27	2	8.0	85	2.1	4.5
92AD60F[a]	100.26	0.22	5.22	1.98	0.55	<0.05	25	<1	6.0	39	0.8	1.9
92AD74C[a]	98.54	0.12	8.40	3.50	0.60	0.21	34	2	13.0	116	2.7	6.5
92AKD837R[a]	89.18	0.13	4.71	2.15	0.55	n.a.	19	1	3.4	28	0.82	<4
93JS06A[a]	93.79	0.02	1.01	3.99	0.02	n.a.	3	<1	0.8	<10	0.08	<4
93JS06C[a]	90.00	0.08	3.93	2.09	0.13	n.a.	12	<1	6.1	<40	0.68	<4
93JS07C[a]	82.21	0.36	6.38	6.32	0.67	n.a.	11	1	8.2	<90	0.85	<4
93JS07J[a]	99.12	0.51	6.58	8.50	0.68	<0.05	13	1	9.0	56	1.1	3.3
93JS13E[a]	98.54	0.09	4.22	0.48	0.47	0.30	48	2	17.0	112	3.1	8.2
94JS07A[a]	88.83	n.a.	4.60	n.a.	n.a.	n.a.	12	1	9.8	<140	1.30	<20
94JS09L[a]	92.62	n.a.	4.20	n.a.	n.a.	n.a.	36	<1	4.3	<29	0.52	<20
94JS17S[a]	93.73	n.a.	2.40	n.a.	n.a.	n.a.	30	1	5.6	69	1.80	<20
94JS17T[a]	88.67	n.a.	6.20	n.a.	n.a.	n.a.	15	2	8.6	78	1.80	<20
98AKD28[a]	99.23	n.a.	3.33	0.06	0.39	n.a.	n.a.	1	7.0	84	2.1	5.3
98AKD29[a]	100.05	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	<1	2.0	24	0.7	1.0
98AKD30[a]	94.51	n.a.	3.37	0.49	0.39	n.a.	n.a.	1	5.0	67	1.7	4.7
99 AD24B[a]	100.16	0.15	2.37	0.84	0.41	0.09	n.a.	1	7.0	105	2.3	3.3
JS-00-6A[a]	99.08	0.08	2.18	0.70	0.31	0.24	n.a.	1	5.0	131	3.3	6.3
JS-00-6B[a]	100.08	0.06	1.92	1.14	0.21	0.15	n.a.	1	8.0	115	3.2	4.4
JS-00-9[a]	99.50	0.07	1.40	0.40	0.34	0.75	n.a.	1	9.0	95	1.6	1.6
JS-00-14[a]	98.38	0.08	5.28	0.62	0.47	0.36	n.a.	1	8.0	120	3.1	4.3
JS-00-15A[a]	100.22	0.06	1.61	0.66	0.26	0.42	n.a.	2	9.0	102	3.0	7.2
JS-00-17[a]	99.73	0.06	2.07	0.66	0.22	0.24	n.a.	1	5.0	99	2.3	5.4
JS-00-20[a]	100.38	0.10	2.42	0.70	0.32	0.24	n.a.	1	5.0	49	1.1	2.8
JS-00-22[a]	100.12	0.14	2.11	0.33	0.37	0.63	n.a.	2	6.0	131	3.2	6.1
JS-00-23B[a]	100.50	0.08	1.87	0.77	0.19	0.45	n.a.	2	9.0	111	2.5	6.5
JS-00-27[a]	100.37	0.07	1.41	0.77	0.41	0.09	n.a.	1	7.0	84	1.9	5.9
JS-03-1A[a]	99.73	0.15	3.26	1.06	0.63	0.12	n.a.	3	26	153	3.2	10.0
JS-03-1B[a]	98.72	0.52	3.96	5.30	0.35	1.20	n.a.	2	17	91	2.2	3.5
JS-03-1C[a]	98.78	0.11	2.36	<0.05	1.83	0.21	n.a.	2	10	165	4.2	8.9

JS-03-1D[a]	99.30	0.14	3.34	<0.05	2.06	0.15	n.a.	2	8	101	2.5	8.7
JS-03-1E[a]	99.77	0.11	1.94	<0.05	1.42	0.09	n.a.	2	10	102	2.9	8.7
JS-03-1F[a]	99.68	0.10	1.84	<0.05	1.95	0.09	n.a.	2	10	98	2.6	8.5
JS-03-1G[a]	99.64	0.09	2.67	0.22	1.36	<0.05	n.a.	2	8	84	2.3	8.0
JS-03-1H[a]	99.49	0.09	1.97	<0.05	1.73	0.09	n.a.	2	8	77	2.2	7.6
JS-05-96[c]	99.11	0.42	5.41	0.36	0.40	0.50	n.a.	1	7.3	25	0.7	1.7

Kuna Formation KE-20 outcrop [cont.]

Sample number	Total	F	TOC	CO_2	Total S	SO_4	Li	Be	Sc	Zr	Hf	Nb
	wt%	wt%	wt%	wt%	wt%	wt%	ppm	ppm	ppm	ppm	ppm	ppm
KE98-20-309[c]	98.59	0.05	3.25	1.28	0.56	0.72	n.a.	1	7	81	2.1	5.2
KE98-20-303[c]	98.57	0.04	3.37	<0.05	0.56	0.60	n.a.	2	9	90	2.5	6.0
KE98-20-268[c]	98.68	0.03	4.65	1.25	0.50	0.54	n.a.	1	6	76	1.8	3.6
KE98-20-262[c]	100.13	0.02	5.29	0.66	0.79	0.57	n.a.	<1	5	54	1.3	2.2
KE98-20-256[c]	100.34	0.03	3.07	<0.05	1.84	0.66	n.a.	<1	4	60	1.7	3.1
KE98-20-250[c]	100.34	0.04	4.98	0.26	0.62	0.48	n.a.	1	8	87	2.0	3.9
KE98-20-244[c]	100.20	0.04	4.15	<0.05	0.69	0.90	n.a.	1	8	92	2.4	4.4
KE98-20-238[c]	100.10	0.03	4.42	<0.05	0.54	0.42	n.a.	<1	6	74	1.8	3.1
KE98-20-232[c]	100.35	0.03	4.44	0.11	0.48	0.24	n.a.	<1	4	67	1.4	2.2
KE98-20-220[c]	99.40	0.03	5.22	0.37	0.83	0.66	n.a.	1	5	73	1.9	3.9
KE98-20-214[c]	100.47	0.03	5.88	0.11	0.67	0.27	n.a.	1	4	59	1.4	2.7
KE98-20-208[c]	100.39	0.03	6.01	<0.05	0.72	0.39	n.a.	1	6	75	1.9	3.6
KE98-20-202[c]	100.48	0.03	5.35	0.22	1.01	0.81	n.a.	1	3	58	1.4	2.4
KE98-20-196[c]	100.12	0.03	5.73	0.22	0.94	0.72	n.a.	1	6	76	1.7	3.3
KE98-20-190[c]	100.17	0.04	5.86	<0.05	1.06	0.51	n.a.	1	6	91	1.9	3.8
KE98-20-184[c]	100.15	0.04	7.20	<0.05	1.13	0.75	n.a.	1	5	71	1.8	3.9
KE98-20-178[c]	100.39	0.03	6.56	0.18	0.81	0.42	n.a.	1	4	65	1.6	3.0
KE98-20-172[c]	99.69	0.05	5.92	0.11	0.72	0.36	n.a.	1	8	82	1.7	4.0
KE98-20-168[c]	100.37	0.03	8.00	<0.05	0.89	0.39	n.a.	1	4	60	1.5	2.9
KE98-20-162[c]	99.66	0.03	6.89	0.15	0.84	0.51	n.a.	1	5	68	1.3	2.7
KE98-20-156[c]	100.09	0.03	4.10	<0.05	0.67	0.57	n.a.	<1	5	52	1.2	2.8
KE98-20-150[c]	100.21	0.02	4.72	<0.05	0.59	0.24	n.a.	<1	2	27	0.7	1.0
KE98-20-132[c]	100.40	0.05	2.81	1.25	0.58	0.51	n.a.	1	6	86	2.3	5.5
KE98-20-126[c]	98.78	0.04	1.89	<0.05	1.11	0.30	n.a.	1	6	90	2.5	5.4
KE98-20-114[c]	100.07	0.04	2.27	<0.05	1.05	0.63	n.a.	1	6	81	1.9	4.3
KE98-20-108[c]	100.14	0.04	5.19	<0.05	0.84	0.66	n.a.	1	4	62	2.2	3.6
KE98-20-96[c]	99.54	0.04	3.68	<0.05	0.76	0.69	n.a.	1	6	81	1.8	4.3
KE98-20-87[c]	98.75	0.04	2.58	<0.05	0.55	0.72	n.a.	1	9	105	2.7	6.2
KE98-20-81[c]	99.53	0.04	5.05	<0.05	0.73	0.60	n.a.	1	8	99	2.6	5.9
KE98-20-75[c]	98.84	0.05	5.80	<0.05	0.78	1.11	n.a.	2	7	88	2.4	5.4
KE98-20-69[c]	98.51	0.05	4.85	<0.05	0.59	0.57	n.a.	1	7	82	2.0	4.8
KE98-20-63[c]	100.15	0.03	n.a.	n.a.	n.a.	n.a.	n.a.	<1	3	44	1.1	2.1
KE98-20-51[c]	99.39	0.05	4.10	<0.05	0.64	0.75	n.a.	1	7	93	2.3	4.6
KE98-20-42[c]	100.44	0.04	1.60	0.18	0.50	0.42	n.a.	1	8	115	3.1	6.9
KE98-20-36[c]	99.35	0.04	1.90	<0.05	0.92	0.72	n.a.	1	9	109	2.9	6.3
KE98-20-30[c]	100.17	0.04	6.51	0.18	1.42	0.63	n.a.	1	5	70	1.8	3.6
KE98-20-24[c]	100.38	0.03	3.27	<0.05	1.93	0.60	n.a.	1	5	63	1.6	3.3
KE98-20-18[c]	100.17	0.28	2.67	<0.05	1.21	1.05	n.a.	1	5	67	1.7	3.1
KE98-20-12[c]	98.55	0.07	3.15	<0.05	0.98	0.33	n.a.	1	6	77	1.9	3.9
KE98-20-6[c]	99.16	0.02	6.00	<0.05	0.74	0.60	n.a.	2	8	98	2.5	5.6
KE98-20-0[c]	100.47	0.01	3.88	0.18	1.59	0.78	n.a.	1	4	56	1.5	1.7

Kuna Formation drill cores [cont.]

Sample number	Total	F	TOC	CO_2	Total S	SO_4	Li	Be	Sc	Zr	Hf	Nb
	wt%	wt%	wt%	wt%	wt%	wt%	ppm	ppm	ppm	ppm	ppm	ppm
50-326[c]	98.73	0.13	3.20	4.50	2.25	1.47	n.a.	2	9	79	1.8	4.2
50-333[c]	98.61	0.13	3.62	3.70	1.95	1.32	n.a.	2	8	85	2.0	5.0
50-378[c]	100.05	0.05	4.72	2.20	1.73	0.63	n.a.	1	4	46	1.2	2.8
50-402.5[c]	98.66	0.07	1.74	4.10	1.84	1.95	n.a.	2	7	76	2.0	4.2
50-425.5[c]	99.00	0.13	2.51	<0.05	2.28	0.36	n.a.	2	6	108	2.7	5.7
50-420[c]	98.91	0.05	2.43	1.17	1.64	0.87	n.a.	1	6	55	1.4	3.2
1105-1155.3[a]	99.14	0.11	1.63	4.40	3.15	2.34	n.a.	1	8.3	140	3.7	7.2
1105-1171.5[a]	98.96	0.12	2.97	1.47	3.15	1.02	n.a.	2	9.9	154	3.9	8.4
1105-1190.7[a]	98.84	0.11	2.63	2.79	2.75	1.62	n.a.	2	9.1	123	3.2	7.3
1105-1211.5[a]	98.84	0.10	2.32	2.82	3.50	1.68	n.a.	2	9.2	125	3.3	7.4

Phosphatic unit (EMA, Skimo thrust sheet) [cont.]

Sample number	Total	F	TOC	CO_2	Total S	SO_4	Li	Be	Sc	Zr	Hf	Nb
	wt%	wt%	wt%	wt%	wt%	wt%	ppm	ppm	ppm	ppm	ppm	ppm
11SKBO-4-(2)[c]	98.97	0.24	4.54	1.74	0.66	1.0	5.1	<1	2.3	32	0.7	1.5
11SKBO-3-(2)[c]	98.03	1.01	7.41	0.95	1.07	0.6	8.8	1	8.8	64	1.7	3.0
11SKBO-2.7-(2)[c]	99.00	0.25	6.39	4.09	0.85	1.8	4.3	<1	4.8	33	0.8	1.8
11SKBO-1.2-(2)[c]	95.83	0.20	8.33	6.62	1.30	2.9	8.9	1	6.4	60	1.4	2.9
11SKBO-0.95-(2)[c]	98.44	0.40	8.59	1.73	1.05	0.4	11.4	<1	5.5	56	1.2	2.9
11SKBO-14-(2)[c]	98.34	0.38	6.04	4.45	0.95	1.9	12.5	1	7.1	91	2.2	4.7
11SKBO-8.2-(2)[c]	94.23	0.14	8.46	8.95	1.23	3.1	9.1	<1	6.5	59	1.4	3.5
11SKBO-7.3-(2)[c]	98.30	0.12	8.42	5.24	0.95	2.2	9.7	<1	4.6	47	1.1	3.0
11SKBO-5.5-(2)[c]	96.24	0.13	9.02	6.05	1.09	2.3	17.7	1	7.7	79	2.0	4.9
11SKBO-4.8-(2)[c]	98.19	0.24	8.67	8.80	1.07	2.7	14.4	<1	6.3	57	1.4	2.7
11SKBO-3.8-(2)[c]	97.91	0.17	8.52	9.41	2.63	5.1	18.8	2	9.1	106	2.3	5.9
CCP-1.35[b]	99.81	0.58	8.05	3.04	0.82	0.90	11.7	2	6.1	67	1.7	2.6
05AD6E[b]	100.22	1.27	15.0	0.53	1.57	0.50	14.2	6	7.7	89	1.6	3.4

Phosphatic unit (EMA, Ivotuk plate; **KRA) [cont.]

Sample number	Total	F	TOC	CO_2	Total S	SO_4	Li	Be	Sc	Zr	Hf	Nb
	wt%	wt%	wt%	wt%	wt%	wt%	ppm	ppm	ppm	ppm	ppm	ppm
92AD31A[b]	98.55	0.66	15.9	4.45	1.53	0.21	28.3	2	11.0	116	3.1	5.8
92AD31H[b]	98.61	1.27	14.7	2.06	1.16	0.09	25.4	2	8.0	79	3.0	4.9
92AD32B[b]	98.80	0.56	2.69	8.10	0.28	0.03	7.6	<1	7.0	86	2.1	3.8
03AD27A[b]**	99.22	0.78	3.00	0.73	1.04	0.05	34.4	2	12.4	120	3.5	8.7
03AD38C[b]**	98.78	0.19	7.68	6.80	0.60	0.06	35.1	1	6.6	69	1.7	3.9
JS-00-2[b]**	99.65	1.53	4.41	1.65	0.38	0.09	43.7	1	19.3	113	3.5	4.5
JS-05-82C[b]	95.31	0.43	17.4	1.14	2.60	0.90	17.6	6	7.1	92	2.4	4.1

Table A4. Whole-rock geochemical data for black mudrocks of the Lisburne Group* [cont.]

[*Data sources: [a], Slack et al. (2004c); [b], Dumoulin et al. (2011); [c], this study. Results for samples having >10 wt% CO_2 or >10 wt% P_2O_5 are excluded. Analytical methods are described in Dumoulin et al. (2011). n.a., not analyzed]

Kuna Formation (and related units) regional outcrops [cont.]

Sample number	Ta	Cr	V	Co	Ni	Cu	Zn	Cd	Mo	Re	Au
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppb
90JS04M[a]	0.2	234	128	0.8	34	22	57	<2	3	n.a.	5
91AD1B3.0[a]	0.2	767	178	1.6	199	130	708	4	17	n.a.	6
91AD1-7.2[a]	0.1	1060	218	2.0	250	150	581	6	33	n.a.	<2
91JS04G[a]	0.2	857	169	1.8	223	130	530	2	22	n.a.	<2
91JS18A[a]	0.8	100	118	13.2	34	21	84	<2	<2	n.a.	<2
91JS19B[a]	<0.1	516	128	0.4	91	58	85	<2	15	n.a.	<2
91JS34B[a]	0.7	400	162	1.0	26	2	20	<2	5	n.a.	<2
91JS38E[a]	0.6	200	158	0.7	<20	3	12	<2	<2	n.a.	2
92AD9B[a]	0.2	350	108	0.6	<20	34	32	<2	5	n.a.	<2
92AD9C[a]	0.2	293	98	3.3	113	52	212	<2	5	n.a.	<2
92AD35A-1[a]	0.1	134	98	0.5	<20	18	33	<2	2	n.a.	3
92AD35A-1.5[a]	0.3	311	140	0.9	23	24	33	<2	3	n.a.	4
92AD35A-12[a]	0.5	288	138	0.7	<20	4	11	<2	3	n.a.	3
92AD35C-43A[a]	0.8	284	141	1.5	38	17	61	<2	3	n.a.	<2
92AD60A[a]	0.4	353	142	0.4	<20	23	36	<2	14	n.a.	7
92AD60D[a]	0.4	218	127	3.3	36	66	112	<2	4	n.a.	<2
92AD60F[a]	0.1	370	116	1.0	90	66	103	<2	8	n.a.	3
92AD74C[a]	0.4	909	145	10.1	342	190	786	4	17	n.a.	<2
92AKD837R[a]	0.23	323	120	1.1	130	45	270	<2	9	n.a.	5
93JS06A[a]	0.02	8	22	0.6	24	17	23	<2	<2	n.a.	4
93JS06C[a]	0.18	56	120	5.3	130	76	123	<2	4	n.a.	6
93JS07C[a]	0.17	508	150	1.6	220	89	409	2	11	n.a.	6
93JS07J[a]	0.1	594	154	2.1	223	110	476	2	11	n.a.	<3
93JS13E[a]	0.7	351	209	1.6	21	44	20	<2	3	n.a.	5
94JS07A[a]	0.29	438	150	5.6	200	70	453	n.a.	7	n.a.	<3
94JS09L[a]	0.17	340	150	0.3	70	10	9	n.a.	10	n.a.	4
94JS17S[a]	0.36	222	100	0.4	30	5	27	n.a.	<5	n.a.	5
94JS17T[a]	0.30	837	150	0.6	70	30	56	n.a.	20	n.a.	19
98AKD28[a]	0.4	416	249	5.1	236	120	431	n.a.	20	n.a.	n.a.
98AKD29[a]	0.2	109	65	3.3	62	30	175	n.a.	5	n.a.	n.a.
98AKD30[a]	0.5	404	233	6.2	251	91	712	n.a.	11	n.a.	n.a.
99 AD24B[a]	0.47	169	118	1.3	43	29	53	n.a.	4	n.a.	7
JS-00-6A[a]	0.62	137	118	2.4	39	26	77	n.a.	2	n.a.	5
JS-00-6B[a]	0.52	110	141	<1	<20	<10	<30	n.a.	7	n.a.	8
JS-00-9[a]	0.53	160	167	<1	<20	<10	<30	n.a.	5	n.a.	7
JS-00-14[a]	0.58	380	168	<1	22	15	<30	n.a.	10	n.a.	14
JS-00-15A[a]	0.72	105	106	2.6	<20	<10	38	n.a.	<2	n.a.	7
JS-00-17[a]	0.52	111	146	<1	<20	16	<30	n.a.	2	n.a.	10
JS-00-20[a]	0.38	218	134	<1	<20	<10	<30	n.a.	<2	n.a.	<2
JS-00-22[a]	0.69	155	125	1.2	28	14	<30	n.a.	3	n.a.	10
JS-00-23B[a]	0.53	205	164	1.5	23	19	<30	n.a.	<2	n.a.	5
JS-00-27[a]	0.51	102	197	<1	<20	<10	<30	n.a.	<2	n.a.	9
JS-03-1A[a]	0.56	201	283	5	151	24	25	0.3	39	n.a.	22
JS-03-1B[a]	0.16	256	206	41	621	458	707	8.1	17	n.a.	10
JS-03-1C[a]	0.71	134	182	3	82	36	32	0.3	22	n.a.	4

JS-03-1D[a]	0.60	189	157	2	115	32	33	0.4	31	n.a.	<2
JS-03-1E[a]	0.67	107	132	1	28	13	22	0.3	5	n.a.	4
JS-03-1F[a]	0.63	103	135	2	39	20	24	0.5	4	n.a.	5
JS-03-1G[a]	0.66	125	155	2	45	17	23	<0.3	4	n.a.	<2
JS-03-1H[a]	0.57	93	111	2	38	18	23	0.5	5	n.a.	4
JS-05-96[c]	0.11	263	91	4	182	68	350	0.9	6	n.a.	<2

Kuna Formation KE-20 outcrop [cont.]

Sample number	Ta ppm	Cr ppm	V ppm	Co ppm	Ni ppm	Cu ppm	Zn ppm	Cd ppm	Mo ppm	Re ppm	Au ppb
KE98-20-309[c]	0.62	120	130	1	79	11	40	n.a.	3	n.a.	4
KE98-20-303[c]	0.71	144	170	<1	<20	<10	<30	n.a.	6	n.a.	<2
KE98-20-268[c]	0.44	311	197	<1	99	10	<30	n.a.	9	n.a.	2
KE98-20-262[c]	0.33	153	136	<1	74	38	40	n.a.	5	n.a.	<2
KE98-20-256[c]	0.46	168	163	2	112	104	72	n.a.	5	n.a.	39
KE98-20-250[c]	0.45	231	175	<1	84	62	34	n.a.	5	n.a.	9
KE98-20-244[c]	0.68	316	181	<1	45	<10	<30	n.a.	4	n.a.	21
KE98-20-238[c]	0.40	225	151	<1	65	29	<30	n.a.	5	n.a.	6
KE98-20-232[c]	0.32	140	147	<1	72	13	35	n.a.	4	n.a.	8
KE98-20-220[c]	0.51	283	186	<1	73	<10	<30	n.a.	7	n.a.	6
KE98-20-214[c]	0.36	205	155	<1	86	<10	<30	n.a.	6	n.a.	5
KE98-20-208[c]	0.44	223	174	<1	106	11	92	n.a.	8	n.a.	12
KE98-20-202[c]	0.35	220	162	<1	66	<10	<30	n.a.	17	n.a.	13
KE98-20-196[c]	0.39	253	177	<1	94	36	129	n.a.	13	n.a.	10
KE98-20-190[c]	0.45	271	225	<1	119	52	177	n.a.	20	n.a.	8
KE98-20-184[c]	0.46	348	294	<1	105	12	38	n.a.	5	n.a.	9
KE98-20-178[c]	0.35	195	224	<1	98	11	48	n.a.	6	n.a.	6
KE98-20-172[c]	0.47	257	235	<1	96	27	58	n.a.	9	n.a.	9
KE98-20-168[c]	0.34	361	305	<1	145	45	46	n.a.	10	n.a.	<2
KE98-20-162[c]	0.35	334	216	<1	113	11	78	n.a.	10	n.a.	5
KE98-20-156[c]	0.29	249	151	2	54	16	50	n.a.	5	n.a.	9
KE98-20-150[c]	0.18	108	81	<1	33	18	95	n.a.	5	n.a.	6
KE98-20-132[c]	0.59	105	108	<1	55	14	32	n.a.	2	n.a.	5
KE98-20-126[c]	0.64	100	108	2	<20	<10	<30	n.a.	1	n.a.	<2
KE98-20-114[c]	0.53	126	121	2	<20	<10	<30	n.a.	2	n.a.	4
KE98-20-108[c]	0.44	179	144	<1	48	14	<30	n.a.	6	n.a.	10
KE98-20-96[c]	0.51	145	135	2	36	14	83	n.a.	3	n.a.	<2
KE98-20-87[c]	0.70	162	175	<1	<20	<10	<30	n.a.	3	n.a.	<2
KE98-20-81[c]	0.61	180	206	<1	<20	<10	47	n.a.	2	n.a.	<2
KE98-20-75[c]	0.62	273	211	<1	35	<10	<30	n.a.	3	n.a.	15
KE98-20-69[c]	0.58	205	168	<1	27	13	<30	n.a.	4	n.a.	<2
KE98-20-63[c]	0.29	81	67	1	28	10	147	n.a.	1	n.a.	<2
KE98-20-51[c]	0.63	127	142	<1	20	<10	<30	n.a.	3	n.a.	<2
KE98-20-42[c]	0.76	107	122	<1	<20	<10	<30	n.a.	1	n.a.	<2
KE98-20-36[c]	0.69	113	121	2	<20	<10	<30	n.a.	1	n.a.	3
KE98-20-30[c]	0.46	160	129	2	51	25	<30	n.a.	7	n.a.	13
KE98-20-24[c]	0.53	119	135	2	32	37	<30	n.a.	5	n.a.	<2
KE98-20-18[c]	0.46	125	112	<1	<20	10	<30	n.a.	6	n.a.	<2
KE98-20-12[c]	0.51	153	140	3	28	24	<30	n.a.	4	n.a.	<2
KE98-20-6[c]	0.65	239	201	<1	39	<10	<30	n.a.	6	n.a.	4
KE98-20-0[c]	0.39	168	133	<1	26	16	<30	n.a.	4	n.a.	11

Kuna Formation drill cores [cont.]

Sample number	Ta	Cr	V	Co	Ni	Cu	Zn	Cd	Mo	Re	Au
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppb
50-326[c]	0.33	194	198	7	193	103	586	5.1	16	n.a.	6
50-333[c]	0.37	190	195	6	191	103	581	4.6	16	n.a.	3
50-378[c]	0.19	70	163	5	165	100	340	2.2	15	n.a.	12
50-402.5[c]	0.31	75	89	4	73	50	197	0.5	6	n.a.	6
50-425.5[c]	0.43	94	156	5	116	76	175	0.6	9	n.a.	7
50-420[c]	0.23	38	122	4	87	50	172	0.3	<2	n.a.	6
1105-1155.3[a]	0.48	161	97	7.0	83	29	284	n.a.	23	n.a.	5
1105-1171.5[a]	0.55	230	153	10.0	153	59	545	n.a.	8	n.a.	9
1105-1190.7[a]	0.49	140	112	9.0	111	38	339	n.a.	5	n.a.	8
1105-1211.5[a]	0.51	170	127	8.0	141	59	447	n.a.	7	n.a.	<2

Phosphatic unit (EMA, Skimo thrust sheet) [cont.]

Sample number	Ta	Cr	V	Co	Ni	Cu	Zn	Cd	Mo	Re	Au
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppb
11SKBO-4-(2)[c]	0.06	480	417	1.0	121	62.9	679	34.1	18.0	0.181	<2
11SKBO-3-(2)[c]	<0.01	870	313	2.1	151	117	698	7.03	16.4	0.153	<2
11SKBO-2.7-(2)[c]	0.08	430	236	1.3	122	61.0	550	13.4	16.3	0.105	10
11SKBO-1.2-(2)[c]	0.20	1030	354	2.8	274	140	1080	30.2	20.8	0.204	7
11SKBO-0.95-(2)[c]	0.14	840	414	2.0	201	125	840	18.3	28.0	0.264	6
11SKBO-14-(2)[c]	0.36	660	649	5.1	255	102	1690	72.0	15.5	0.248	9
11SKBO-8.2-(2)[c]	0.26	460	442	3.4	195	79.5	814	24.5	18.8	0.167	6
11SKBO-7.3-(2)[c]	0.21	470	249	2.5	191	71.0	669	15.7	14.0	0.215	7
11SKBO-5.5-(2)[c]	0.41	600	564	5.5	315	93.7	1130	33.2	38.1	0.327	9
11SKBO-4.8-(2)[c]	0.30	540	296	2.8	254	67.4	861	13.2	15.1	0.243	9
11SKBO-3.8-(2)[c]	0.46	1280	607	6.0	519	149	2660	142	78.2	0.383	11
CCP-1.35[b]	0.12	1070	576	2.1	238	135	1090	43.9	46.8	0.367	<0.5
05AD6E[b]	0.24	1660	2831	1.8	447	295	1740	136	135	0.495	9.1

Phosphatic unit (EMA, Ivotuk plate; **KRA) [cont.]

Sample number	Ta	Cr	V	Co	Ni	Cu	Zn	Cd	Mo	Re	Au
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppb
92AD31A[b]	0.54	1690	1720	6.5	416	202	1650	126	74.6	0.187	58.7
92AD31H[b]	0.38	1340	1180	3.3	330	222	1070	52.6	92.6	0.166	21.4
92AD32B[b]	0.31	573	169	5.2	171	96.2	537	10.3	26.0	0.112	<0.5
03AD27A[b]**	0.57	205	249	5.6	72.2	92.4	203	1.01	18.8	0.084	<0.5
03AD38C[b]**	0.25	39	160	8.2	257	133	643	3.3	23.5	0.114	<0.5
JS-00-2[b]**	0.47	210	190	12.8	186	124	363	1.89	15.8	0.200	<0.5
JS-05-82C[b]	0.34	1150	1499	2.4	332	183	895	80.3	84.1	0.695	<0.5

Table A4. Whole-rock geochemical data for black mudrocks of the Lisburne Group* [cont.]

[*Data sources: [a], Slack et al. (2004c); [b], Dumoulin et al. (2011); [c], this study. Results for samples having >10 wt% CO_2 or >10 wt% P_2O_5 are excluded. Analytical methods are described in Dumoulin et al. (2011). n.a., not analyzed]

Kuna Formation (and related units) regional outcrops [cont.]

Sample number	Ag	Tl	Pb	Ga	Ge	Cs	Rb	Sr	Sn	W	Th	U
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
90JS04M[a]	<0.5	<0.1	7	5	<1	3.2	45.4	39	<1	1.5	2.9	7.83
91AD1B3.0[a]	<0.5	0.18	<5	7	<1	2.8	49.0	119	<1	3.7	6.3	18.52
91AD1-7.2[a]	14.5	<0.1	26	3	<1	1.8	27.8	71	<1	<1	5.0	10.98
91JS04G[a]	1.8	<0.1	5	5	<1	2.0	29.2	69	<1	1.4	4.1	9.89
91JS18A[a]	<0.5	0.69	7	17	<1	11.6	137.4	142	3	1.8	11.8	2.32
91JS19B[a]	1.7	<0.1	<4	3	<1	1.2	21.0	100	<1	<1	3.1	12.95
91JS34B[a]	<0.5	<0.1	12	9	<1	11.1	108.5	42	7	1.3	4.2	2.00
91JS38E[a]	0.5	0.17	<5	13	<1	8.3	121.0	33	2	1.6	4.3	1.67
92AD9B[a]	<0.5	<0.1	<5	5	<1	2.5	36.2	52	<1	1.2	2.8	3.55
92AD9C[a]	2.5	<0.1	7	4	<1	2.2	31.8	57	<1	<1	2.7	2.44
92AD35A-1[a]	0.5	0.1	9	4	<1	1.8	30.0	28	<1	<1	2.1	2.15
92AD35A-1.5[a]	<0.5	<0.1	<5	6	<1	4.0	61.8	39	<1	1.2	4.1	7.31
92AD35A-12[a]	1.3	0.1	<5	12	<1	7.6	111.2	34	1	1.2	3.4	1.76
92AD35C-43A[a]	0.9	<0.1	<5	10	<1	5.7	83.2	73	<1	1.2	4.6	3.21
92AD60A[a]	7.1	0.33	10	8	<1	7.2	60.6	78	<1	1.4	4.7	4.79
92AD60D[a]	<0.5	1.11	<5	7	<1	6.8	56.7	34	<1	<1	4.7	5.93
92AD60F[a]	1.1	<0.1	<5	3	<1	1.7	21.3	44	<1	<1	1.9	16.37
92AD74C[a]	<0.5	<0.1	<5	7	<1	3.0	48.7	263	<1	1.1	8.4	33.23
92AKD837R[a]	4.0	n.a.	6	<4	n.a.	2.1	21.0	47	<5	n.a.	2.08	3.93
93JS06A[a]	<2	n.a.	<4	<4	n.a.	0.3	2.8	130	<5	n.a.	0.22	1.40
93JS06C[a]	<2	n.a.	7	5	n.a.	3.0	37.2	160	<5	n.a.	2.27	8.49
93JS07C[a]	6.0	n.a.	<4	<4	n.a.	1.8	25.0	350	<5	n.a.	2.50	14.70
93JS07J[a]	<0.5	<0.1	<5	3	<1	1.7	24.6	275	<1	<1	3.1	13.92
93JS13E[a]	0.7	0.25	<5	15	1.80	12.6	138.3	69	7	1.6	10.5	4.33
94JS07A[a]	10.0	n.a.	<10	<5	n.a.	5.4	51.0	100	<10	n.a.	4.81	6.70
94JS09L[a]	7.0	n.a.	<10	<5	n.a.	1.0	18.0	<100	<10	n.a.	1.69	7.20
94JS17S[a]	1.0	n.a.	<10	<5	n.a.	8.1	51.2	<100	<10	n.a.	2.23	1.50
94JS17T[a]	10.0	n.a.	<10	<5	n.a.	10.4	42.0	<100	<10	n.a.	2.97	20.20
98AKD28[a]	3.8	0.92	<5	11	1.81	3.3	49.6	89	1	2.0	5.22	12.54
98AKD29[a]	3.3	0.63	<5	4	0.71	1.1	15.3	53	1	10.6	1.72	5.24
98AKD30[a]	4.1	0.99	33	10	1.99	2.7	48.0	70	1	2.7	4.14	10.66
99 AD24B[a]	1.5	0.16	<5	8	0.70	10.3	59.1	41	<1	0.6	4.60	6.77
JS-00-6A[a]	<0.5	0.30	<5	10	<0.5	8.0	80.9	43	1	1.1	4.60	6.62
JS-00-6B[a]	<0.5	<0.05	<5	8	<0.5	7.7	77.8	46	<1	1.1	4.31	6.46
JS-00-9[a]	<0.5	0.13	<5	11	0.98	7.0	96.1	71	<1	1.2	6.26	5.10
JS-00-14[a]	<0.5	<0.05	<5	9	<0.5	10.7	95.5	31	<1	1.1	4.58	5.57
JS-00-15A[a]	<0.5	0.16	<5	11	<0.5	9.3	104.5	47	2	2.0	5.57	2.68
JS-00-17[a]	<0.5	<0.05	<5	7	0.51	9.0	81.4	44	<1	0.6	3.68	6.32
JS-00-20[a]	<0.5	0.13	<5	7	<0.5	9.1	68.2	16	<1	0.5	2.35	1.65
JS-00-22[a]	<0.5	0.45	<5	10	1.00	12.8	86.6	73	1	0.8	6.33	5.72
JS-00-23B[a]	<0.5	0.33	<5	9	1.56	11.4	101.3	44	1	1.2	4.83	1.85
JS-00-27[a]	<0.5	0.09	<5	10	0.75	7.9	101.8	51	1	0.6	4.12	2.50
JS-03-1A[a]	7.1	0.75	20	17	1.1	8.7	97	174	<1	1.5	6.84	19.1
JS-03-1B[a]	15.2	0.08	<5	4	0.6	1.9	23	775	<1	0.7	3.33	96.4
JS-03-1C[a]	2.3	0.31	16	11	0.7	13.7	99	91	<1	1.2	8.43	9.78

JS-03-1D[a]	4.1	0.96	16	10	0.5	10.7	114	65	<1	1.2	6.11	6.16
JS-03-1E[a]	1.9	0.61	14	11	0.8	10.0	122	60	1	1.1	7.40	3.50
JS-03-1F[a]	1.7	0.52	15	11	0.6	10.4	118	53	<1	1.9	7.29	3.05
JS-03-1G[a]	2.4	0.79	11	11	<0.5	10.9	118	46	1	1.1	6.25	2.32
JS-03-1H[a]	1.2	0.59	15	10	<0.5	9.5	105	44	<1	1.5	5.93	2.52
JS-05-96[c]	1	0.42	<5	5	0.8	2	30	145	1	0.8	2.09	8.58

Kuna Formation KE-20 outcrop [cont.]

Sample number	Ag ppm	Tl ppm	Pb ppm	Ga ppm	Ge ppm	Cs ppm	Rb ppm	Sr ppm	Sn ppm	W ppm	Th ppm	U ppm
KE98-20-309[c]	0.8	1.79	<5	11	0.5	15.7	118	80	2	0.8	4.35	2.00
KE98-20-303[c]	<0.5	0.76	<5	11	1.1	15.0	117	72	1	0.9	6.90	4.67
KE98-20-268[c]	2.3	2.16	<5	9	<0.5	12.9	88	147	2	0.6	4.79	9.74
KE98-20-262[c]	1.9	1.45	19	6	<0.5	7.8	58	46	<1	0.9	2.82	6.35
KE98-20-256[c]	1.3	0.75	15	7	<0.5	9.4	69	71	<1	0.7	3.97	5.52
KE98-20-250[c]	1.3	1.52	81	9	<0.5	12.4	84	173	1	0.8	5.04	7.64
KE98-20-244[c]	1.8	1.10	46	10	1.0	14.9	95	95	1	0.9	4.74	7.28
KE98-20-238[c]	1.6	0.97	23	7	<0.5	10.0	71	63	<1	0.5	4.01	5.17
KE98-20-232[c]	1.5	0.43	20	6	<0.5	7.6	56	41	2	0.8	3.21	2.74
KE98-20-220[c]	2.7	0.43	54	8	0.5	10.9	80	79	<1	0.6	4.28	7.22
KE98-20-214[c]	2.4	1.05	30	7	1.0	10.3	67	72	<1	13.8	3.20	5.79
KE98-20-208[c]	4.0	1.24	44	9	1.8	12.9	80	65	<1	1.1	3.50	7.61
KE98-20-202[c]	8.7	2.89	17	6	<0.5	8.3	57	93	<1	0.9	3.85	7.45
KE98-20-196[c]	3.0	2.30	15	8	1.1	10.8	72	102	8	0.7	4.63	9.69
KE98-20-190[c]	3.9	4.03	30	10	1.1	13.6	89	81	3	0.8	4.17	10.2
KE98-20-184[c]	6.4	3.60	39	9	1.2	15.0	88	64	<1	1.3	3.59	3.68
KE98-20-178[c]	2.4	1.57	41	8	1.3	11.6	71	42	<1	0.8	3.16	3.24
KE98-20-172[c]	2.5	3.52	36	11	1.2	15.6	100	64	<1	0.8	4.45	3.86
KE98-20-168[c]	6.4	0.83	52	7	0.5	12.7	74	62	<1	0.9	2.75	2.63
KE98-20-162[c]	5.2	2.37	30	8	<0.5	11.5	75	74	4	<0.5	3.07	4.52
KE98-20-156[c]	4.0	2.28	45	7	1.0	10.0	65	46	<1	1.1	3.06	2.74
KE98-20-150[c]	2.2	0.70	95	4	<0.5	5.5	36	41	<1	<0.5	1.65	2.52
KE98-20-132[c]	2.7	2.72	39	12	0.9	14.8	111	76	2	0.9	6.89	2.64
KE98-20-126[c]	9.8	2.04	<5	12	<0.5	13.6	105	51	<1	0.8	5.40	1.72
KE98-20-114[c]	2.2	2.06	40	11	<0.5	13.5	97	48	<1	0.6	4.57	1.92
KE98-20-108[c]	0.7	1.23	29	9	1.0	12.5	86	62	<1	1.4	2.91	3.50
KE98-20-96[c]	4.1	2.74	72	12	0.8	14.6	105	57	2	1.0	3.92	2.37
KE98-20-87[c]	<0.5	2.81	7	14	0.8	18.3	123	63	3	0.8	5.66	2.98
KE98-20-81[c]	1.9	2.29	17	14	1.5	19.7	127	82	2	1.3	4.82	2.77
KE98-20-75[c]	2.2	0.87	84	11	0.7	17.7	112	61	1	0.9	3.83	4.05
KE98-20-69[c]	1.6	3.10	21	13	<0.5	14.7	108	60	1	0.8	4.84	3.29
KE98-20-63[c]	0.6	1.65	29	6	0.6	7.9	56	29	1	<0.5	3.05	2.20
KE98-20-51[c]	0.7	2.10	33	13	1.0	18.7	122	58	1	1.0	4.38	1.97
KE98-20-42[c]	<0.5	1.53	<5	14	0.9	17.6	122	54	2	0.9	7.46	2.22
KE98-20-36[c]	<0.5	1.85	7	13	0.7	18.3	119	54	2	0.9	7.34	1.86
KE98-20-30[c]	1.8	1.28	33	11	1.7	17.7	101	50	1	0.9	3.97	2.56
KE98-20-24[c]	<0.5	1.43	44	9	0.6	13.2	84	34	1	0.6	4.11	1.40
KE98-20-18[c]	1.1	3.05	13	11	0.7	12.9	99	40	5	0.6	3.57	2.40
KE98-20-12[c]	0.8	1.92	45	12	0.5	15.6	113	62	3	1.1	6.21	3.16
KE98-20-6[c]	<0.5	0.19	<5	13	0.8	20.1	149	87	1	0.7	5.51	3.64
KE98-20-0[c]	0.9	1.14	27	9	0.5	12.9	76	30	1	0.5	2.37	1.24

Kuna Formation drill cores [cont.]

Sample number	Ag	Tl	Pb	Ga	Ge	Cs	Rb	Sr	Sn	W	Th	U
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
50-326[c]	6.6	0.84	29	6	<0.5	7.9	47	103	<1	0.8	4.41	18.9
50-333[c]	6.7	0.52	44	6	<0.5	8.6	50	103	<1	1.9	4.85	19.4
50-378[c]	3.3	0.23	14	4	<0.5	5.7	30	32	<1	<0.5	2.07	2.14
50-402.5[c]	1.0	0.19	11	5	<0.5	6.4	42	126	<1	0.6	4.03	6.11
50-425.5[c]	1.5	0.34	25	8	<0.5	10.2	63	130	<1	1.0	5.95	6.48
50-420[c]	1.1	0.29	45	4	<0.5	5.9	34	64	<1	<0.5	2.80	3.49
1105-1155.3[a]	2.1	1.50	8	8	<0.5	6.5	69	75	<1	0.9	5.36	8.29
1105-1171.5[a]	2.8	0.10	31	11	0.7	9.6	85	59	<1	1.0	6.00	7.52
1105-1190.7[a]	1.4	0.26	52	8	<0.5	8.7	74	80	<1	0.8	5.40	6.05
1105-1211.5[a]	2.3	0.10	38	9	<0.5	8.5	80	87	<1	0.9	5.94	6.57

Phosphatic unit (EMA, Skimo thrust sheet) [cont.]

Sample number	Ag	Tl	Pb	Ga	Ge	Cs	Rb	Sr	Sn	W	Th	U
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
11SKBO-4-(2)[c]	12.8	0.58	4.53	2	< 0.5	0.55	7.9	89.5	<1	<0.5	1.21	13.8
11SKBO-3-(2)[c]	21.3	0.91	5.62	6	1.1	1.13	20.0	306	<1	0.9	5.60	40.6
11SKBO-2.7-(2)[c]	13.9	0.33	3.68	2	< 0.5	0.57	9.5	116	<1	1.0	2.17	13.0
11SKBO-1.2-(2)[c]	25.4	0.70	6.48	5	< 0.5	1.09	12.7	132	<1	8.3	3.14	14.9
11SKBO-0.95-(2)[c]	16.8	0.87	7.72	5	< 0.5	1.23	16.7	150	<1	<0.5	3.23	26.3
11SKBO-14-(2)[c]	25.1	1.82	9.80	7	< 0.5	1.91	24.5	138	<1	0.8	4.44	19.6
11SKBO-8.2-(2)[c]	11.0	0.54	6.55	5	< 0.5	1.07	12.2	130	<1	<0.5	3.38	11.4
11SKBO-7.3-(2)[c]	9.56	0.28	5.02	5	< 0.5	1.16	12.6	76.0	<1	0.7	2.83	8.19
11SKBO-5.5-(2)[c]	16.2	0.92	8.45	7	< 0.5	2.29	25.1	108	<1	0.7	4.69	13.4
11SKBO-4.8-(2)[c]	12.3	0.38	7.23	5	< 0.5	1.84	19.4	177	<1	0.5	9.13	14.2
11SKBO-3.8-(2)[c]	34.7	2.81	11.8	10	2.6	1.65	18.1	145	<1	1.8	5.60	19.3
CCP-1.35[b]	21.5	0.65	8.92	3	4.1	2.3	31	146	<1	1.2	3.40	25.7
05AD6E[b]	46.5	1.80	15.9	4	10.0	3.3	44	226	<1	1.5	4.22	59.4

Phosphatic unit (EMA, Ivotuk plate; **KRA) [cont.]

Sample number	Ag	Tl	Pb	Ga	Ge	Cs	Rb	Sr	Sn	W	Th	U
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
92AD31A[b]	37.9	0.54	13.9	4	0.5	5.0	70	129	<1	1.8	6.82	31.4
92AD31H[b]	28.7	< 0.05	15.2	5	0.5	4.1	56	293	<1	1.5	7.18	49.9
92AD32B[b]	12.6	< 0.05	5.65	5	0.5	3.4	40	68	4	1.2	4.61	13.0
03AD27A[b]**	2.50	0.61	8.61	7	0.5	6.7	88	328	<1	1.2	5.42	22.3
03AD38C[b]**	5.86	0.06	6.86	4	0.8	1.4	36	136	<1	<0.5	3.88	14.7
JS-00-2[b]**	1.85	< 0.05	11.1	8	0.3	6.0	65	875	<1	1.1	4.91	35.9
JS-05-82C[b]	21.4	1.99	13.0	3	1.0	4.1	56	77	<1	<0.5	5.13	27.2

Table A4. Whole-rock geochemical data for black mudrocks of the Lisburne Group* [cont.]

[*Data sources: [a], Slack et al. (2004c); [b], Dumoulin et al. (2011); [c], this study. Results for samples having >10 wt% CO_2 or >10 wt% P_2O_5 are excluded. Analytical methods are described in Dumoulin et al. (2011). n.a., not analyzed]

Kuna Formation (and related units) regional outcrops [cont.]

Sample number	As	Sb	Te	Se	Ba	Y	La	Ce	Pr	Nd	Sm	Eu	Gd
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
90JS04M[a]	7.8	1.78	n.a.	10	381	23.0	18.6	13.9	3.52	15.4	3.36	0.772	3.20
91AD1B3.0[a]	13.0	6.00	n.a.	25	529	242	121	50.3	23.5	105	20.7	4.886	23.9
91AD1-7.2[a]	13.0	4.60	n.a.	28	369	162	79.0	29.7	15.6	68.2	13.1	3.200	17.4
91JS04G[a]	10.9	4.49	n.a.	30	435	131	70.7	26.3	12.5	61.0	11.6	2.574	12.9
91JS18A[a]	9.3	0.40	n.a.	2	1280	27.6	29.8	59.0	6.69	26.5	5.31	1.080	4.79
91JS19B[a]	7.2	4.50	n.a.	34	468	179	92.3	28.1	16.5	74.5	14.2	3.447	16.7
91JS34B[a]	19.0	2.01	n.a.	11	1040	15.1	22.7	30.9	4.48	17.5	2.79	0.442	1.91
91JS38E[a]	4.9	1.80	n.a.	5	1000	15.5	22.6	35.1	4.20	15.7	1.68	0.245	1.30
92AD9B[a]	11.0	2.00	n.a.	12	136	71.2	37.6	24.8	7.04	32.0	6.23	1.549	7.43
92AD9C[a]	8.5	1.50	n.a.	10	127	30.5	18.8	15.9	3.59	15.8	3.12	0.745	3.40
92AD35A-1[a]	7.9	1.30	n.a.	7	310	5.86	9.13	9.08	1.82	7.69	1.63	0.331	1.30
92AD35A-1.5[a]	9.2	1.90	n.a.	10	394	27.0	23.5	17.7	4.70	20.8	4.06	0.874	3.81
92AD35A-12[a]	4.5	2.70	n.a.	9	601	12.4	22.2	29.9	4.09	13.9	1.37	0.210	1.00
92AD35C-43A[a]	3.8	1.20	n.a.	7	1540	27.2	32.4	29.3	5.64	23.6	3.47	0.639	3.18
92AD60A[a]	29.5	4.02	n.a.	33	935	11.6	25.9	27.3	4.02	16.6	2.32	0.373	1.61
92AD60D[a]	13.0	2.44	n.a.	26	464	30.9	23.6	26.5	4.65	19.9	3.64	0.805	3.59
92AD60F[a]	7.3	2.69	n.a.	20	746	35.1	13.2	8.92	2.87	12.8	2.78	0.639	3.16
92AD74C[a]	25.0	5.62	n.a.	40	829	274	162	56.7	30.8	133	24.2	5.661	28.0
92AKD837R[a]	6.5	2.25	n.a.	12	180	29.0	14.3	10.00	n.a.	12.0	2.55	0.542	n.a.
93JS06A[a]	0.6	0.19	n.a.	<5	39	5.00	2.27	2.60	n.a.	1.80	0.38	0.100	n.a.
93JS06C[a]	4.4	1.27	n.a.	<5	160	13.0	9.30	14.4	n.a.	8.30	1.80	0.403	n.a.
93JS07C[a]	6.9	3.53	n.a.	<5	641	140	50.9	20.0	n.a.	49.0	11.1	2.380	n.a.
93JS07J[a]	8.7	4.31	n.a.	28	743	113	48.4	19.7	10.0	46.0	9.49	2.250	11.0
93JS13E[a]	8.9	2.46	n.a.	8	1000	25.0	32.3	56.2	7.17	27.9	5.08	0.924	3.76
94JS07A[a]	17.0	3.87	n.a.	18	531	100	86.1	41.3	n.a.	73.0	16.1	3.400	n.a.
94JS09L[a]	1.6	1.87	n.a.	16	220	50.0	51.8	17.0	n.a.	39.0	8.36	1.750	n.a.
94JS17S[a]	3.6	2.20	n.a.	12	510	<10	13.4	15.8	n.a.	8.60	1.10	0.160	n.a.
94JS17T[a]	35.6	10.10	n.a.	44	731	30.0	24.0	16.0	n.a.	22.0	5.27	1.130	n.a.
98AKD28[a]	20.0	2.2	n.a.	n.a.	459	42.1	30.8	26.4	7.27	31.5	6.73	1.440	6.58
98AKD29[a]	<5	0.4	n.a.	n.a.	348	11.3	6.48	6.93	1.69	7.60	1.77	0.364	1.78
98AKD30[a]	15.9	2.1	n.a.	n.a.	364	31.1	22.6	20.2	5.08	22.7	4.82	0.955	4.54
99 AD24B[a]	6.0	0.8	n.a.	<3	319	19.9	17.3	25.4	3.76	15.3	2.69	0.501	2.43
JS-00-6A[a]	5.2	1.4	n.a.	10	644	23.7	20.6	31.4	4.31	17.3	2.87	0.483	2.24
JS-00-6B[a]	5.5	2.2	n.a.	<3	438	20.7	26.4	41.4	5.67	21.4	2.60	0.404	1.93
JS-00-9[a]	4.8	0.9	n.a.	3	1450	21.4	22.9	37.1	5.43	22.0	4.11	0.747	3.43
JS-00-14[a]	1.9	2.3	n.a.	5	815	15.7	18.5	26.3	3.53	13.1	1.86	0.278	1.47
JS-00-15A[a]	<5	0.7	n.a.	3	796	16.9	29.5	52.6	6.30	23.6	3.65	0.598	2.58
JS-00-17[a]	<5	0.6	n.a.	5	644	11.6	19.2	29.1	3.98	15.6	2.35	0.330	1.42
JS-00-20[a]	<5	<0.2	n.a.	5	533	7.04	14.4	15.5	2.38	8.92	1.00	0.132	0.78
JS-00-22[a]	<5	0.9	n.a.	8	2530	20.6	22.1	36.4	4.87	19.6	2.96	0.304	2.14
JS-00-23B[a]	7.1	3.3	n.a.	<3	411	17.1	18.7	30.1	4.01	15.8	3.00	0.727	2.62
JS-00-27[a]	<5	<0.2	n.a.	4	309	12.9	26.1	43.6	5.66	21.6	3.25	0.533	2.05
JS-03-1A[a]	47	7.3	n.a.	21	1317	36.9	38.8	77.4	9.18	38.9	8.22	1.992	7.85
JS-03-1B[a]	<5	1.4	n.a.	32	664	276	99.3	50.0	16.5	74.8	15.5	4.346	25.9
JS-03-1C[a]	27	3.8	n.a.	15	907	22.7	34.7	57.6	7.56	28.9	5.07	0.994	4.18

JS-03-1D[a]	6	1.6	n.a.	16	970	19.2	26.5	41.7	5.33	19.8	3.10	0.533	2.52
JS-03-1E[a]	31	1.3	n.a.	10	1079	17.0	26.8	47.1	5.61	20.7	3.44	0.658	2.73
JS-03-1F[a]	33	1.5	n.a.	6	1120	16.0	28.0	46.3	5.64	20.7	2.91	0.505	1.98
JS-03-1G[a]	11	0.7	n.a.	11	1083	12.1	25.2	43.4	5.14	18.6	2.46	0.398	1.62
JS-03-1H[a]	29	0.8	n.a.	5	1041	13.5	24.1	40.9	4.76	17.0	2.35	0.401	1.59
JS-05-96[c]	6.4	1.7	n.a.	<3	371	104	50	21.3	9.85	37.3	7.88	2.050	8.81

Kuna Formation KE-20 outcrop [cont.]

Sample number	As	Sb	Te	Se	Ba	Y	La	Ce	Pr	Nd	Sm	Eu	Gd
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
KE98-20-309[c]	18.3	1.6	n.a.	7	793	15.5	26.8	42.1	5.05	18.3	2.62	0.450	1.67
KE98-20-303[c]	19.4	1.9	n.a.	12	960	17.4	32.5	47.8	6.89	26.4	4.26	0.654	2.53
KE98-20-268[c]	13.2	2.0	n.a.	20	533	23.0	32.8	37.9	8.92	37.8	6.99	1.078	4.11
KE98-20-262[c]	18.4	3.3	n.a.	33	455	19.2	14.7	19.7	3.08	12.1	2.12	0.374	1.82
KE98-20-256[c]	24.6	1.9	n.a.	12	517	12.6	20.1	27.4	4.00	14.8	2.50	0.409	1.69
KE98-20-250[c]	12.0	2.5	n.a.	16	570	25.5	28.5	36.4	7.40	31.6	5.76	0.943	4.28
KE98-20-244[c]	19.3	3.7	n.a.	21	692	27.2	22.8	30.8	4.81	19.5	3.30	0.539	2.66
KE98-20-238[c]	12.9	4.8	n.a.	28	626	17.1	18.5	25.9	4.24	16.3	2.73	0.436	2.02
KE98-20-232[c]	13.3	2.6	n.a.	23	473	12.9	15.5	20.4	3.28	12.4	1.92	0.329	1.44
KE98-20-220[c]	12.3	3.0	n.a.	28	599	21.7	27.2	33.2	5.81	22.6	3.76	0.539	2.53
KE98-20-214[c]	7.5	2.8	n.a.	24	505	15.4	20.1	24.5	4.72	18.7	2.84	0.429	1.79
KE98-20-208[c]	13.0	3.3	n.a.	34	587	18.6	18.0	25.6	3.57	13.9	2.31	0.410	1.86
KE98-20-202[c]	15.5	3.8	n.a.	38	477	16.3	26.6	28.2	7.32	31.9	4.95	0.631	2.65
KE98-20-196[c]	35.1	3.3	n.a.	31	632	30.8	25.1	29.4	6.25	26.0	4.39	0.763	3.50
KE98-20-190[c]	36.2	3.2	n.a.	25	875	34.4	25.0	31.5	4.88	19.4	3.40	0.637	3.11
KE98-20-184[c]	11.5	4.9	n.a.	31	699	18.5	24.1	25.9	4.55	17.1	2.35	0.380	1.76
KE98-20-178[c]	26.3	1.9	n.a.	16	560	12.3	17.4	22.7	3.23	11.5	1.46	0.224	1.02
KE98-20-172[c]	48.5	3.1	n.a.	25	937	19.9	27.3	32.3	5.16	18.8	2.67	0.430	1.86
KE98-20-168[c]	37.1	3.8	n.a.	19	594	11.8	27.5	24.1	4.62	15.5	1.71	0.270	1.25
KE98-20-162[c]	26.0	4.1	n.a.	22	740	12.0	23.6	23.8	4.61	17.4	1.93	0.269	1.26
KE98-20-156[c]	34.3	3.0	n.a.	19	723	16.3	19.1	21.0	3.73	14.0	2.06	0.323	1.50
KE98-20-150[c]	29.3	1.3	n.a.	10	507	9.7	11.3	11.4	2.30	9.00	1.57	0.316	1.43
KE98-20-132[c]	21.8	1.3	n.a.	6	884	16.1	22.7	37.9	4.78	17.8	3.10	0.516	2.13
KE98-20-126[c]	12.1	0.9	n.a.	<3	748	18.5	21.3	37.3	4.42	16.7	3.06	0.530	2.08
KE98-20-114[c]	16.8	1.2	n.a.	6	615	12.7	18.5	31.6	3.74	13.7	2.16	0.349	1.51
KE98-20-108[c]	40.1	1.7	n.a.	14	723	21.4	22.5	29.2	5.17	21.4	3.93	0.686	2.61
KE98-20-96[c]	30.3	1.3	n.a.	7	629	23.2	23.3	33.0	4.88	19.7	3.36	0.547	2.33
KE98-20-87[c]	12.6	1.3	n.a.	9	612	19.8	25.3	39.3	4.92	18.0	2.81	0.462	2.04
KE98-20-81[c]	15.8	1.8	n.a.	19	615	19.2	32.8	41.9	5.99	19.2	2.70	0.424	1.80
KE98-20-75[c]	10.6	2.8	n.a.	32	640	20.6	28.7	34.2	5.37	19.8	3.38	0.612	2.39
KE98-20-69[c]	19.9	1.5	n.a.	16	759	15.7	29.3	37.3	5.62	19.5	2.74	0.471	1.99
KE98-20-63[c]	13.4	0.8	n.a.	8	504	15.3	12.0	17.5	2.59	10.4	1.99	0.371	1.78
KE98-20-51[c]	16.4	1.0	n.a.	5	663	11.7	25.5	40.3	4.84	17.0	2.58	0.389	1.35
KE98-20-42[c]	8.5	1.1	n.a.	<3	662	13.8	24.0	43.1	4.93	17.5	2.82	0.473	1.82
KE98-20-36[c]	12.1	1.1	n.a.	4	575	17.6	23.8	40.0	5.12	19.7	3.17	0.509	2.02
KE98-20-30[c]	22.2	1.2	n.a.	11	449	11.8	21.9	30.6	4.06	13.6	2.03	0.332	1.18
KE98-20-24[c]	21.3	1.3	n.a.	10	428	9.3	16.0	22.8	2.71	9.76	1.51	0.247	0.90
KE98-20-18[c]	19.0	1.7	n.a.	8	515	12.9	19.6	29.7	3.89	14.6	2.45	0.381	1.44
KE98-20-12[c]	27.0	1.6	n.a.	5	521	19.3	23.1	35.6	4.72	17.2	2.92	0.560	2.37
KE98-20-6[c]	22.6	1.9	n.a.	15	486	16.3	37.3	45.8	6.96	23.5	3.04	0.503	2.12
KE98-20-0[c]	28.5	2.0	n.a.	14	406	8.4	14.9	20.1	2.45	8.10	1.17	0.209	0.77

Kuna Formation drill cores [cont.]

Sample number	As	Sb	Te	Se	Ba	Y	La	Ce	Pr	Nd	Sm	Eu	Gd
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
50-326[c]	36	5.2	n.a.	26	787	42.1	27.1	32.7	5.77	24.1	4.85	1.102	5.64
50-333[c]	38	3.3	n.a.	23	664	41.5	28.6	35.3	6.15	25.3	5.02	1.177	5.85
50-378[c]	53	4.9	n.a.	17	376	4.64	7.88	12.1	1.39	5.00	0.77	0.143	0.76
50-402.5[c]	27	1.3	n.a.	7	699	17.8	15.1	23.8	2.92	11.0	2.00	0.411	2.10
50-425.5[c]	34	2.0	n.a.	10	1325	34.9	26.3	40.9	5.65	22.8	4.39	0.962	4.89
50-420[c]	11	1.5	n.a.	6	542	11.4	8.72	13.3	1.53	5.60	1.02	0.250	1.31
1105-1155.3[a]	29.8	5.5	n.a.	15	1350	24.0	24.7	41.6	5.62	21.7	4.12	0.886	3.91
1105-1171.5[a]	24.9	5.1	n.a.	21	767	21.1	26.6	42.5	5.54	19.8	3.74	0.787	3.48
1105-1190.7[a]	17.4	2.8	n.a.	17	760	21.8	21.9	35.7	4.82	18.0	3.40	0.823	3.53
1105-1211.5[a]	20.3	3.3	n.a.	22	792	20.0	22.1	35.2	4.81	17.8	3.33	0.764	3.32

Phosphatic unit (EMA, Skimo thrust sheet) [cont.]

Sample number	As	Sb	Te	Se	Ba	Y	La	Ce	Pr	Nd	Sm	Eu	Gd
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
11SKBO-4-(2)[c]	9.20	2.33	0.12	25.1	41	98.1	63.0	19.2	9.19	36.2	5.68	1.290	7.73
11SKBO-3-(2)[c]	19.3	3.91	0.13	39.8	112	575	335	79.4	56.0	222	38.8	8.840	51.2
11SKBO-2.7-(2)[c]	10.0	2.43	0.07	23.5	67	159	74.5	21.7	12.4	52.1	8.79	2.070	10.8
11SKBO-1.2-(2)[c]	20.1	4.18	0.18	45.5	142	116	62.8	27.5	11.2	44.6	7.79	1.840	10.2
11SKBO-0.95-(2)[c]	18.6	4.30	0.14	32.5	124	264	108	34.8	17.8	76.5	13.6	3.090	16.8
11SKBO-14-(2)[c]	23.3	6.05	0.17	17.9	222	91.8	57.4	31.4	9.13	35.8	6.18	1.400	7.75
11SKBO-8.2-(2)[c]	18.4	2.93	0.09	21.2	109	57.3	41.4	31.2	7.38	28.3	4.77	1.060	5.51
11SKBO-7.3-(2)[c]	13.4	3.34	0.09	12.0	83	40.0	28.3	24.1	5.72	22.1	3.96	0.891	4.33
11SKBO-5.5-(2)[c]	34.3	7.60	0.24	21.6	939	44.0	31.3	27.8	6.01	22.9	4.27	0.881	4.68
11SKBO-4.8-(2)[c]	18.9	3.79	0.11	23.3	1936	117	57.8	34.4	10.5	43.6	7.64	1.570	8.57
11SKBO-3.8-(2)[c]	44.6	10.7	0.25	76.5	190	63.3	32.1	26.1	6.09	25.0	4.74	0.998	4.97
CCP-1.35[b]	19.7	4.34	0.24	38.0	106	250	121	33.2	19.3	72.9	13.8	3.540	15.3
05AD6E[b]	31.8	6.71	0.53	111	291	232	117	39.4	18.9	73.1	13.9	3.570	16.7

Phosphatic unit (EMA, Ivotuk plate; **KRA) [cont.]

Sample number	As	Sb	Te	Se	Ba	Y	La	Ce	Pr	Nd	Sm	Eu	Gd
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm
92AD31A[b]	50.4	11.6	0.61	65.0	850	160	76.2	45.0	11.7	54.1	9.73	2.183	11.3
92AD31H[b]	49.9	12.3	0.67	55.8	980	340	150	57.4	25.3	117	20.9	4.978	26.1
92AD32B[b]	32.6	5.70	0.25	51.3	326	86.7	46.2	29.0	8.21	35.9	6.64	1.531	7.47
03AD27A[b]**	15.5	1.70	0.34	29.2	2050	26.1	26.4	37.0	4.42	16.1	2.87	0.619	2.50
03AD38C[b]**	19.8	3.90	0.18	33.9	150	52.2	27.6	23.7	5.09	21.5	4.66	1.067	4.69
JS-00-2[b]**	23.8	3.29	0.42	25.2	8770	112	56.5	68.4	10.7	46.8	10.4	2.480	12.7
JS-05-82C[b]	31.8	7.23	0.40	85.8	715	97.2	51.4	28.7	9.31	33.4	6.70	1.600	7.21

Table A4. Whole-rock geochemical data for black mudrocks of the Lisburne Group* [cont.]

[*Data sources: [a], Slack et al. (2004c); [b], Dumoulin et al. (2011); [c], this study. Results for samples having >10 wt% CO_2 or >10 wt% P_2O_5 are excluded. Analytical methods are described in Dumoulin et al. (2011). n.a., not analyzed]

Kuna Formation (and related units) regional outcrops [cont.]

Sample number	Tb	Dy	Ho	Er	Tm	Yb	Lu
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
90JS04M[a]	0.50	3.01	0.58	1.87	0.267	1.8	0.272
91AD1B3.0[a]	3.76	21.8	4.65	13.9	1.875	10.5	1.597
91AD1-7.2[a]	2.44	13.9	3.03	9.10	1.210	6.7	1.019
91JS04G[a]	2.04	12.1	2.50	7.61	1.011	5.8	0.808
91JS18A[a]	0.78	4.48	0.89	2.81	0.420	2.7	0.418
91JS19B[a]	2.68	15.5	3.25	9.94	1.358	7.5	1.118
91JS34B[a]	0.27	1.73	0.41	1.54	0.278	2.0	0.357
91JS38E[a]	0.25	1.86	0.43	1.52	0.247	1.7	0.283
92AD9B[a]	1.21	7.12	1.46	4.82	0.641	3.6	0.518
92AD9C[a]	0.54	3.20	0.68	2.09	0.299	1.9	0.291
92AD35A-1[a]	0.19	1.00	0.18	0.51	0.072	0.5	0.070
92AD35A-1.5[a]	0.61	3.31	0.62	2.10	0.325	2.0	0.332
92AD35A-12[a]	0.17	1.37	0.33	1.23	0.226	1.6	0.278
92AD35C-43A[a]	0.45	2.67	0.57	1.91	0.306	1.9	0.290
92AD60A[a]	0.22	1.42	0.32	1.15	0.217	1.6	0.278
92AD60D[a]	0.62	3.73	0.81	2.65	0.426	2.7	0.461
92AD60F[a]	0.55	3.42	0.79	2.51	0.376	2.4	0.414
92AD74C[a]	4.19	23.0	4.90	14.8	1.966	10.4	1.596
92AKD837R[a]	0.44	n.a.	n.a.	n.a.	n.a.	1.69	0.245
93JS06A[a]	0.08	n.a.	n.a.	n.a.	n.a.	0.30	0.042
93JS06C[a]	0.33	n.a.	n.a.	n.a.	n.a.	1.16	0.159
93JS07C[a]	1.95	n.a.	n.a.	n.a.	n.a.	6.74	0.984
93JS07J[a]	1.84	10.9	2.33	7.22	1.019	5.9	0.921
93JS13E[a]	0.60	3.51	0.74	2.48	0.414	2.7	0.430
94JS07A[a]	2.45	n.a.	n.a.	n.a.	n.a.	7.64	1.100
94JS09L[a]	1.27	n.a.	n.a.	n.a.	n.a.	4.07	0.580
94JS17S[a]	0.11	n.a.	n.a.	n.a.	n.a.	1.30	0.210
94JS17T[a]	0.87	n.a.	n.a.	n.a.	n.a.	4.09	0.660
98AKD28[a]	0.92	5.60	1.25	3.78	0.576	4.18	0.733
98AKD29[a]	0.28	1.80	0.40	1.16	0.179	1.38	0.226
98AKD30[a]	0.74	4.47	0.93	2.75	0.458	3.01	0.462
99 AD24B[a]	0.42	2.57	0.55	1.77	0.271	1.78	0.285
JS-00-6A[a]	0.41	2.65	0.62	2.06	0.320	2.29	0.371
JS-00-6B[a]	0.33	2.56	0.63	2.20	0.348	2.45	0.402
JS-00-9[a]	0.51	3.22	0.69	2.28	0.344	2.33	0.368
JS-00-14[a]	0.28	2.06	0.49	1.79	0.308	2.37	0.412
JS-00-15A[a]	0.46	3.07	0.67	2.11	0.322	2.23	0.348
JS-00-17[a]	0.26	1.86	0.44	1.45	0.242	1.78	0.287
JS-00-20[a]	0.12	0.84	0.21	0.75	0.143	1.06	0.182
JS-00-22[a]	0.43	2.96	0.64	2.11	0.337	2.35	0.369
JS-00-23B[a]	0.46	2.63	0.54	1.65	0.252	1.77	0.270
JS-00-27[a]	0.34	2.38	0.54	1.84	0.293	2.04	0.323
JS-03-1A[a]	1.09	6.51	1.42	4.83	0.771	5.28	0.904
JS-03-1B[a]	4.05	26.2	5.97	19.6	3.128	20.0	3.373
JS-03-1C[a]	0.60	3.71	0.81	2.59	0.404	2.63	0.406

JS-03-1D[a]	0.38	2.48	0.57	1.92	0.311	2.05	0.319
JS-03-1E[a]	0.41	2.63	0.56	1.80	0.299	2.12	0.326
JS-03-1F[a]	0.30	2.10	0.51	1.79	0.303	2.06	0.323
JS-03-1G[a]	0.24	1.66	0.39	1.40	0.231	1.54	0.245
JS-03-1H[a]	0.26	1.75	0.42	1.44	0.240	1.69	0.263
JS-05-96[c]	1.54	8.92	1.88	5.64	0.840	5.28	0.797

Kuna Formation KE-20 outcrop [cont.]

Sample number	Tb ppm	Dy ppm	Ho ppm	Er ppm	Tm ppm	Yb ppm	Lu ppm
KE98-20-309[c]	0.29	1.98	0.46	1.67	0.278	1.84	0.299
KE98-20-303[c]	0.33	2.16	0.53	1.83	0.299	1.83	0.296
KE98-20-268[c]	0.45	2.98	0.70	2.59	0.419	2.64	0.467
KE98-20-262[c]	0.35	2.25	0.54	2.00	0.325	1.98	0.349
KE98-20-256[c]	0.25	1.71	0.41	1.48	0.268	1.63	0.281
KE98-20-250[c]	0.63	3.57	0.79	2.79	0.439	2.69	0.463
KE98-20-244[c]	0.50	3.40	0.80	2.97	0.469	2.93	0.504
KE98-20-238[c]	0.31	2.17	0.53	1.87	0.304	2.02	0.363
KE98-20-232[c]	0.25	1.60	0.37	1.38	0.226	1.51	0.269
KE98-20-220[c]	0.38	2.67	0.66	2.33	0.381	2.40	0.405
KE98-20-214[c]	0.26	1.79	0.44	1.65	0.269	1.74	0.312
KE98-20-208[c]	0.37	2.31	0.52	1.99	0.336	2.16	0.372
KE98-20-202[c]	0.30	2.01	0.48	1.79	0.305	1.95	0.348
KE98-20-196[c]	0.60	3.79	0.89	3.26	0.511	3.14	0.539
KE98-20-190[c]	0.63	4.11	0.95	3.52	0.580	3.56	0.629
KE98-20-184[c]	0.25	1.74	0.46	1.86	0.337	2.29	0.415
KE98-20-178[c]	0.20	1.27	0.32	1.37	0.268	1.87	0.347
KE98-20-172[c]	0.29	1.89	0.49	1.97	0.358	2.39	0.441
KE98-20-168[c]	0.17	1.22	0.31	1.34	0.263	1.86	0.345
KE98-20-162[c]	0.20	1.31	0.32	1.37	0.267	1.84	0.355
KE98-20-156[c]	0.24	1.57	0.39	1.59	0.279	1.84	0.332
KE98-20-150[c]	0.20	1.19	0.29	0.93	0.138	0.83	0.135
KE98-20-132[c]	0.35	2.08	0.46	1.64	0.261	1.54	0.259
KE98-20-126[c]	0.35	2.30	0.55	1.97	0.307	1.86	0.318
KE98-20-114[c]	0.24	1.66	0.40	1.44	0.239	1.53	0.258
KE98-20-108[c]	0.39	2.60	0.60	2.06	0.294	1.78	0.265
KE98-20-96[c]	0.36	2.44	0.62	2.21	0.323	1.92	0.325
KE98-20-87[c]	0.34	2.30	0.57	2.05	0.358	2.22	0.381
KE98-20-81[c]	0.34	2.06	0.50	1.99	0.349	2.11	0.365
KE98-20-75[c]	0.33	2.38	0.59	2.13	0.340	2.19	0.370
KE98-20-69[c]	0.25	1.73	0.47	1.73	0.303	2.00	0.349
KE98-20-63[c]	0.32	1.91	0.45	1.47	0.205	1.30	0.208
KE98-20-51[c]	0.19	1.31	0.34	1.37	0.248	1.63	0.278
KE98-20-42[c]	0.29	1.89	0.46	1.57	0.258	1.76	0.290
KE98-20-36[c]	0.31	2.04	0.52	1.90	0.326	2.06	0.356
KE98-20-30[c]	0.21	1.30	0.31	1.28	0.231	1.37	0.233
KE98-20-24[c]	0.14	1.05	0.27	1.07	0.203	1.37	0.241
KE98-20-18[c]	0.20	1.51	0.35	1.35	0.220	1.40	0.237
KE98-20-12[c]	0.39	2.49	0.57	2.02	0.305	2.06	0.326
KE98-20-6[c]	0.28	1.95	0.48	1.81	0.319	2.05	0.360
KE98-20-0[c]	0.12	0.90	0.23	0.97	0.182	1.32	0.245

Kuna Formation drill cores [cont.]

Sample number	Tb	Dy	Ho	Er	Tm	Yb	Lu
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
50-326[c]	0.84	5.11	1.10	3.70	0.564	3.74	0.616
50-333[c]	0.88	5.32	1.11	3.54	0.545	3.50	0.567
50-378[c]	0.12	0.73	0.16	0.55	0.099	0.71	0.119
50-402.5[c]	0.36	2.38	0.56	1.98	0.328	2.15	0.346
50-425.5[c]	0.75	4.80	1.06	3.33	0.504	3.08	0.493
50-420[c]	0.26	1.78	0.41	1.37	0.222	1.44	0.231
1105-1155.3[a]	0.63	3.90	0.81	2.55	0.429	2.83	0.446
1105-1171.5[a]	0.58	3.59	0.74	2.36	0.402	2.51	0.398
1105-1190.7[a]	0.59	3.63	0.74	2.30	0.381	2.37	0.372
1105-1211.5[a]	0.56	3.41	0.70	2.23	0.367	2.36	0.370

Phosphatic unit (EMA, Skimo thrust sheet) [cont.]

Sample number	Tb	Dy	Ho	Er	Tm	Yb	Lu
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
11SKBO-4-(2)[c]	1.07	6.78	1.58	4.51	0.566	3.54	0.580
11SKBO-3-(2)[c]	7.47	45.8	10.7	30.6	4.000	23.9	3.880
11SKBO-2.7-(2)[c]	1.63	10.4	2.43	7.07	0.992	5.87	0.969
11SKBO-1.2-(2)[c]	1.57	9.66	2.23	6.57	0.907	5.82	0.988
11SKBO-0.95-(2)[c]	2.50	16.2	3.85	11.6	1.640	9.82	1.590
11SKBO-14-(2)[c]	1.14	7.10	1.65	4.69	0.639	4.08	0.664
11SKBO-8.2-(2)[c]	0.81	5.08	1.14	3.37	0.461	2.93	0.490
11SKBO-7.3-(2)[c]	0.64	3.82	0.83	2.40	0.331	2.08	0.343
11SKBO-5.5-(2)[c]	0.72	4.30	0.98	2.82	0.395	2.72	0.480
11SKBO-4.8-(2)[c]	1.24	7.95	1.83	5.35	0.742	4.37	0.702
11SKBO-3.8-(2)[c]	0.74	4.77	1.11	3.41	0.536	3.60	0.640
CCP-1.35[b]	2.82	18.1	3.87	11.6	1.600	9.49	1.440
05AD6E[b]	2.88	18.5	4.00	12.3	1.820	11.6	1.890

Phosphatic unit (EMA, Ivotuk plate; **KRA) [cont.]

Sample number	Tb	Dy	Ho	Er	Tm	Yb	Lu
	ppm	ppm	ppm	ppm	ppm	ppm	ppm
92AD31A[b]	1.82	11.6	2.53	8.47	1.263	7.48	1.154
92AD31H[b]	3.89	24.4	5.67	16.2	2.163	12.0	1.785
92AD32B[b]	1.24	7.29	1.62	5.08	0.719	4.11	0.638
03AD27A[b]**	0.47	3.26	0.74	2.87	0.528	3.62	0.599
03AD38C[b]**	0.83	4.91	1.07	3.52	0.544	3.35	0.542
JS-00-2[b]**	2.20	14.1	3.10	9.62	1.390	9.36	1.460
JS-05-82C[b]	1.22	7.28	1.58	4.83	0.682	4.19	0.612