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DISTRIBUTION OF ALBIAN-CENOMANIAN FORAMINIFERA FROM QUEEN CHARLOTTE ISLANDS, BRITISH COLUMBIA, CANADA: CONSTRAINTS ON THE TIMING OF THE NORTHWARD MIGRATION OF THE WRANGELLIA TERRANE

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ABSTRACT

This is the first major survey of the Cretaceous foraminifera of the Queen Charlotte Islands (QCI), British Columbia, Canada. Fifty-seven species of benthic and planktic foraminifera are identified in 267 samples collected from mudstones of the Albian-Cenomanian (Cretaceous) Haida and Bearskin Bay formations of the Queen Charlotte Group on Moresby and Graham islands within the QCI, British Columbia, Canada. Most of the fauna characterizes shallow-shelf environments, but outer-shelf assemblages of Cenomanian age occur at one station on northwest Graham Island where the lower part of the section appears to have been deposited during an early transgressive phase corresponding to the Greenhorn marine cycle of the North American Western Interior.

Nearly 60% of the identified foraminiferal species have affinities with Albian-Cenomanian foraminifera from Alaska. This correlation indicates that the northward drift of Wrangellia terrane, which includes the QCI, had entered the boreal realm much earlier than previously suggested by some research results.

INTRODUCTION

Cretaceous strata of the Queen Charlotte Islands (QCI), British Columbia, are known for their abundant and highly diverse molluscan faunas (e.g. Whiteaves, 1876, 1884, 1900; McLearn, 1972; Jeletzky, 1977; Haggart, 1986), and have thus served as a standard reference for biostratigraphic zonation of Cretaceous strata throughout the northeast Pacific region. The molluscan fauna is typically restricted to the coarser-clastic relatively- nearshore facies; consequently, biostratigraphic control for the deeper, offshore facies is poor or lacking. Some preliminary work on the deeper facies has been carried out on Cretaceous radiolarians (Haggart and Carter, 1993; Carter and Haggart, 2006) and calcareous nannofossils (Haggart and others, 1994). Well-preserved Jurassic foraminifera of the QCI have also been studied (Kottachchi and others, 2002, 2003).

Field parties from the Geological Survey of Canada collected samples of Cretaceous sedimentary rock from various localities on the QCI for foraminiferal analysis. For the present study, samples are assessed from four areas: the north shore of Cumshewa Inlet, Moresby Island; Onward Point on northeastern Moresby Island; from road-cuts along Rennell Sound Road on south-central Graham Island; and the Beresford Bay area of northwestern Graham Island (Fig. 1; Table 1). Stratigraphic sections were collected with three objectives: 1) to establish a foraminiferal biostratigraphic framework to complement existing molluscan biostratigraphic data; 2) to provide some evidence of the paleogeographic position of the QCI during the Albian and Cenomanian; and 3) to provide baseline foraminiferal distribution data as an aid to future researchers. Biostratigraphy is a particularly useful tool on the QCI, as the region has undergone several phases of tectonism that have resulted in a structurally complex and intensely deformed collage of geological units (see Thompson and others, 1991; Lewis and others, 1991). Fossil control, when available, is thus of great value in unraveling the original stratigraphic relationships of rock units, as well as determining their subsequent geological history.

BACKGROUND

REGIONAL GEOLOGICAL SETTING

The Upper Triassic through Cretaceous succession of the QCI is perhaps the most complete Mesozoic biostratigraphic reference section in the northeast Pacific region. The Cretaceous succession comprises 21 molluscan zones (Fig. 2). Its Triassic-Lower Jurassic part is the classic Wrangellia terrane succession (see Jones and others, 1977) – a thick accumulation of Upper Triassic massive oceanic basalts (Karmutsen Formation) conformably overlain by uppermost Triassic to lowermost Jurassic fringing-reef carbonates (Sadler Limestone) and deep-water clastics with local tuffaceous beds (Peril and Sandilands formations). The superjacent Lower Jurassic Maude Group is characterized by a progressive increase in continentally derived clastics and is capped by Middle to lower Upper Jurassic volcanics (Yakoun and Moresby groups) marking the initiation of andesitic arc volcanism in the QCI region (see summaries in Sutherland Brown, 1968; Haggart, 1987; Cameron and Hamilton, 1988; Woodsworth and Tercier, 1991; Haggart and others, 1995).

Cretaceous strata on the QCI accumulated in a forearc basin west of an active magmatic arc. Deposition was essentially continuous within the basin from at least Valanginian through Campanian time (Haggart, 1991). The basin appears to have been open to the proto-Pacific Ocean to the west (Haggart, 1991, 1993). In the Cretaceous, as now, the prevailing wind patterns in the paleo-QCI region would have been onshore and from the west. As the paleo-QCI was west (upwind) of the active arc, there was little volcaniclastic deposition in the area. Overall, the regional stratigraphy for most of the Cretaceous reflects

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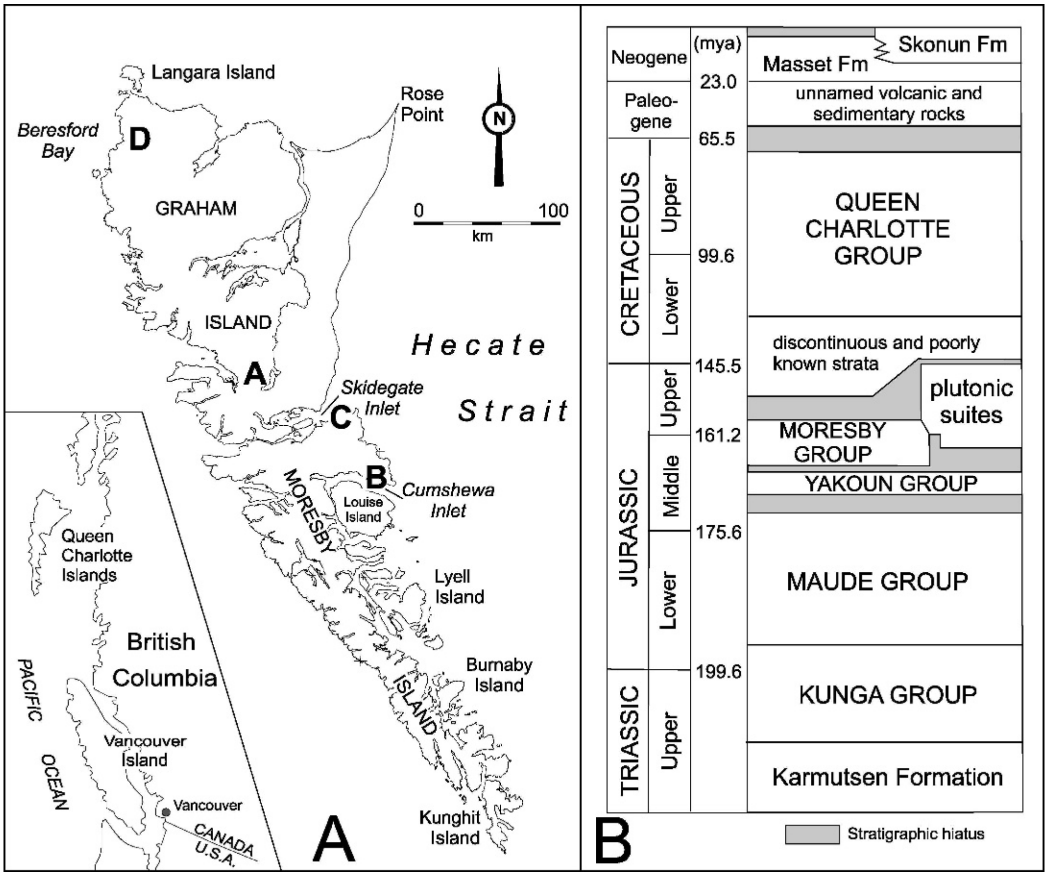

FIGURE 1. A. Locality map of Queen Charlotte Islands, British Columbia, showing localities discussed in text. A = Rennell Sound Road, southern Graham Island; B = north shore of Cumshewa Inlet; C = Onward Point, Moresby Island; D = Beresford Bay area, northwestern Graham Island. B. General lithostratigraphic column of Queen Charlotte Islands, adapted from Haggart (1991, 2004) and Haggart and others (1995). Absolute ages after Gradstein and others (2004).

TABLE 1. Sample locality data for Albian and Cenomanian foraminiferal collections, Queen Charlotte Islands, British Columbia.

Area	Station	NTS Map-Area	UTM Zone	Coordinates *		Stratigraphic Unit
				Latitude	Longitude	
Rennell Sound Road	1	103F/08	8	53°22.10′	132°18.67′	Bearskin Bay fm
	8	103G/04	9	53°03.56′	131°53.21′	Bearskin Bay fm
	7	103G/04	9	53°04.25′	131°50.07′	Bearskin Bay fm
	6	103G/04	9	53°03.99′	131°49.79′	Bearskin Bay fm
	5	103G/04	9	53°03.51′	131°48.41′	Bearskin Bay fm
	4	103G/04	9	53°03.81′	131°47.87′	Bearskin Bay fm
	3	103G/04	9	53°03.30′	131°46.70′	Bearskin Bay fm
	2	103G/04	9	53°03.16′	131°46.06′	Bearskin Bay fm
Cumshew Inlet	1	103G/04	9	53°02.69′	131°45.14′	Bearskin Bay fm
	5	103G/04	9	53°13.49′	131°56.33′	Haida Fm
	4	103G/04	9	53°14.44′	131°55.15′	Haida Fm
	3	103G/04	9	53°14.33′	131°55.05′	Haida Fm
	2	103G/04	9	53°14.43′	131°55.06′	Haida Fm
Onward Point	1	103G/04	9	53°14.40′	131°54.80′	Haida Fm
	5	103K/03	8	54°00.98′	133°05.67′	Bearskin Bay fm
	4	103K/03	8	54°01.40′	133°04.10′	Bearskin Bay fm
	3	103K/03	8	54°01.80′	133°03.16′	Bearskin Bay fm
	2	103K/03	8	54°02.13′	133°03.62′	Bearskin Bay fm
Beresford Bay	1	103K/03	8	54°02.95′	133°03.26′	Haida Fm

* NAD27 coordinate system; coordinate data from Geological Survey of Canada paleontology database.

TABLE 2. Taxonomic list of foraminiferal taxa identified from Albian and Cenomanian strata of Queen Charlotte Islands, British Columbia. Generic names in square brackets indicate original generic designation. Taxa also found in the Albian and Cenomanian of Alaska indicated by an x.

Foraminifera Recorded from Albian–Cenomanian Strata	
Queen Charlotte Islands, British Columbia	Alaska
Ammodiscus kiowensis Loeblich and Tappan 1950	
Ammodiscus pennyi Cushman and Jarvis 1928	
Ammodiscus rotalarius Loeblich and Tappan 1949	x
Glomospira charoides (Jones and Parker, 1860)	x
Miliammina ischnia Tappan 1957	x
Miliammina manitobensis Wickenden 1932	x
Psamminopelta subcircularis Tappan 1957	x
Bathysiphon brosgei Tappan 1957	x
Bathysiphon vitta Nauss 1947	x
Trochammina wetteri Stelck and Wall 1955	
Trochammina sp.	
Gaudryina cf. *G. nanushukensis* Tappan 1951	x
Protomarssonella sp.	
Gaudryinella irregularis Tappan 1943	x
Tritaxia tricarinata (Reuss 1845)	
Clavulinoides sp.	
Scherochorella cylindracea (Chapman 1892)	
Scherochorella minuta (Tappan 1940)	x
Reophax sp. A	
Reophax sp. B	
Reophax sp. C	
Hormosina sp.	
Hippocrepina barksdalei Tappan 1957	x
Kalamopsis sp. A	
Kalamopsis sp. B	
Haplophragmoides concava (Chapman 1892)	
Haplophragmoides cf. *H. calcula* Cushman and Waters 1927	
Haplophragmoides cf. *suborbicularis* (Grzybowski 1896)	
Haplophragmoides topagorukensis Tappan 1957	x
Ammobaculites fragmentarius Cushman 1927	x
Ammobaculites wenonahae Tappan 1960	x
Ammobaculites sp.	
Textulariopsis losangica (Loeblich and Tappan 1951)	
*Textulariopsis topagorukensis (*Tappan 1957)	x
Textulariopsis sp.	
Laevidentalina distincta (Reuss 1860)	x
Nodosaria doliiformis Eichenberg 1933	x
Nodosaria flexocarinata Khan 1950	x
Nodosaria sp. A	
Frondicularia extensa Morrow 1934	
Frondicularia sp. A	
Frondicularia sp. B	
Lenticulina cf. *L. ingenua* (Berthelin 1880)	x
Lenticulina macrodisca (Reuss 1863)	x
Saracenaria grandstandensis Tappan 1960	x
Saracenaria projectura Stelck and Wall 1956	x
Saracenaria valanginiana (Bartenstein and Brand 1951)	x
Marginulina cf. *inepta* (Reuss 1846)	x
Marginulina planiuscula (Reuss 1862)	x
Citharina sp.	
Gavelinella sp. A	
Gavelinella sp. B	
Schackoina cenomana (Schacko 1897)	
Praebulimina reussi (Morrow 1934)	
Hedbergella planispira (Tappan, 1940)	
Hedbergella sp.	
Hedbergella delrioensis (Carsey 1926)	

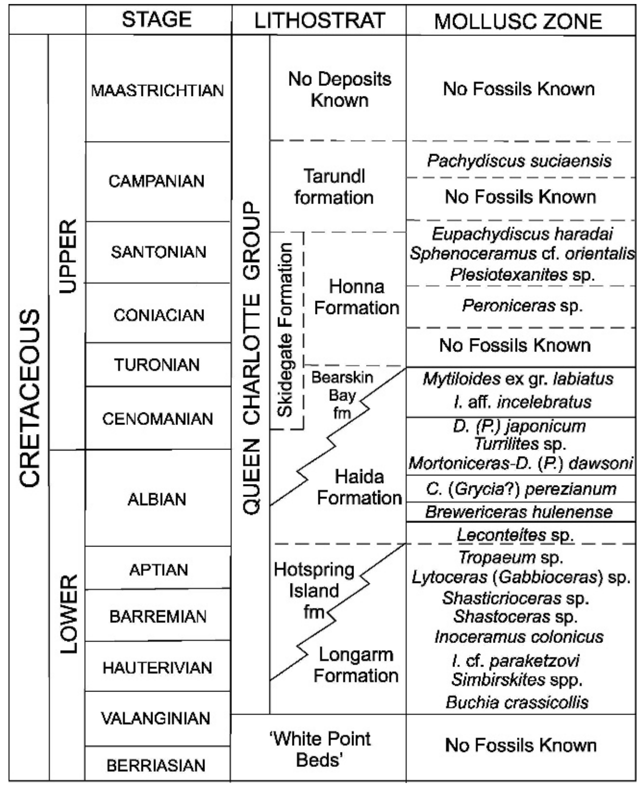

FIGURE 2. Cretaceous lithostratigraphic and biostratigraphic succession of Queen Charlotte Islands (see Haggart, 2004 and references in text).

continuous basin subsidence with an eastward-migrating shoreline (Haggart, 1991). Earlier studies (e.g., Yorath and Chase, 1981; Fogarassy and Barnes, 1991) proposed that the QCI region was characterized by uplift and erosion during the Aptian, but subsequent detailed stratigraphic studies demonstrated that continuous deposition prevailed within the basin during that epoch (Haggart, 1991; Haggart and Carter, 1993).

Plutonism in the QCI region occurred in two discrete pulses, first during the Middle to early Late Jurassic, and second during the Paleogene to possibly earliest Neogene (Anderson and Reichenbach, 1991; Hickson, 1991; Hamilton and Dostal, 1993). Thermal metamorphism related to plutonism plutonic intrusion adversely affected fossil preservation in many areas throughout the region (Orchard and Forster, 1991).

CRETACEOUS STRATIGRAPHY

The bulk of Cretaceous strata on the islands belong to the Longarm and Haida formations of the Queen Charlotte Group (Sutherland Brown, 1968; Haggart, 1991, 2004; Fig. 2). The Longarm Formation accumulated in the western parts of the basin during the Valanginian-Aptian interval, whereas the Haida Formation was deposited in more easterly parts of the basin from the Albian to the Turonian. Both units are characterized by basal conglomerate and coarse-grained sandstone that constitute the basal transgressive sequence. Longarm Formation strata fine upward into a succession of outer-shelf mudstones locally with calcareous concretions, assigned to the informally designated Hotspring Island formation of Hauterivian(?)-Aptian age. Haida Formation strata grade upward into siltstone, mudstone, and shale previously referred to as the Haida Shale Member but now assigned to the informally

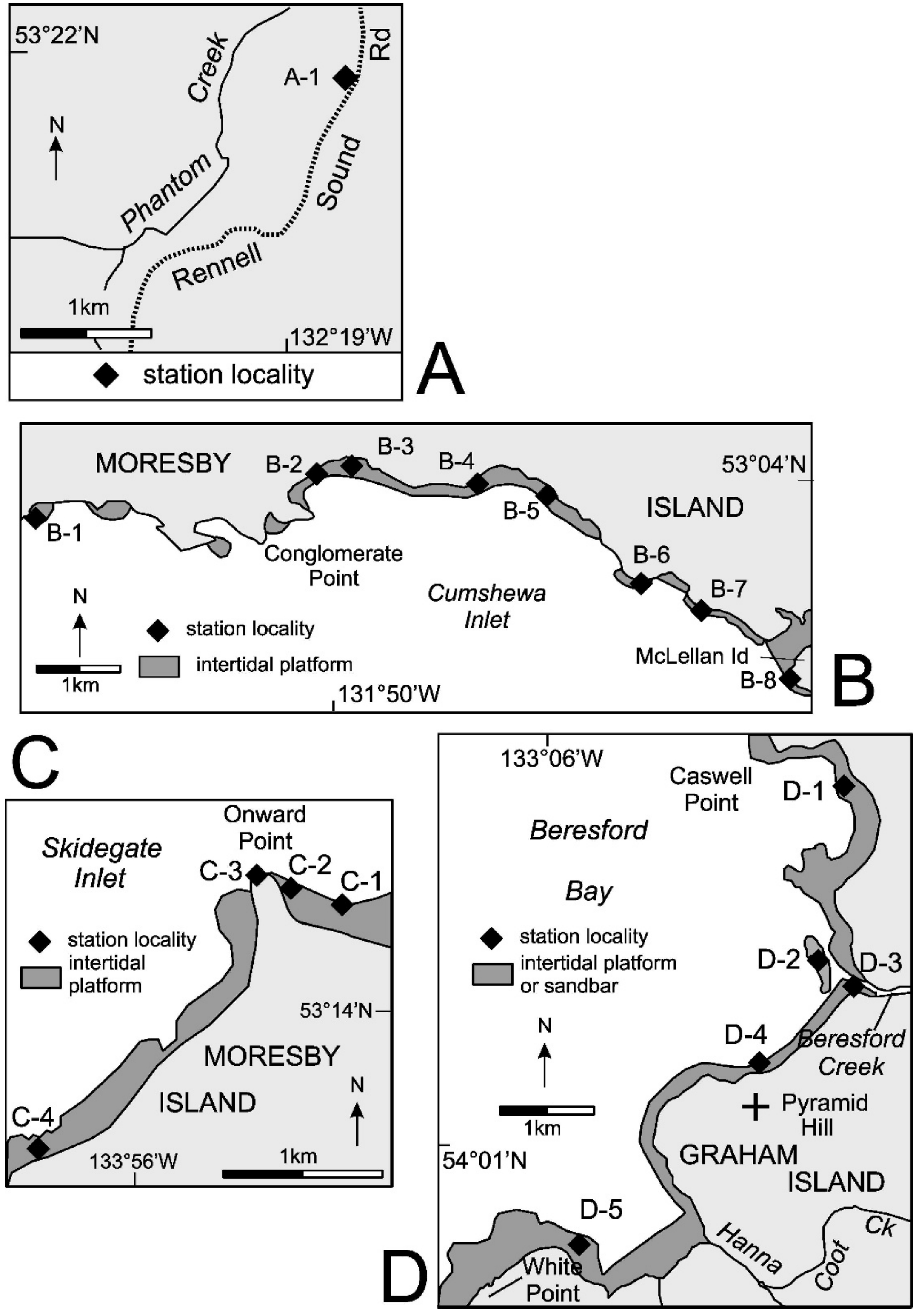

FIGURE 3. Locality map of Cretaceous foraminiferal-bearing exposures along: A = Rennell Sound Road, south-central Graham Island; B = north shore of Cumshewa Inlet; C = vicinity of Onward Point, northeastern Moresby Island; and D = vicinity of Beresford Bay, northwest coast of Queen Charlotte Islands.

designated Bearskin Bay formation of Albian-Cenomanian age. Localized distal turbidites of the Skidegate Formation represent outer-shelf and distal-fan facies that accumulated in deeper parts of the basin during the Cenomanian to early Turonian. Subsequently, in the Turonian and Coniacian, coarse-grained fan-delta and submarine-fan complexes of the Honna Formation prograded into the basin from the east (Higgs, 1990, 1991; Haggart, 1991). Latest Cretaceous

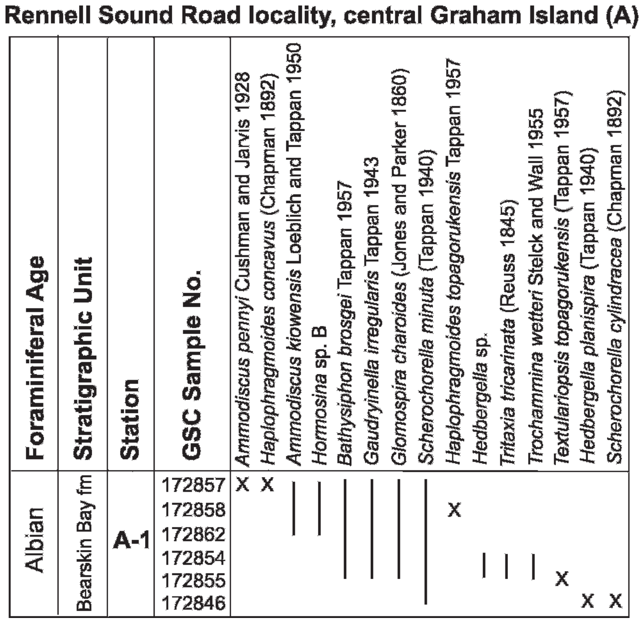

FIGURE 4. Stratigraphic distribution of foraminiferal taxa in samples from along Rennell Sound Road, south-central Graham Island, Queen Charlotte Islands. Samples are presented in relative stratigraphic order, with highest at top; positions above section base are unknown.

deposition is represented by upper Santonian to upper Campanian shelf mudstones of the informally named Tarundl formation (Haggart, 2004; Haggart and others, in press). Deep-basin Cretaceous facies are apparently absent on the islands and may have been truncated by late Neogene strike-slip movement (Haggart, 1991).

The principal biostratigraphic groups utilized in correlating the Cretaceous strata of the islands are ammonites and bivalves (McLearn, 1972; Jeletzky, 1977; Riccardi, 1981; Haggart, 1995; Fig. 2). Recent research on radiolarians (Haggart and Carter, 1993; Carter and Haggart, 2006) has demonstrated their promise as a potential Cretaceous biostratigraphic correlation tool in the region.

MATERIALS AND METHODS

Fieldwork for this project was carried out on Graham and Moresby islands during several field seasons between 1980 and 1993 by B. E. B. Cameron and J. W. Haggart of the Geological Survey of Canada (GSC). Station numbers were assigned to each locality (Table 1) in four general areas (Fig. 1): (1) road-cuts along Rennell Sound Road on south-central Graham Island (Fig. 3A); (2) the north shore of Cumshewa Inlet, southeastern Moresby Island (Fig. 3B); (3) Onward Point on northeastern Moresby Island (Fig. 3C); and (4) in the Beresford Bay area of northwestern Graham Island (Fig. 3D). At most stations, several 5-kg samples were collected in stratigraphic sequence; a few isolated outcrops lacking stratigraphic context are represented by single samples. Most bulk samples were processed at the Geological Survey of Canada's Pacific Geoscience Centre Paleontology Laboratory at Sidney, British Columbia, using techniques developed at the Geological Survey of Canada and summarized in Then and Dougherty (1993) and Johns and others (2006). Samples were initially immersed in Quaternary-O to enhance disaggregation, and then oscillated, and screen washed. Microfossils were picked from the dried residues and mounted on slides for identification. A taxonomic summary of species (Dalby and others, in press) serves as a companion to this contribution.

Specimens were coated with Au-Pb and imaged with a JEOL 6400 scanning electron microscope at the Carleton University Research Facility for Electron Microscopy (CURFEM). Photographs of specimens obscured by the coating were taken with a Javelin video camera mounted on an Olympus SZH stereomicroscope. Some coarsely agglutinated specimens were embedded in Lakeside 70 epoxy resin and carefully ground on 15 µm wet/dry emery paper to determine their chamber arrangements.

RESULTS

Stratigraphic ranges of identified taxa were plotted on stratigraphic sections, based on first and last occurrences for each taxon. Samples were collected stratigraphically through the exposed sections at each locality although the exact interval between collected samples was only recorded at Station C-3 at Onward Point in Skidegate Inlet, and from stations D-1, D-3, D-4 and D-5 around Beresford Bay (S. Irwin, oral communication, 1996; see Haggart and others, 1997).

RENNELL SOUND ROAD, SOUTH-CENTRAL GRAHAM ISLAND

Fine-grained clastic strata are exposed at six road-cuts along one kilometer of Rennell Sound Road on south-central Graham Island and collectively designated as Station A-1 (Figures 1, 3A). The six samples collected yielded generally sparse specimens of 13 benthic and two planktic foraminiferal species (Fig. 4). Previously, these strata were assigned to both the Longarm Formation (Sutherland Brown, 1968) and the Skidegate Formation (Haggart, 2002a), but they are now ascribed to the informal Bearskin Bay formation (Haggart, 2004). Haggart and others (1997) suggest an Albian age for this locality based on ammonite biostratigraphy. This determination is confirmed by the presence of the benthic foraminifer *Ammodiscus kiowensis* Loeblich and Tappan 1950.

NORTH SHORE CUMSHEWA INLET, MORESBY ISLAND

Cretaceous strata along the north shore of Cumshewa Inlet, Morseby Island (Figs. 1, 3B), crop out in a shallow, northwest-trending syncline (Haggart, 2004). The lowermost strata exposed on the limbs of the syncline are sandstones of the Haida Formation. Shales and mudstones in the center of the syncline were originally assigned to the Shale Member of the Haida Formation (Sutherland Brown, 1968; Haggart, 2002b), but are now referred to the Bearskin Bay formation (Haggart, 2004).

Thirty-two samples from eight stations, numbered stratigraphically from lowest to highest, were examined from outcrops of the Bearskin Bay formation along the shoreline of Cumshewa Inlet (Figs. 3B, 5). This area yielded 33 foraminiferal species, which is the most from any area in

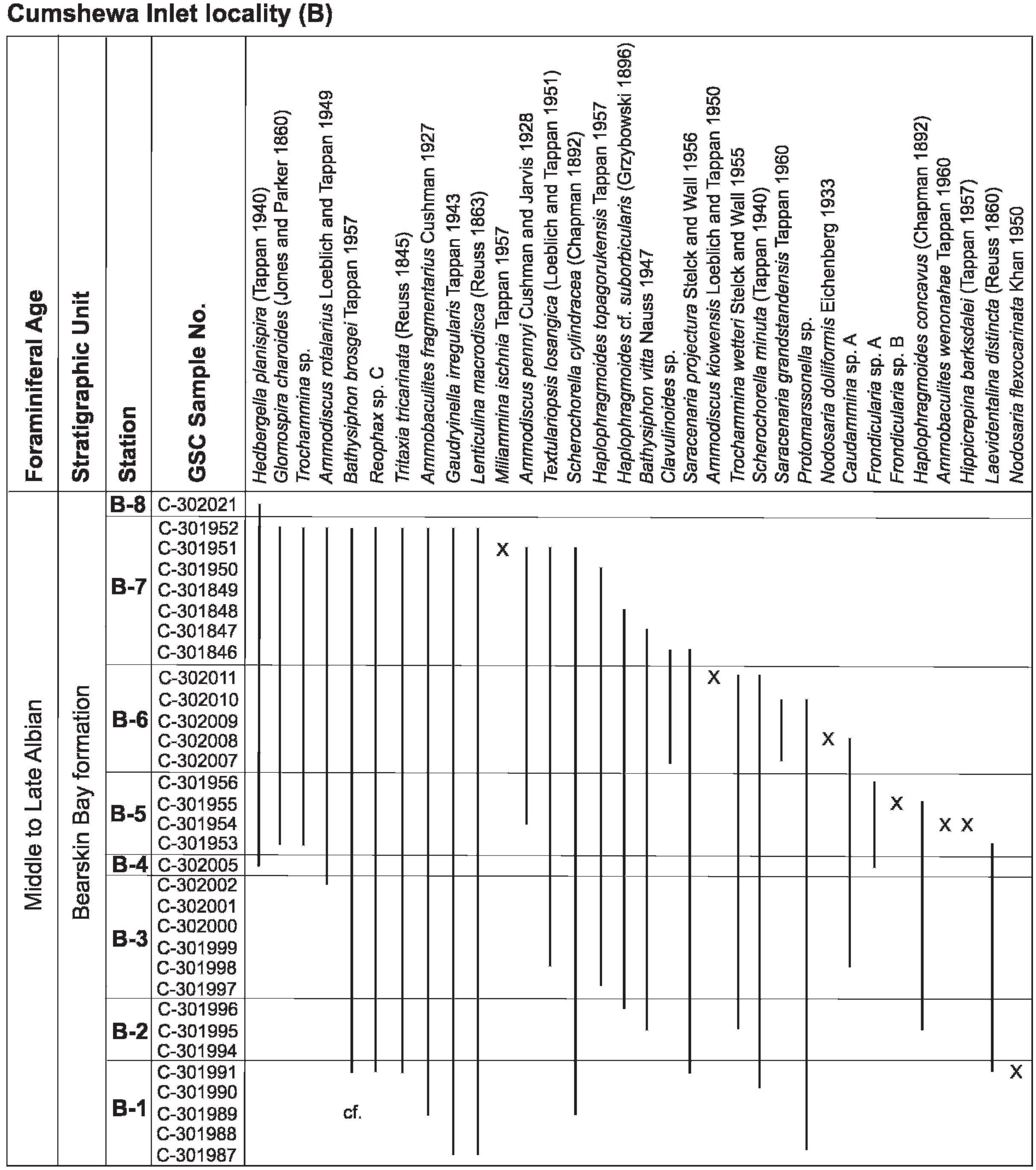

FIGURE 5. Stratigraphic distribution of foraminiferal taxa from exposures along north shore of Cumshewa Inlet, Queen Charlotte Islands. All samples from each station are from a continuous stratigraphic section and are presented in relative stratigraphic order, with highest at top, although positions above section base are unknown; stations are arranged in inferred stratigraphic order with highest at top.

this study. Previous studies of the molluscan fauna from these localities suggested a middle to late Albian age, which is corroborated by the presence of the middle to late Albian foraminiferal taxa *Ammobaculites fragmentarius* Cushman 1927 and *A. wenonahae* Tappan 1960 (Stritch and Schröder-Adams, 1999). The paucity of planktic foraminifera suggests deposition on the inner shelf.

ONWARD POINT, SKIDEGATE INLET, MORESBY ISLAND

Onward Point is located on the south shore of Skidegate Inlet (Figs. 1, 3C), where the exposures consist of fine-grained sandstone with intermittent siltstone and mudstone assigned to the upper part of the Haida Formation (Haggart, 2002b, 2004). Seventy-one samples from four

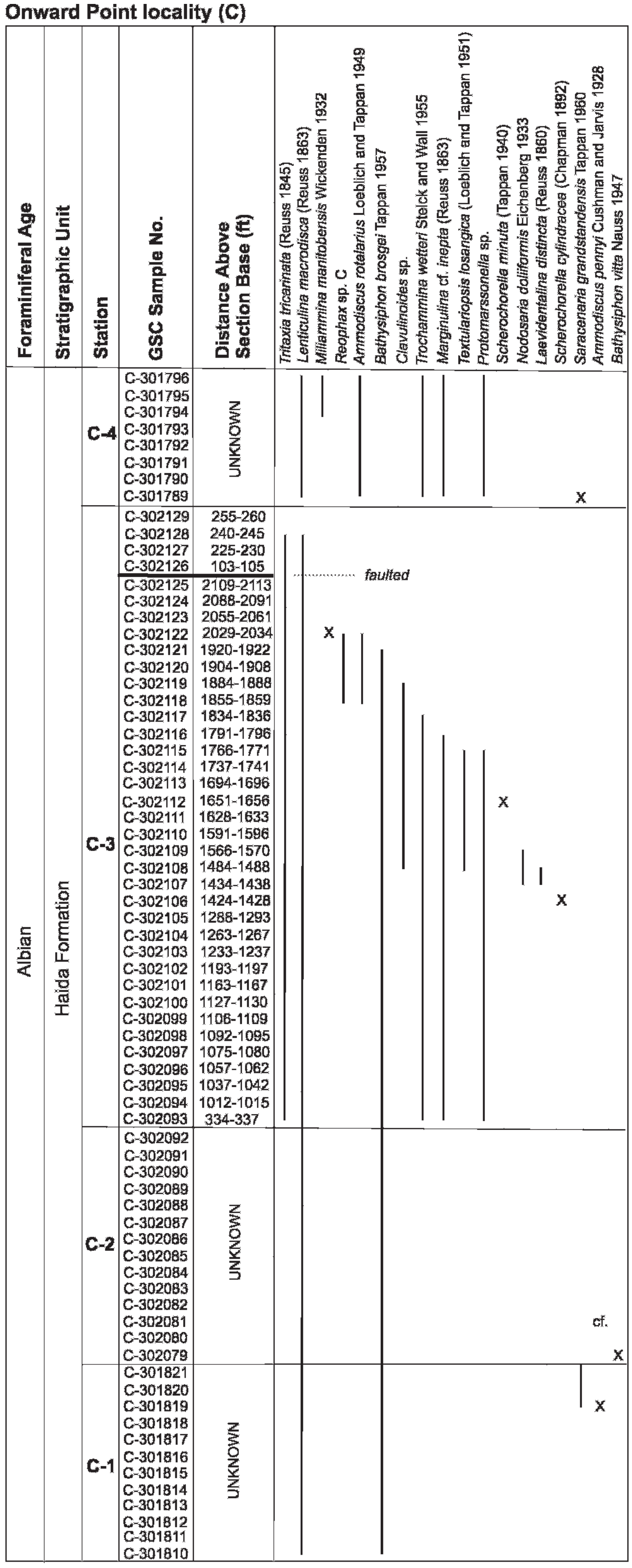

FIGURE 6. Stratigraphic distribution of foraminiferal taxa from exposures in vicinity of Onward Point, northeastern Moresby Island, Queen Charlotte Islands. All samples from each station are from a continuous stratigraphic section and are presented in relative stratigraphic order, with highest at top, positions above base of section are given, where known; stations are arranged in inferred stratigraphic order with highest at top.

stations yielded 18 species of foraminifera, with the greatest number of species in samples from Station C-3 (Fig. 6). Ammonite biostratigraphy of this locality indicates a late Albian age (Sutherland Brown, 1968; McLearn, 1972) that is consistent with the foraminiferal results, particularly the presence of *Miliammina manitobensis* Wickenden 1932 in Station C-4, the stratigraphically highest part of the locality. The youngest strata in the Onward Point locality, which were not sampled for foraminifera, contain early Cenomanian ammonites (McLearn, 1972).

There are no planktic foraminifera in the Onward Point assemblages, which suggests inner-shelf deposition. This is supported by the rich molluscan fauna from this area that indicates an open-marine, shallow-shelf environment (Haggart and others, 1995).

Beresford Bay, Northwest Graham Island

Cretaceous strata along Beresford Bay, northwest Graham Island, comprise sandstones and siltstones assigned to the Haida Formation, as well as mudstones and shales placed in the Bearskin Bay formation (Haggart, 2004). These outcrops, all previously assigned to the Haida Formation (Sutherland Brown, 1968; Haggart, 2002c), are overlain by basaltic and rhyolitic volcanic rocks of the Paleogene-Neogene Masset Formation (Haggart, 2002c). All five stations sampled for foraminifera are intertidal exposures of the Bearskin Bay and Haida formations (Figs. 1, 3D). Combining data from sedimentology, structural geology, and ammonite biostratigraphy (Sutherland Brown, 1968; Haggart, 1986) made it possible to establish the stratigraphic order of the sections at each station, with D-1 at the base and D-5 at the top of the succession.

Eight foraminiferal species were identified from the 11 samples collected at Station D-1 (Fig. 7A). Haggart (1986) designated this section as being late Albian based on its ammonite fauna. The presence of *Miliammina manitobensis* Wickenden 1932 in these samples is consistent with this interpretation.

Both station localities D-2 and D-3, found at the mouth of Beresford Creek, are approximately along strike equivalents (Figs. 7B, 7C). Thirty-four foraminiferal species in 15 samples were recorded from Station D-2, while 27 species of foraminifera were observed in 31 samples from Station D-3. Ammonite faunas from both sections indicate a late Albian age (Haggart, 1986). A middle Albian or later age was indicated for Station D-2 based on the presence of *Ammobaculites fragmentarius* Cushman 1927 and *A. wenonahae*, while the presence of *M. manitobensis* in Station D-3 is not inconsistent with the ammonite biostratigraphic results (Haggart, 1986; Stritch and Schröder-Adams, 1999).

Station D-4, situated ~1 km south of Beresford Creek, is represented by 68 samples from which 40 foraminiferal species are identified (Fig. 7D). Approximately 5 km to the south at White Point, Station D-5 and is of the source of 26 samples from which 22 species are identified (Fig. 7E). The presence of the planktic foraminifer *Shackoina cenomana* (Schacko 1897) in most Station D-4 samples confirms the age of their section as Cenomanian. of the occurrence of *S. cenomana* in a sample from the basal part of the Station D-5 section also indicates a Cenomanian age.

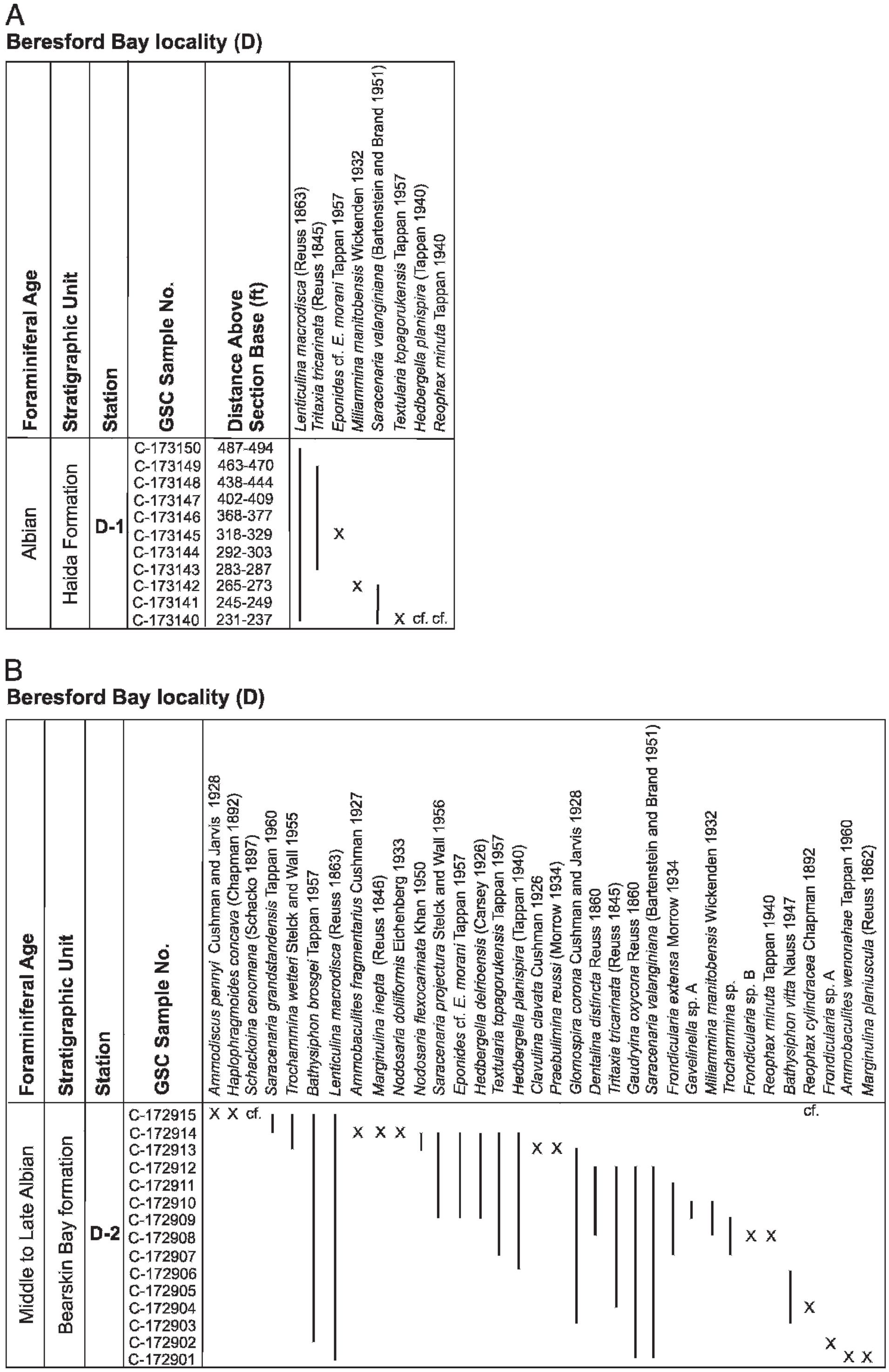

FIGURE 7. Stratigraphic distribution of foraminiferal taxa from exposures in vicinity of Beresford Bay, northwest coast of Queen Charlotte Islands. **A** Caswell Point Ranges; **B** Beresford Creek North Ranges; **C** Beresford Creek; **D** Beresford Bay Ranges; **E** White Point Ranges. See Fig. 3D for distribution of sample stations. All samples from each station are from a continuous stratigraphic section and are presented in stratigraphic order, with highest at top; stations are arranged in inferred stratigraphic order with highest at top and sampling footages are given, where known.

Planktic foraminiferal specimens are rare in most of the Beresford Bay sections, indicating deposition in a near-shore, shelf environment (Berggren and Haq, 1976; Haggart, 1986). The basal part of the Station D-4 section is an exception, as its foraminiferal fauna consists almost exclusively of planktic specimens, chiefly *Hedbergella delrioensis* (Carsey 1926) and to a lesser extent *Hedbergella planispira* (Tappan 1940) (Fig. 7D). The high planktic: benthic (P:B) ratio in this part of the Station D-4 section suggests deposition in deeperwater farther offshore, which

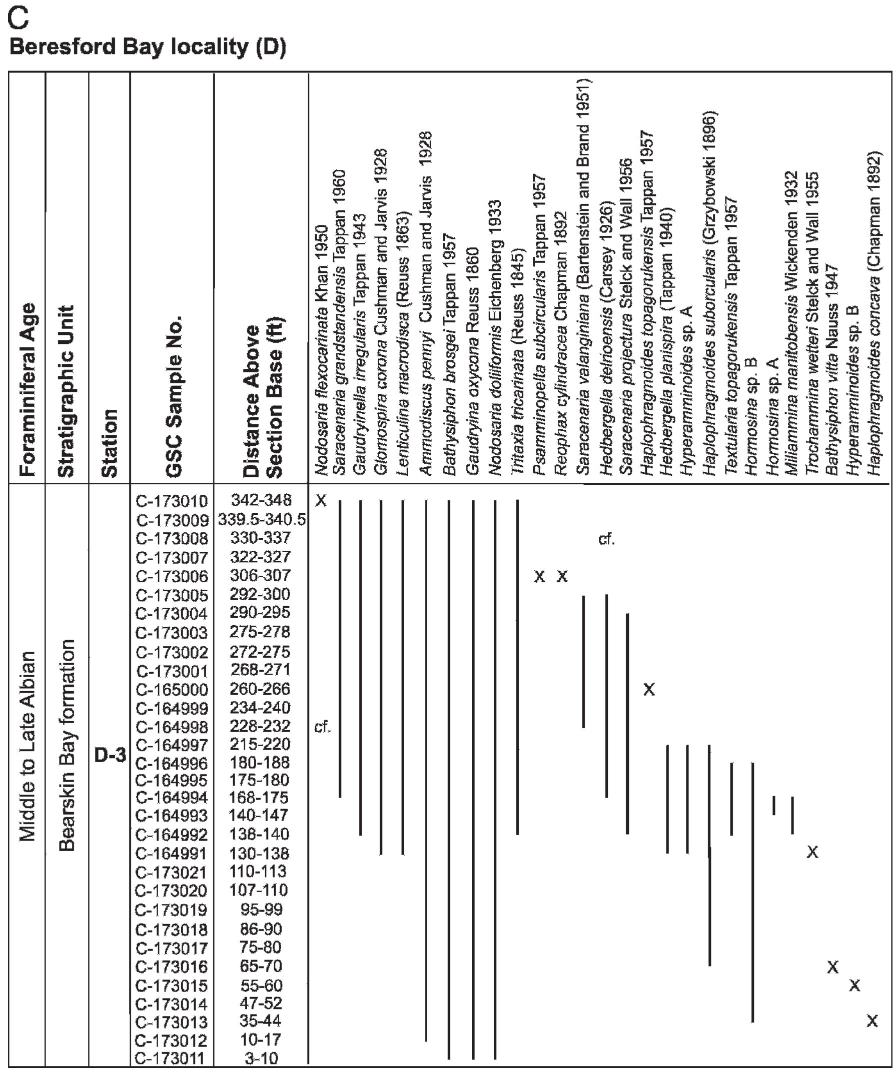

FIGURE 7. Continued.

is also indicated by the associated molluscan fauna (Haggart, 1986). The P:B ratio decreases up–section and benthic foraminifera dominate the upper two-thirds of the section, indicating a regressive sequence.

DISCUSSION

BIOSTRATIGRAPHY AND PALEOECOLOGY

The Albian-Cenomanian stratigraphy and paleontology of the collected localities in the Haida and Bearskin Bay formations on Moresby and Graham islands reveal the shoaling of an open-marine shelf (Fig. 2). Although some of the sections analyzed in this project contained diverse and well-preserved foraminiferal assemblages, the majority of sampled material has been subject to varying degrees of thermal diagenesis and tectonic activity. As a result, a significant proportion of the recovered foraminifera are highly deformed or fractured, often rendering them unidentifiable, especially the delicate planktic and the more-fragile benthic taxa. However, sufficient numbers of identifiable tests were recovered for biostratigraphic and paleoecological determinations. The depauperate Cretaceous foraminiferal fauna of this study is in sharp contrast to the diverse and well-preserved foraminiferal faunas that Kottachchi and others (2002, 2003) recovered from Jurassic strata elsewhere in the QCI.

The Cretaceous is characterized by several global sea-level cycles (Cobban and Reeside, 1952; Dean and Arthur, 1998). The latest Albian–middle Turonian Greenhorn marine cycle, first recognized in the North American Western Interior region (Sloss, 1963), is a first-order eustatic cycle characterized by oceanographic and climatic phenomena that had a major impact on global sea level (Sageman and Arthur, 1994; Leckie and others, 1998; Meyers and others, 2001). Yet, only a few studies to date have focused on the latest Albian-Turonian biostratigraphy along west coast of North America, the greater North Pacific region.

Limited analyses of Cenomanian-Turonian molluscan (Haggart, 1995) and radiolarian (Haggart and Carter, 1993; Carter and Haggart, 2006) faunas of the QCI suggest temperate latitudes and the molluscan fauna indicates

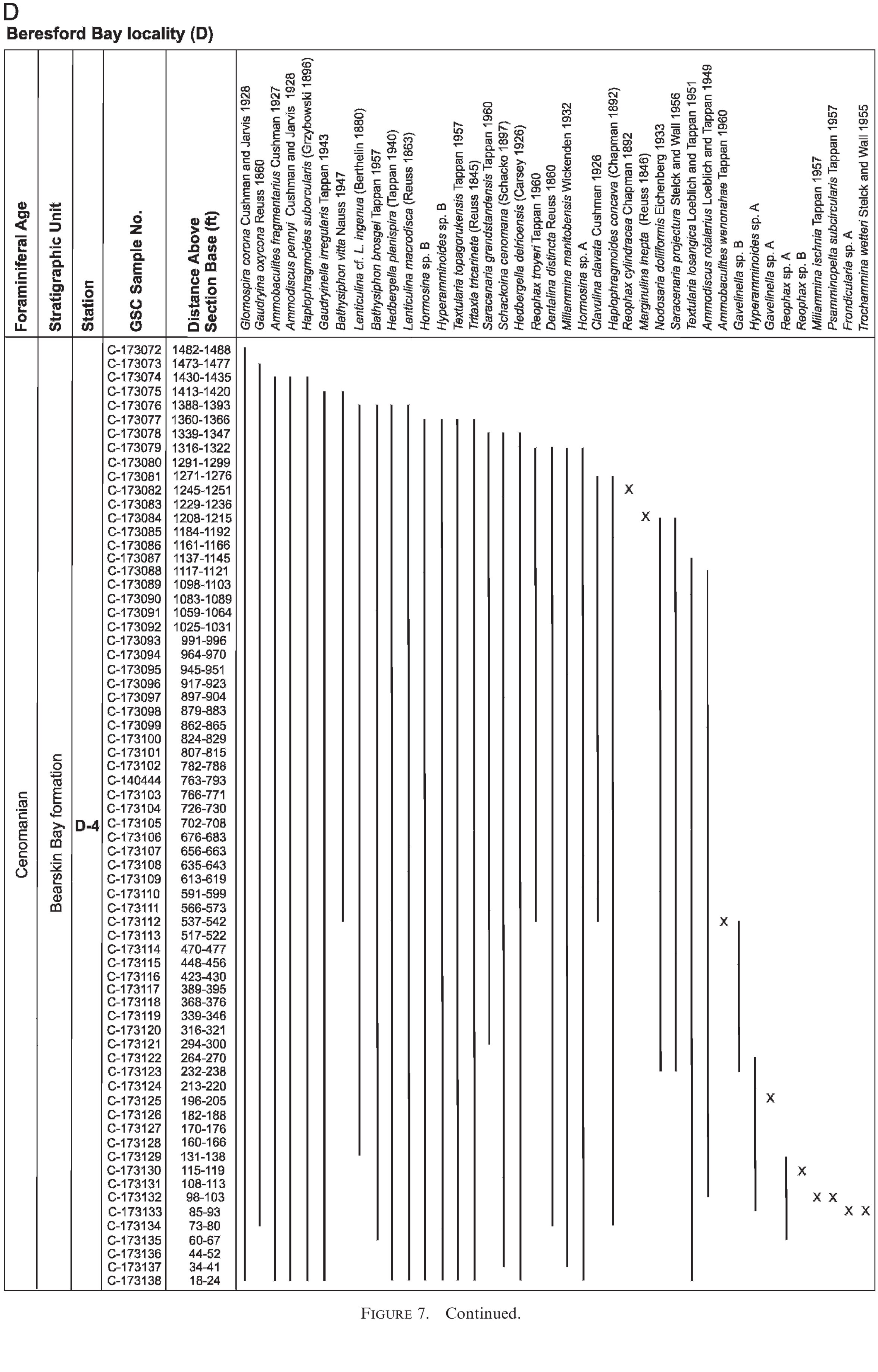

FIGURE 7. Continued.

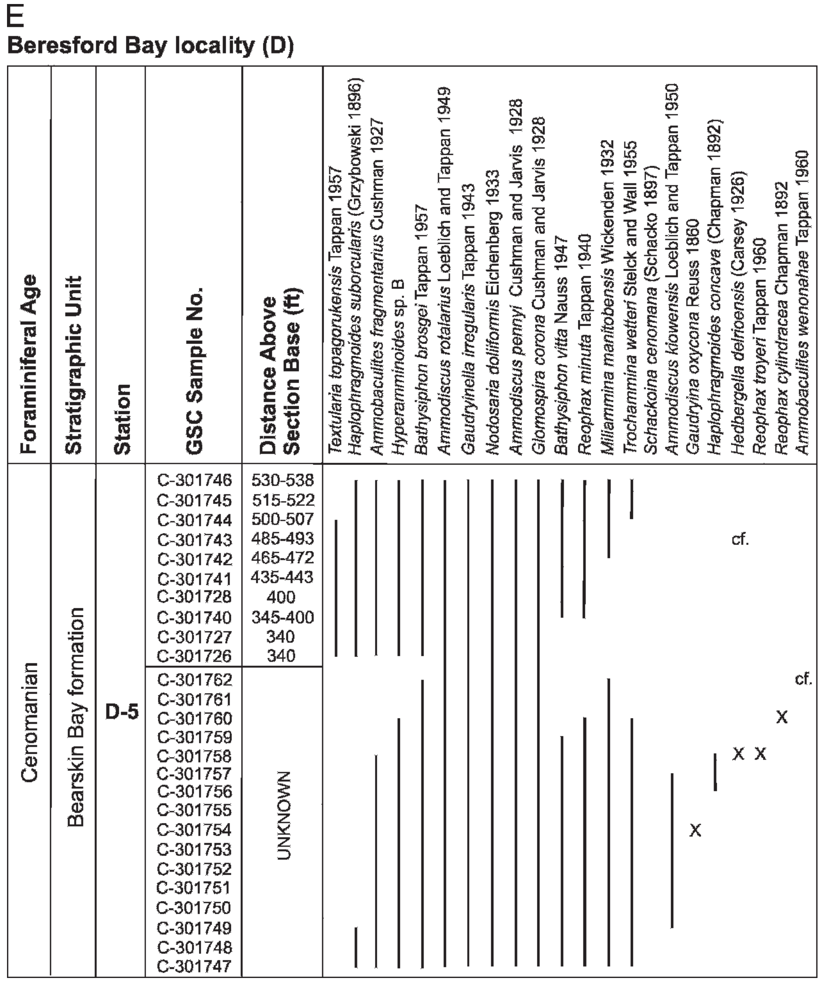

FIGURE 7. Continued.

shallow marine depositional environments. Haggart (1986, 1987, 1991) recognized the eustatic nature of the Albian-Turonian succession of Queen Charlotte Islands, with an early to middle Turonian transgression followed by a the onset of a regressive phase in the late Turonian. This cycle is also recognizable elsewhere along the NE Pacific margin (Haggart, 1991, 1993; Haggart and others, 2005). The apparent deepening and subsequent shallowing noted in the Cenomanian strata of Beresford Bay discussed above may thus reflect a local transgressive-regressive phase near the beginning of the Greenhorn marine cycle.

PALEOGEOGRAPHY

Nearly 60% of the species identified in this study have been previously reported from the Albian-Cenomanian of Alaska (Tappan, 1951, 1957, 1960, 1962), suggesting that the two regions were in close geographic proximity and part of the same boreal water mass during the Albian and Cenomanian. During Mesozoic and Tertiary time, allochthonous terranes of different origins and ages were accreted onto the western margin of North America (Monger and Irving, 1980; Tipper, 1984). The QCI are part of the Wrangellia terrane, the most outboard of the allochthonous terranes in the central Cordilleran region of western British Columbia. Rock paleomagnetism studies and faunal biostratigraphy and biogeography indicate that Wrangellia was at tropical latitudes during the Triassic (Tozer, 1982), but the precise timing of its post-Triassic northward drift is a source of continuing disagreement (see discussions in Cowan and others, 1997 and Enkin, 2006). Some paleomagnetism studies suggest that Wrangellia was still at low latitudes relative to the North American craton in the Late Cretaceous, as late as the Campanian (Ward and others, 1997; Enkin, 2006), a scenario that requires it to have had a significant rate of northward movement during the latest Cretaceous and Paleogene. In contrast, geological and previous paleontological (molluscan, radiolarian, and foraminiferal) biogeographic analyses (see Haggart and others, 2006) suggest that Wrangellia was likely at its approximate present-day position, relative to the craton, by Late or Middle Jurassic time. With their boreal affinities, the foraminiferal faunas analyzed in this study provide additional evidence that the QCI was in a northerly position where it became strongly influenced by boreal water masses by the Albian, supporting the hypothesis that the northward migration of Wrangella occurred earlier.

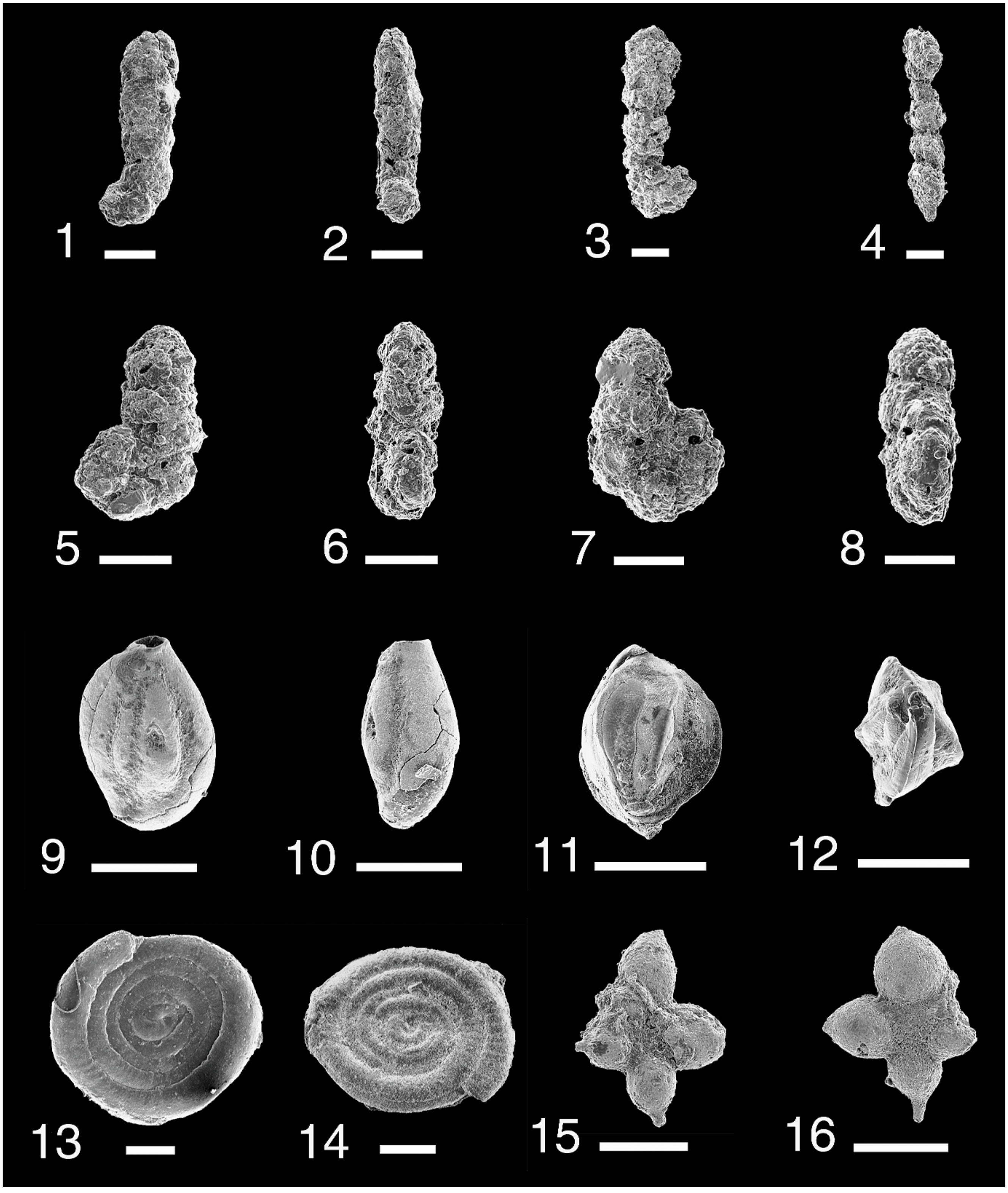

PLATE 1

Scanning electron micrographs of selected taxa. All scale bars = 100 µm, **1–4** *Ammobaculites fragmentarius* Cushman 1927, **1** side view, **2** edge view, GSC No. 126562, from Beresford Bay Station 5 (GSC Loc. C-301740). **3** side view, **4** edge view, GSC No. 126563, from Cumshewa Inlet Station 8 (GSC Loc. C-301991). **5–8** *Ammobaculites wenonahae* Tappan 1960, **5** side view, **6** edge view, GSC No. 126564, from Beresford Bay Station 4 (GSC Loc. C-173112). **7** side view, **8** edge view, GSC No. 126565, from Beresford Bay Station 4 (GSC Loc. C-173112). **9–12** *Miliammina manitobensis* Wickenden 1932, **9** side view, **10** edge view, GSC No. 126599, from Beresford Bay Station 2 (GSC Loc. C-172907). **11** side view, **12** apertural view, GSC No. 126600, from Beresford Bay Station 4 (GSC Loc. C-173137). **13,14** *Ammodiscus kiowensis* Loeblich and Tappan 1950. **13** spiral view, GSC No. 126530, from Beresford Bay Station 6 (GSC Loc. C-301756); **14** oblique view, GSC No. 126531, from Rennell Sound Road (GSC Loc. C-172862). **15,16** *Schackoina cenomana* (Schacko 1897), **15** side view, **16** reverse side view, GSC No. 126603, from Beresford Bay Station 4 (GSC Loc. C-173137).

CONCLUSIONS

Albian-Cenomanian foraminiferal faunas described from localities on Moresby and Graham islands in the Queen Charlotte Islands (QCI) inhabited shallow- to outer-shelf environments, as determined by their P:B ratios. The only deeper, outer-shelf facies recognized in this study are Cenomanian strata in the lower part of a succession exposed at Beresford Bay on northwest Graham Island. This unit was deposited during a prolonged Albian-Turonian transgressive phase that correlates with the Greenhorn marine cycle of the North American Western Interior region. Nearly 60% of the foraminiferal fauna identified in this study show boreal affinities, based on comparison with Albian-Cenomanian foraminiferal faunas of northern Alaska. The high degree of faunal similarity between these two regions suggests that the QCI region was in a similar boreal water mass at the time of deposition. Our results provide additional supporting evidence that the Wrangellia terrane, of which the QCI is a part, had migrated to relatively high latitudes by mid-Cretaceous time, significantly earlier than suggested by paleomagnetic data.

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