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Lithostratigraphic, conodont, and other faunal links between lower Paleozoic strata in northern and central Alaska and northeastern Russia

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ABSTRACT

Lower Paleozoic platform carbonate strata in northern Alaska (parts of the Arctic Alaska, York, and Seward terranes; herein called the North Alaska carbonate platform) and central Alaska (Farewell terrane) share distinctive lithologic and faunal features, and may have formed on a single continental fragment situated between Siberia and Laurentia. Sedimentary successions in northern and central Alaska overlie Late Proterozoic metamorphosed basement; contain Late Proterozoic ooid-rich dolostones, Middle Cambrian outer shelf deposits, and Ordovician, Silurian, and Devonian shallow-water platform facies, and include fossils of both Siberian and Laurentian biotic provinces. The presence in the Alaskan terranes of Siberian forms not seen in well-studied cratonal margin sequences of western Laurentia implies that the Alaskan rocks were not attached to Laurentia during the early Paleozoic.

The Siberian cratonal succession includes Archean basement, Ordovician shallow-water siliciclastic rocks, and Upper Silurian–Devonian evaporites, none of which have counterparts in the Alaskan successions, and contains only a few of the Laurentian conodonts that occur in Alaska. Thus we conclude that the lower Paleozoic platform successions of northern and central Alaska were not part of the Siberian craton during their deposition, but may have formed on a crustal fragment rifted away from Siberia during the Late Proterozoic. The Alaskan strata have more similarities to coeval rocks in some peri-Siberian terranes of northeastern Russia (Kotelny, Chukotka, and Omulevka). Lithologic ties between northern Alaska, the Farewell terrane, and the peri-Siberian terranes diminish after the Middle Devonian, but Siberian affinities in northern and central Alaskan biotas persist into the late Paleozoic.

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INTRODUCTION

Lower Paleozoic platform carbonate strata crop out discontinuously across northern Alaska, from westernmost Seward Peninsula to the northeastern Brooks Range (Figs. 1 and 2). Lithologic and faunal similarities between these carbonate successions strongly suggest that they formed along a single continental margin (Dumoulin and Harris, 1994). Microfossil and megafossil assemblages from the Alaskan successions have Siberian elements not found in coeval strata of the Canadian Cordillera or the Canadian Arctic Islands (Dumoulin et al., 1998c, 2000a), but they also contain Laurentian elements. This distinctive co-occurrence of Siberian and Laurentian faunal elements is also documented in coeval carbonate rocks of the Farewell terrane in central Alaska (Dumoulin et al., 1998b; Blodgett, 1998), in successions that have many lithologic similarities with those of northern Alaska. In this chapter we compare lower Paleozoic stratigraphies and faunas from northern and central Alaska to coeval stratigraphies and faunas from northeastern Russia. These comparisons provide critical data that constrain models of Arctic paleogeography and tectonic evolution.

NORTHERN ALASKA

Lower Paleozoic carbonate strata in northern Alaska crop out on the Seward Peninsula and discontinuously throughout the Brooks Range (Fig. 2). Their present configuration is primarily the result of Mesozoic and Tertiary tectonism, but may also reflect Paleozoic tectonic events (Moore et al., 1994, 1997). Original facies relations, such as those between shallow- and deep-water strata, have been disrupted and obscured by widespread thrust and perhaps extensional faulting. In the Brooks Range, lower Paleozoic rocks have been assigned to the Arctic Alaska terrane, whereas coeval strata on Seward Peninsula have been assigned to the York and Seward terranes (Nokleberg et al., 1994, 1998; Silberling et al., 1994). The Arctic Alaska terrane includes numerous subterranes; lower Paleozoic carbonate rocks in the western and central Brooks Range belong to the Hammond subterrane, whereas those in the northeastern Brooks Range are part of the North Slope subterrane (Moore et al., 1994). Stratigraphic and faunal evidence suggests that lower Paleozoic carbonate successions in all three terranes were once part of a contiguous carbonate platform (herein called the North Alaska carbonate platform) that was disrupted by later tectonic events (Dumoulin and Harris, 1994).

Paleogeographic reconstruction of northern Alaska is further complicated by extensive exposures, particularly in the southern Brooks Range, of undated, deformed, chiefly metasiliciclastic and lesser metavolcanic rocks that could include both shallow- and deep-water facies of early Paleozoic age (parts of the Hammond and Coldfoot subterranes of the Arctic Alaska terrane of Moore et al., 1994). The stratigraphic and depositional positions of these strata are uncertain. They have been interpreted as largely Devonian deposits that accumulated in block-

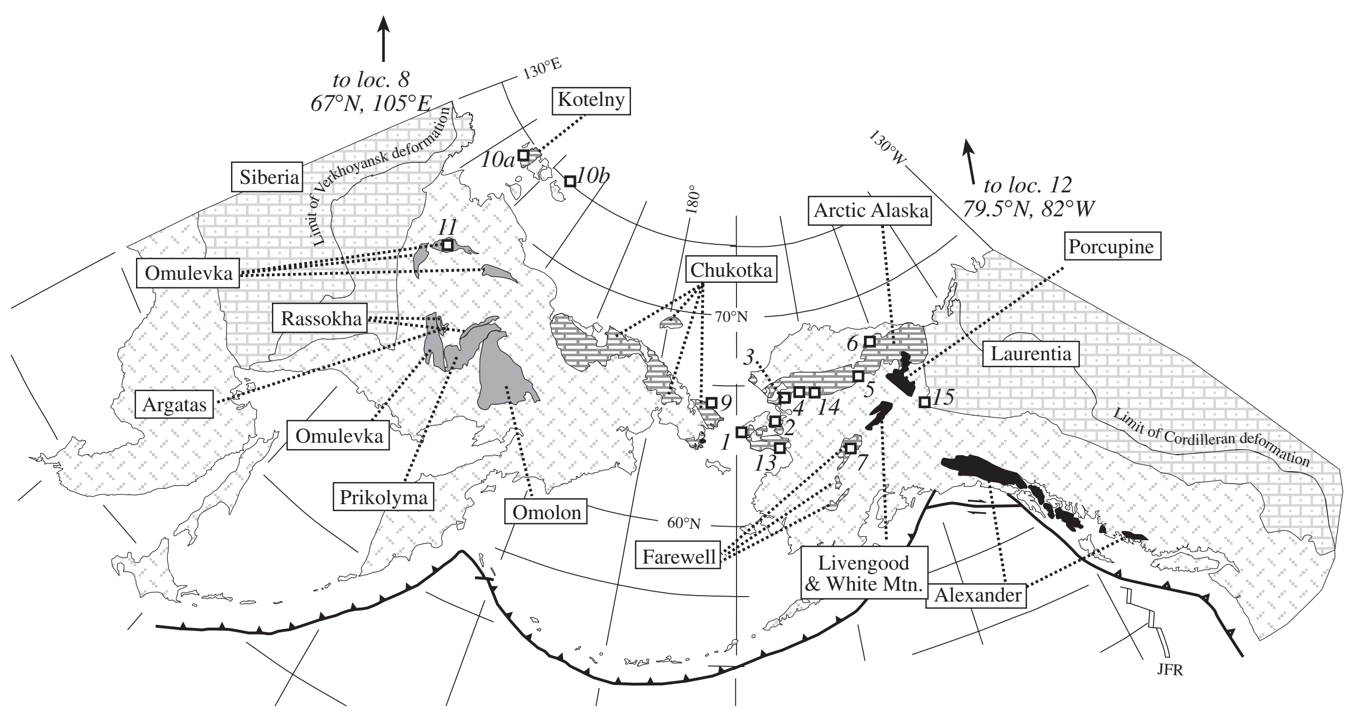


Figure 1. Terranes of northeastern Russia and Alaska, modified from Nokleberg et al. (1998), as follows: Chukotka includes Russian part of Seward terrane; Arctic Alaska consists of parts of Arctic Alaska, Seward (Alaskan part), and York terranes that contain lower Paleozoic carbonate rocks. Numbers 1–12 are areas of stratigraphic sections shown in Figure 3; 13–15 are localities mentioned in text: 13, southeast Seward Peninsula; 14, northeast Ambler River Quadrangle; 15, Jones Ridge.

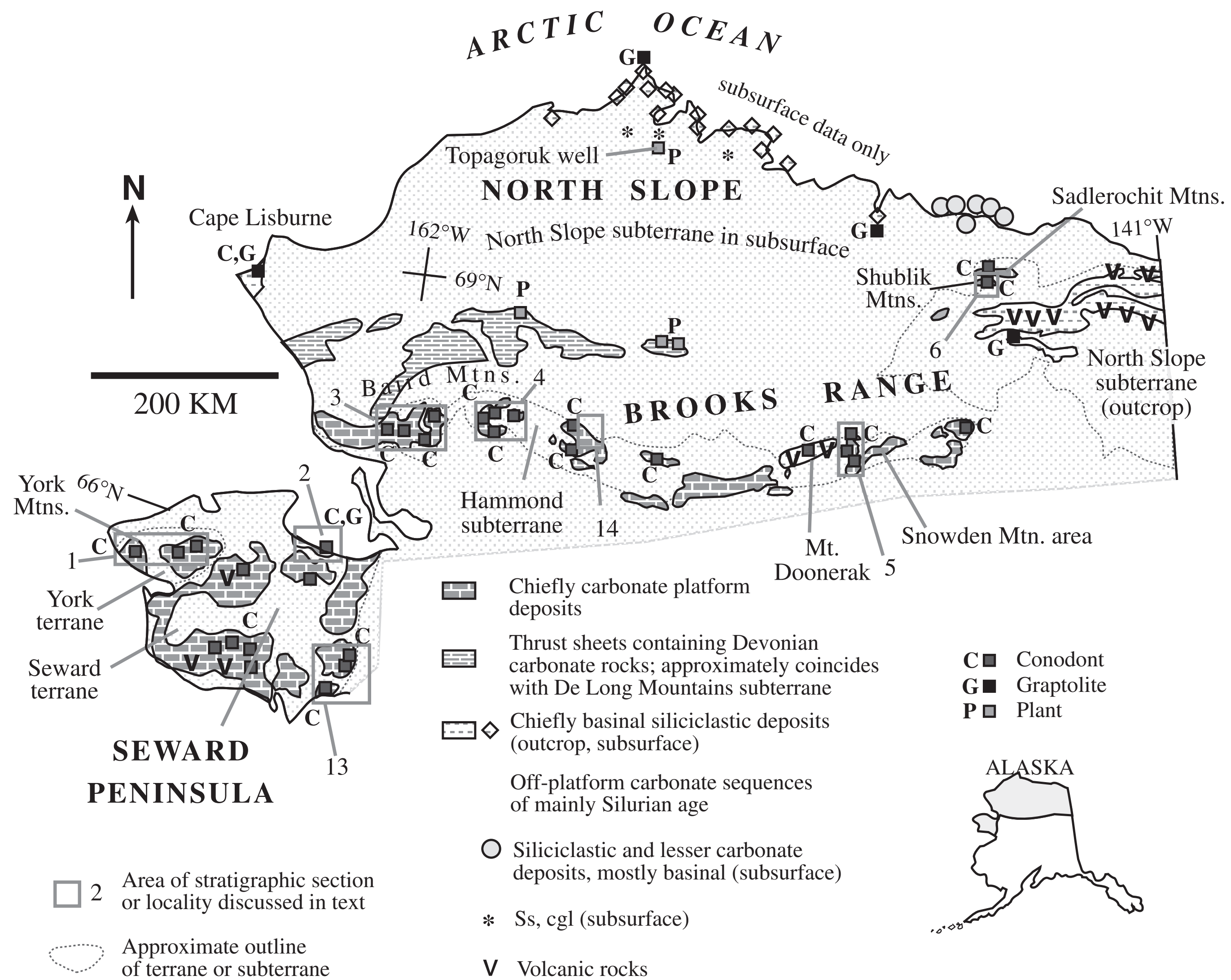


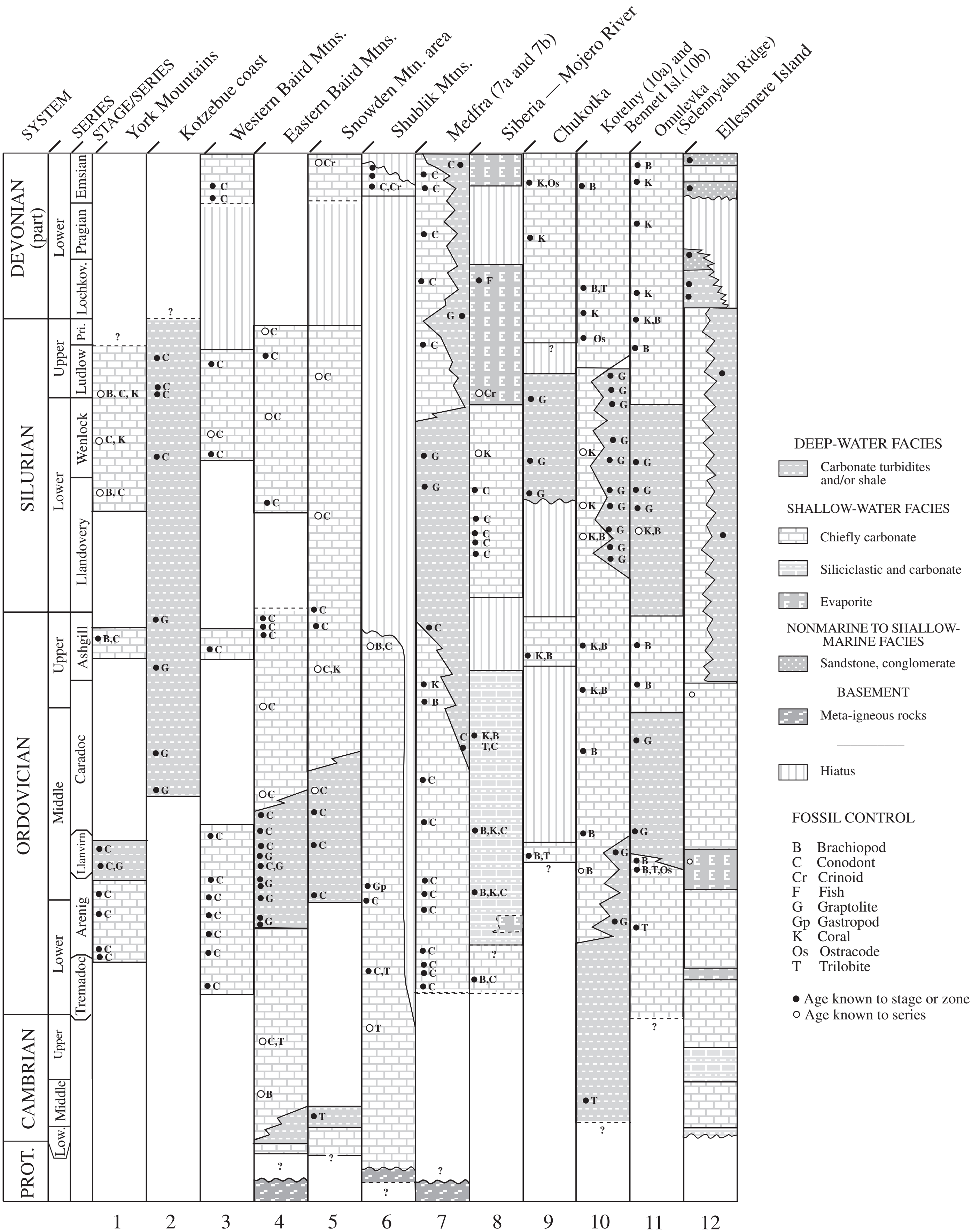
Figure 2. Distribution of lower Paleozoic lithofacies and selected fossil localities across northern Alaska. Patterns and symbols refer to outcrop data unless specified as subsurface.

faulted basins within the North Alaska carbonate platform during inferred middle Paleozoic extension (Moore et al., 1997), or alternatively, as Devonian and older basinal successions that formed along the southern margin of the carbonate platform (Oldow et al., 1998).

In northernmost Alaska (north of lat 68°N), lower Paleozoic strata are largely deep-water, siliciclastic and lesser volcanic deposits included in the North Slope subterrane of the Arctic Alaska terrane (Moore et al., 1994). These rocks crop out to the west near Cape Lisburne, in the central Brooks Range at Mount Doonerak, and in the far northeastern Brooks Range, and have been encountered by numerous exploratory wells drilled for petroleum beneath the North Slope (Fig. 2). The lower Paleozoic deep-water strata of northernmost Alaska could have formed along the northern margin of the North Alaska carbonate platform, but they cannot be depositionally tied to that platform until Devonian time or later (Moore et al., 1994); this point is further discussed in the following.

Lithofacies

Carbonate successions of early Paleozoic age have been studied in detail in the York Mountains (western Seward Peninsula), the central and eastern Seward Peninsula, the western and eastern Baird Mountains (western Brooks Range), the Snowden Mountain area (central Brooks Range), and the Shublik and Sadlerochit Mountains (eastern Brooks Range) (Figs. 2 and 3, columns 1–6; Dumoulin and Harris, 1994; Harris et al., 1995, and references therein). Strata in the York, Shublik, and Sadlerochit Mountains are unmetamorphosed. The other successions


SYSTEM
SERIES
STAGE/SERIES
York Mountains
Kotzebue coast
Western Baird Mtns.
Eastern Baird Mtns.
Snowden Mtn. area
Shublik Mtns.
Medfra (7a and 7b)
Siberia — Mojero River
Chukotka
Kotelny (10a) and Bennett Isl.(10b)
Omulevka (Selennyakh Ridge)
Ellesmere Island
DEVONIAN (part)
Lower
Emsian
Pragian
Lochkov.
SILURIAN
Upper
Pri.
Ludlow
Lower
Wenlock
Llandovery
ORDOVICIAN
Upper
Ashgill
Caradoc
Middle
Llanvirn
Arenig
Lower
Tremadoc
CAMBRIAN
Upper
Middle
Low.
PROT.
1
2
3
4
5
6
7
8
9
10
11
12
DEEP-WATER FACIES
Carbonate turbidites and/or shale
SHALLOW-WATER FACIES
Chiefly carbonate
Siliciclastic and carbonate
Evaporite
NONMARINE TO SHALLOW-MARINE FACIES
Sandstone, conglomerate
BASEMENT
Meta-igneous rocks
Hiatus
FOSSIL CONTROL
B Brachiopod
C Conodont
Cr Crinoid
F Fish
G Graptolite
Gp Gastropod
K Coral
Os Ostracode
T Trilobite
● Age known to stage or zone
○ Age known to series

are metamorphosed to greenschist and blueschist facies, but sedimentary features and faunal assemblages are locally well preserved.

Rocks interpreted as basement to the carbonate platform succession are not widely exposed and have been little studied. In the eastern Baird Mountains, this basement consists of amphibolite facies metasedimentary rocks that have calculated Nd crustal residence ages of 2.0 Ga and are intruded by metagranites with Late Proterozoic (750 ± 6 Ma) U-Pb zircon crystallization ages (Nelson et al., 1993). On the central Seward Peninsula, schists intruded by orthogneiss bodies with U-Pb crystallization ages of 676 ± 15 Ma and 681 ± 3 Ma structurally underlie lower Paleozoic carbonate rocks (Patrick and McClelland, 1995). In the Shublik and Sadlerochit Mountains, carbonate strata overlie metasedimentary rocks intruded by a mafic dike with an Rb-Sr age of 801 ± 20 Ma (Clough and Goldhammer, 1995).

Carbonate strata of Late Proterozoic and Cambrian age in northern Alaska compose a chiefly shallow-water succession of at least 100 m in the western and central Brooks Range and as much as 3300 m in the eastern Brooks Range. Dolostones of known or inferred Late Proterozoic age crop out in the eastern Baird Mountains, Snowden Mountain area, and Shublik-Sadlerochit Mountains and contain abundant stromatolites and coated grains (both oncoids and ooids). These rocks are overlain by peritidal cycles of limestone and dolostone of Middle and Late Cambrian age in the eastern Baird and Shublik-Sadlerochit Mountains; fossils from these strata include protoconodonts, acrotretid brachiopods, and trilobites. Rare Lower (and lower Middle?) Cambrian carbonate rocks on the central and eastern Seward Peninsula contain protoconodonts and the problematic microfossil *Lapworthella* sp., which indicates a shallow-water setting (Till et al., 1986). Somewhat deeper-water (outer shelf and slope) deposits of Middle Cambrian and older (?) age occur locally in the eastern Baird Mountains and in the Snowden Mountain area. Pre-Ordovician strata are not recognized in the York or western Baird Mountains, but redeposited Late Cambrian conodonts are found in basal parts of the Ordovician sections in the western Baird and Snowden areas.

Shallow-water carbonate rocks of Early and Middle Ordovician age in the York, western Baird, Shublik, and Sadlerochit Mountains are widely distributed, at least 250–450 m thick, and formed in a range of supratidal to subtidal, locally restricted, inner and middle shelf environments. The York and western Baird sections are differentiated into two lithofacies: yellow- to orange-weathering carbonate that contains abundant argillaceous material and quartz silt and local ooids and intraclasts, and relatively pure, gray peloidal micrite. Decameter-scale shallowing-upward cycles characterize both lithofacies in both areas. The Shublik-Sadlerochit section consists chiefly of peloidal, locally oolitic, pack-grainstone.

An intraplatform basin or basins developed within the North Alaska carbonate platform during late Early Ordovician time and persisted throughout most of the Middle Ordovician. Basinal strata are longest lived in the eastern Baird and Snowden Mountain sections, where they overlie shallower-water strata of Cambrian and possibly Early Ordovician age. However, deep-water rocks also crop out to the west, in the western Baird Mountains and on the Seward Peninsula, where they are underlain by and intercalated with shallow-water carbonate rocks of Early and Middle Ordovician age. Basinal lithofacies range from at least 50 to more than 200 m thick, are of Arenig to early Caradoc (?) age, and consist of graptolitic shale or phyllite grading upward into carbonate turbidites. On the central and eastern Seward Peninsula, a continental platform succession was punctuated by at least one episode of Ordovician rifting during which iron- and titanium-rich metagabbros that are compositionally similar to modern ridge tholeiites intruded a thick sequence of calcareous and volcanogenic sediments (Till and Dumoulin, 1994).

Deposition of neritic carbonate resumed in the Late Ordovician across most of Seward Peninsula and the Brooks Range and persisted through the Silurian and locally into the Middle Devonian. Upper Ordovician through Devonian carbonate rocks are 150–300 m thick and generally similar across northern Alaska; variations mainly reflect differential erosion during Early Silurian and/or post–Early Devonian time. Meter- to decameter-scale shallowing-upward cycles characterize Upper Ordovician strata in the eastern Baird and Snowden Mountain areas, Silurian rocks in all northern Alaskan sections that contain neritic carbonate, and Lower–Middle Devonian strata in the western Brooks Range.

Shallow-water carbonate platform deposits of late Early and Middle Devonian age are widely distributed across southern and central Seward Peninsula and the western Baird Mountains, but are of more limited extent elsewhere in northern Alaska. The youngest strata known in the York Mountains are a single outcrop of coralline carbonate rocks of probable Late Silurian (late Ludlow) to Early Devonian age (Dumoulin and Harris, 1994). The youngest parts of the carbonate succession elsewhere consist of rare outcrops of upper Lower and/or lower Middle Devonian metalimestone in the Snowden Mountain area

Figure 3. Correlation of Upper Proterozoic to Lower Devonian rocks in selected areas of northern Alaska, interior Alaska, northeastern Russia, and Ellesmere Island, Arctic Canada. See Figures 1, 2, and 4 for locations of columns. Only fossil groups that most narrowly restrict age of collection or unit are listed; fossil groups that provide age control for column 12 not given by sources. Data sources: columns 1–6, Dumoulin and Harris (1994), Harris et al. (1995); column 7, Dutro and Patton (1982), Dumoulin et al. (1999, 2000b); columns 8–11, stratigraphic columns compiled in 1992 by Valentyn Bondarev and colleagues, VNII-Okeangeologiya, Saint Petersburg, for Geological Survey of Canada Paleozoic Circumpolar Correlation Project, with additional information from Kanygin et al. (1988) (column 8), Oradovskaya (1988) (columns 9–11) and Kos'ko et al. (1990) (column 10); column 12, de Freitas et al. (1997), stratigraphic column compiled in 1992 for Geological Survey of Canada Paleozoic Circumpolar Correlation Project. Former Llandeilo Series (Middle Ordovician) is now considered a stage of Llanvirn Series (Fortey et al., 1995).

and Lower Devonian (Emsian) limestone that disconformably overlies Upper Ordovician limestone in the Shublik Mountains.

Devonian shallow-water carbonate rocks also occur in a series of thrust sheets north of the lower Paleozoic carbonate platform in the western Brooks Range (Kelly River and Ipnavik River allochthons of Mayfield et al., 1988; approximately equivalent to the De Long Mountains subterrane of the Arctic Alaska terrane of Moore et al., 1994), but the relationship of these strata to the North Alaska carbonate platform is uncertain. The thrust sheets contain 50–700 m of chiefly unmetamorphosed limestone and lesser dolostone that is Middle to Late Devonian (Eifelian, Givetian, Frasnian, and Famennian) (Mayfield et al., 1990; Dumoulin and Harris, 1992; Baxter and Blodgett, 1994). The lower boundary of this unit is invariably a thrust fault and the upper boundary is a thrust fault or a conformable contact with Mississippian carbonate rocks.

Devonian carbonate strata in the thrust sheets are lithologically similar to, but largely younger than, the Devonian part of the North Alaska carbonate platform; no carbonate rocks definitively older than Eifelian are known in the thrust sheets, and none definitively younger than Givetian are found in the North Alaska platform. Carbonate rocks in the thrust sheets may be the structurally detached uppermost part of the North Alaska platform, or they may be part of a discrete Devonian-Mississippian carbonate platform that was not originally contiguous with the North Alaska carbonate platform, as suggested by some stratigraphic evidence (discussed in the following). Faunal assemblages, however, discussed in the section "Paleobiogeography," imply ties between the two successions.

Siliciclastic rocks of Devonian and Mississippian age that accumulated chiefly in shallow-marine and nonmarine settings overlie older carbonate and noncarbonate strata across much of northern Alaska. In the western Baird and Snowden sections, Devonian platform carbonates grade up into interbedded limestones and quartz-rich sandstones of Middle and early Late Devonian age. These rocks in turn grade up into the siliciclastic Endicott Group (Upper Devonian and Lower Mississippian), which contains abundant detrital chert and is locally as much as 2600 m thick (Moore and Nilsen, 1984). The Endicott Group is largely absent from thrust sheets of the Kelly River and Ipnavik River allochthons, however (Mayfield et al., 1988). This difference in stratigraphic succession suggests the possibility that Devonian carbonate rocks in these thrust sheets were not originally part of the North Alaska carbonate platform.

The deep-water siliciclastic successions of early Paleozoic age in northern Alaska are generally overlain by Devonian-Mississippian siliciclastic strata (Endicott Group and related rocks). These younger rocks are Mississippian near Cape Lisburne and Mount Doonerak, but Middle Devonian to Early Mississippian in the northeastern Brooks Range (Tailleur, 1965; Armstrong et al., 1976; Anderson et al., 1994). Chert-rich sandstone and conglomerate were also penetrated in several wells beneath the coastal plain in the north-central North Slope; in the Topagoruk well (Fig. 2), this sequence contains plant fragments of probable late Early–early Middle Devonian age (Witmer et al., 1981). These strata are compositionally similar to, but somewhat older than, exposures of the Endicott Group in the thrust sequences of the Brooks Range to the south.

Thus, both pre-Carboniferous platform carbonate strata and coeval deep-water siliciclastics now exposed to the north are overlain by chert-rich, siliciclastic shallow-marine and nonmarine rocks of Devonian and Mississippian age. These chert-rich younger siliciclastic strata may have been produced by a single depositional system that overlapped older Paleozoic rocks throughout northern Alaska, but no simple age progression for this overlap has been established.

Fault-bounded, off-platform carbonate sequences of primarily Silurian age and limited geographic extent are recognized at several localities on Seward Peninsula and in the Brooks Range, primarily along the present-day northern margin of the North Alaska carbonate platform. Basinal strata on the northern Seward Peninsula (Kotzebue coast; Fig. 2, location 2; Fig. 3, column 2) are the best documented of these occurrences, and consist of Middle and Upper Ordovician graptolitic shales and radiolarian cherts that grade upward into Silurian (middle Wenlock and lower to middle Ludlow) limestone turbidites and debris flows (Till et al., 1986; Ryherd and Paris, 1987; Ryherd et al., 1995). Off-platform deposits that are lithologically similar to and generally coeval with those on the Kotzebue coast are also found on the southeastern Seward Peninsula (Fig. 2, location 13; Till et al., 1986) and in the central Brooks Range (Ambler River Quadrangle; Fig. 2, location 14; Dumoulin and Harris, 1988); these rocks are largely carbonate turbidites and lesser graptolite- and radiolarian-bearing phyllites of Silurian age. The paleogeographic significance of these deep-water carbonate strata is uncertain. Broad lithologic and faunal correlations suggest that they were derived from the North Alaska carbonate platform; they may be intraplatform deposits like those of Middle Ordovician age described here, or (less likely) remnants of continental slope and rise deposits that accumulated along the carbonate platform margin.

Paleobiogeography

Both Siberian and North American affinities have been reported for various fossils from the lower Paleozoic carbonate platform successions in northern Alaska (Dumoulin and Harris, 1994, and references therein). In this paper we use "Laurentian" in place of "North American" to more faithfully represent Paleozoic paleogeography. Specifically, Laurentia includes the originally contiguous cratonic cores of North America and Greenland and excludes terranes accreted to these cratons in Phanerozoic time. The paleobiogeographic data we present here are derived primarily from conodonts, supplemented where possible by information from other fossil groups. Conodonts have numerous advantages for such studies, including abundance and preservation in a wide variety of lithofacies and diagenetic and metamorphic regimes. In addition, conodonts are the principal micropaleontologic index fossils in marine rocks of Late Cambrian through Triassic age. In this chapter we rely heavily on Ordovician conodonts for paleobiogeographic comparisons between Alaska and northeast Russia because conodont provinciality worldwide is strongest during this period (Bergström, 1990b). Cambrian conodonts are comparatively rare and Silurian and Devonian conodonts are relatively cosmopolitan. Our conodont database for Ordovician rocks in northern Alaska and the Farewell terrane of central Alaska consists of 284 samples (Table 1) that have yielded ~20 000 specimens. Megafossils of various types also provide useful paleobiogeographic data (e.g., Blodgett et al., this volume), but the use of these data is complicated for several reasons. Paleobiogeographic realms defined by one fossil group may differ from those outlined by another group during the same time period, and realms defined by the same fossil group may shift through time.

In the following analysis we distinguish conodonts representative of two realms and two provinces; in addition, some other conodonts have mixed provincial affinities (Table 1). The cosmopolitan realm includes conodont genera in which most species have worldwide distribution (includes the relatively high latitude conodont faunal realm of Sweet and Bergström, 1986). Taxa of this realm are generally abundant in most depositional settings in relatively high paleolatitudes, but in low paleolatitudes they are found chiefly in basin and continental margin deposits. The tropical cosmopolitan realm includes genera in which most species have worldwide distribution in the tropics or are known from at least three large, distinct tropical cratons and their margins (see Scotese, 1997, for Ordovician paleogeographic reconstructions). Some tropical cosmopolitan species, however, may occur as rare components in cosmopolitan faunas (e.g., rare specimens of *Rossodus manitouensis,* an Early Ordovician tropical cosmopolite, were reported by Löfgren et al., 1998, from a relatively high paleolatitude cosmopolitan assemblage in Scandinavia).

Conodont provinces are more limited in geographic extent than realms. The Laurentian province includes conodont genera in which some or most species are restricted to or are most common in the tropical shallow-water, cratonic, platform, and shelf deposits of Laurentia and peri-Laurentia (the North American midcontinent conodont province or faunal succession of Ethington and Clark, 1971; Sweet et al., 1971; Sweet, 1984, among others). Laurentia encompassed much of present-day North America and Greenland, but Ordovician conodont faunas with Laurentian affinities may occur in other tropical areas that were near, or were part of, the Ordovician Laurentian plate (e.g., Bergström, 1990a; Lehnert, 1995). From time to time, plate movements and/or changes in oceanic circulation allowed some Laurentian taxa to invade higher-paleolatitude shelf or platform areas. The Siberian province includes conodont genera in which some or most species are restricted to, or most common in, the tropical, shallow-water cratonic, platform, and shelf deposits of Siberia and peri-Siberia (e.g., Abaimova, 1975; Moskalenko, 1970, 1973, 1983). Ordovician conodont faunas with Siberian affinities may also occur in other tropical areas that were near the Ordovician Siberian plate (Dumoulin and Harris, 1994).

We recognize in addition some conodonts of mixed provincial affinity. Species that are limited to Siberia and northern and/or central Alaska are designated Siberian-Alaskan forms; these forms have not been recognized in areas established as parts of Laurentia. Similarly, species found in Ordovician Laurentia, western and central Alaska, Siberia, and peri-Siberia but unknown elsewhere are designated Laurentian-Siberian forms. In all our collections, we have recognized only two conodont species representative of the low-latitude, relatively shallow water North Chinese province (Wang et al., 1996). *Tangshanodus tangshanensis* An and *Tasmanognathus sishuiensis* Zhang both occur in our northeast Russian collections, and *T. tangshanensis* was also found in a collection from the western Brooks Range (Tables 1 and 2).

In northern Alaska, fossils with Siberian affinities occur in the same successions and commonly at the same stratigraphic levels as forms with Laurentian provinciality. Conodonts illustrate this pattern of mixed affinities particularly well. Tropical cosmopolitan and cosmopolitan forms dominate most Ordovician conodont collections from northern Alaska (Table 1), but four Ordovician time intervals are characterized by an important component of Siberian-Alaskan conodonts. These intervals—early Arenig, late Arenig–early Llanvirn, latest Llanvirn-early Caradoc, and middle (?) Ashgill—coincide approximately with global sea-level highstands (Ross and Ross, 1988). Siberian-Alaskan conodonts (Table 2) include *Fryxellodontus?* n. sp. (Dumoulin and Harris, 1994, Fig. 24, no. 99; = *Acodina? bifida* of Abaimova, 1975) in early Arenig time, acanthodinids and acanthocordylodids in late Arenig–early Caradoc time, *Stereoconus corrugatus* Moskalenko and *Plectodina?* cf. *P.? dolboricus* (Moskalenko) in early Caradoc time, and *Belodina? repens* Moskalenko in middle (?) Ashgill time. Our lower Paleozoic conodont database for northern Alaska encompasses several hundred collections from more than 100 localities. Siberian elements occur in several tens of collections, and are strikingly abundant in a few. However, typical Laurentian conodonts—such as species of *Clavohamulus* in the early Arenig—occur along with the Siberian forms and are locally abundant. In our Ordovician collections, Laurentian province species outnumber Siberian-Alaskan species throughout northern Alaska (Table 1).

Northern Alaskan megafossils also have mixed affinities. Fossils with Siberian affinities include Middle Cambrian trilobites from the central Brooks Range (both from the carbonate platform rocks and from the siliciclastic-volcanic sequence at Mount Doonerak), Early and Late Ordovician trilobites from the Seward Peninsula, and Late Ordovician brachiopods and gastropods from the Seward Peninsula and the western and eastern Brooks Range (Dumoulin and Harris, 1994, and references therein; Ormiston and Ross, 1976; Blodgett et al., 1992, and this volume). Laurentian forms include Early and Late Cambrian trilobites from the eastern Brooks Range, and Late Ordovician corals, stromatoporoids, and brachiopods from the Seward

TABLE 1. FAUNAL AFFINITIES AND DISTRIBUTION OF LATEST CAMBRIAN AND ORDOVICIAN CONODONT TAXA IN NORTHEASTERN RUSSIA AND THE FAREWELL TERRANE, SEWARD PENINSULA, AND BROOKS RANGE, ALASKA

Taxon	Northeastern Russia	Farewell terrane, central Alaska	Seward Peninsula	Western Brooks Range	Central and eastern Brooks Range
Acanthodina sp. indet.	SA	SA			
Acanthocordylodus sp. indet.	SA	SA	SA	SA	
“Acanthodus” lineatus (Furnish)	TC	TC	TC	TC	
“Acanthodus” uncinatus Furnish		TC			
Acodus deltatus Lindström			C	C	
Acodus cf. *A. deltatus* Lindström				C	
Aloxoconus iowensis (Furnish)		L		L	
Amorphognathus sp. indet.	C	C	C	C	
Ansella nevadensis (Ethington & Clark)		L?			
Ansella sp.		C		C	
Aphelognathus divergens Sweet				L	L
Baltoniodus aff. *B. variabilis* Bergström				C	
Belodinids				TC	TC
Belodina compressa (Branson & Mehl)		TC		TC	
Belodina monitorensis Ethington & Schumacher?		L		L	
Belodina? repens Moskalenko	SA	SA	SA		
Bergstroemognathus extensus Serpagli	TC				
Cahabagnathus sweeti (Bergström)		C			
Chosonodina rigbyi Ethington & Clark				L	
Clavohamulus densus Furnish					L
Clavohamulus n. sp. of Dumoulin & Harris, 1987			L	L	
Clavohamulus n. sp. cf. *C.* n. sp. A of Repetski, 1982	LS				
Colaptoconus quadraplicatus (Branson & Mehl)	TC		TC	TC	
Coleodus sp.	TC				
Complexodus sp. indet.	C				
Cordylodus angulatus Pander	C			C	
Cordylodus intermedius Furnish	C	C			C
Cordylodus proavus Müller	C	C			C
Cordylodus sp.	C	C			
Cornuodus longibasis (Lindström)		C			
Cornuodus? sp.	C	C			
Culumbodina occidentalis Sweet		L	L		L
Diaphorodus sp.			LS		
Drepanodus arcuatus Pander			C	C	C
Drepanodus concavus (Branson & Mehl)		TC		TC	
Drepanodus sp.	C	C			
Drepanoistodus basiovalis (Sergeeva)		C		C	
Drepanoistodus forceps Lindström			C	C	
Drepanoistodus pervetus Nowlan		L?	L?	L?	
Drepanoistodus suberectus (Branson & Mehl)		C	C	C	
Drepanoistodus spp.	C	C	C		
Eoplacognathus elongatus Bergström transitional to *Polyplacognathus* sp.					C
Erraticodon balticus Dzik		C	C		C
Erraticodon patu Cooper		C?			
Erraticodon sp. indet.	C				
Eucharodus parallelus (Branson & Mehl)		TC	TC	TC	
Eucharodus toomeyi Ethington & Clark				L	
Evencodus sibericus Moskalenko		SA			
Fahraeusodus marathonensis (Bradshaw)	TC		TC	TC	
Fryxellodontus? n. sp. (= *Acodina? bifida* Abaimova)		SA	SA	SA	
Gapparodus bisulcata Müller				C	
Hirsutodontus hirsutus Miller	TC	TC			
Histiodella donnae Repetski		TC		TC	
Histiodella holodentata Ethington & Clark	C				
Histiodella n. sp. 2 of Harris et al., 1979	LS			LS	
Histiodella n. sp. (Early Ordovician)			L	L	
Iapetognathus sprakersi Landing	C				
Juanognathus jaanussoni Serpagli	C				
Juanognathus variabilis Serpagli	TC			TC	TC

TABLE 1. (continued)

Taxon	Northeastern Russia	Farewell terrane, central Alaska	Seward Peninsula	Western Brooks Range	Central and eastern Brooks Range
Juanognathus? sp. indet.	TC				
Jumudontus gananda Cooper	C			C	
Loxodus? spp.		LS			
Macerodus n. sp.				TC	
Oepikodus communis (Ethington & Clark)	TC		TC		TC
Oepikodus evae (Lindström)	C				
Oistodus bransoni Ethington & Clark		L			
Oistodus lanceolatus Pander			C		
Oistodus? lecheguillensis Repetski				L	
"Oistodus" mehli Furnish s.f.				L	
Oistodus multicorrugatus Harris	LS	LS			
Oistodus cf. *O multicorrugatus* Harris	TC	TC			
Oneotodus costatus Ethington & Brand				L	
"*Oneotodus*" *gracilis* (Furnish)		TC			
Oneotodus simplex (Furnish) as used by Ethington & Brand, 1981		L			
"*Oneotodus*" *variabilis* Lindström		C	C	C	
Ozarkodina hassi (Pollock, Rexroad, & Nicoll)		C			
Ozarkodina sesquipedalis Nowlan & McCracken		L			
"*Paltodus*" *acuminatus* (Pander)				C	
Paltodus cf. *P. deltifer* (Lindström)				C	
Paltodus inaequalis (Pander)				C	
Paltodus spurius Ethington & Clark				L	
Paltodus subequalis Pander			C	C	
Panderodus gracilis (Branson & Mehl)	C	C	C	C	
Panderodus sp.	C	C	C	C	C
Paracordylodus gracilis Lindström			C	C	
Parapanderodus? consimilis (Moskalenko)	LS			LS	
Parapanderodus paracornuformis (Ethington & Clark)		TC			
Parapanderodus striatus (Graves & Ellison)			C	C	C
Paraprioniodus costatus (Mound)?				L	
Paraserratognathus abruptus (Repetski)		TC	TC		
Paroistodus? horridus (Barnes & Poplawski)				C	
Paroistodus? mutatus (Rhodes)	C	C	C	C	C
Paroistodus cf. *P. neumarcuatus* Lindström		C		C	
Paroistodus originalis (Lindström)		C			
Paroistodus parallelus (Pander)			C	C	
Paroistodus proteus (Lindström)		C	C	C	
Paroistodus sp. indet.	C		C	C	
Periodon aculeatus Hadding	C	C	C	C	C
Periodon flabellum (Lindström)	C		C		C
Periodon sp. indet.	C	C	C		
Phakelodus tenuis (Müller)				C	C
Phragmodus flexuosus Moskalenko	TC			TC	
Phragmodus n. sp. of Barnes, 1974					L*
Plectodina? cf. *P.? dolboricus* (Moskalenko)				SA	SA†
Plectodina? tunguskaensis (Moskalenko)		TC	TC	TC	TC
Polonodus tablepointensis Stouge	C				
Polonodus sp. indet.	C			C	
Polycostatus aff. *Po. minutus* Ji & Barnes		L			
Prattognathus rutriformis (Sweet & Bergström)					L
Prioniodus elegans Pander				C	
Prioniodus sp. indet.	C				
Proconodontus muelleri Miller				C	
Protopanderodus graeai (Hamar)					C
Protopanderodus insculptus (Branson and Mehl)	TC	TC		TC	
Protopanderodus leei Repetski		TC	TC	TC	
Protopanderodus liripipus Kennedy, Barnes, & Uyeno	C			C	C
Protopanderodus elongatus Serpagli		C	C	C	

TABLE 1. (continued)

Taxon	Northeastern Russia	Farewell terrane, central Alaska	Seward Peninsula	Western Brooks Range	Central and eastern Brooks Range
Protopanderodus gradatus Serpagli				C	
Protopanderodus rectus (Lindström)	C		C	C	
Protopanderodus robustus (Hadding)	C			C	
Protopanderodus varicostatus (Sweet and Bergström)					C
Protopanderodus cf. *P. varicostatus* (Sweet and Bergström)	C	C		C	
Protopanderodus sp. indet.	C	C	C	C	C
Protoprioniodus aranda Cooper	TC	TC	TC		
Pseudobelodina adentata Sweet			L		
Pseudobelodina dispansa (Glenister)			TC	TC	
Pseudooneotodus mitratus (Moskalenko)	C	C			
Pygodus anserinus Lamont & Lindström		C		C	C
Pygodus serra (Hadding)					C
Rossodus manitouensis Repetski and Ethington	TC	TC			TC
Rossodus n. sp.			L	L	
Scalpellodus sp.		C	C	C	
Scandodus brevibasis (Sergeeva) s.f.				C	
Scandodus sinuosus Mound				L	
Scolopodus bolites Repetski			TC	TC	
Scolopodus *cornutiformis* Branson & Mehl s.f.				L	
"Scolopodus" filosus Ethington & Clark		TC	TC	TC	
Scolopodus floweri Repetski	TC	TC	TC	TC	
Scolopodus kelpi Repetski	LS		LS		
Scolopodus rex Lindström		C	C	C	
Scolopodus sulcatus Furnish		TC	TC	TC	
Semiacontiodus nogamii (Miller)	TC				
Spinodus spinatus (Hadding)	C	C		C	C
Strachanognathus parvus Rhodes		C			
Staufferella aff. *S. brevispinata* Nowlan & Barnes			L		
Stereoconus corrugatus Moskalenko		SA	SA	SA	
Striatodontus prolificus Ji & Barnes			TC	TC	
Tangshanodus tangshanensis An	NC-SA			NC-SA	
Tasmanognathus sishuiensis Zhang	NC-S				
Teridontus nakamurai (Nogami)	C	C			C
Triangulodus cf. *T. brevibasis* (Sergeeva)				C	
Tripodus laevis Bradshaw	TC			TC	TC
Tripodus sp.	C				
Tropodus comptus (Branson & Mehl)			TC		
Tropodus sp.			TC	TC	
Ulrichodina deflexa Furnish				L	
Ulrichodina n. sp. 1 of Repetski, 1982		L		L	
Utahconus longipinnatus Ji & Barnes		TC			
Variabiloconus bassleri (Furnish)	TC	TC	TC	TC	TC
Walliserodus australis			TC	TC	
Walliserodus ethingtoni (Fåhraeus)	C		C	C	
Walliserodus sp.	C			C	

Note: Conodont taxa in this list are from collections distributed as follows: northeastern Russia, 88; Farewell terrane, 80; Seward Peninsula, 50; western Brooks Range, 132; and central and eastern Brooks Range, 22. Abbreviations of conodont faunal affinities: C, cosmopolitan realm; TC, tropical cosmopolitan realm; L, Laurentian province (species occur in Laurentia and peri-Laurentia); LS, Laurentian-Siberian (species occur in Laurentia, peri-Laurentia, Siberia, and peri-Siberia); SA, Siberian-Alaskan (species restricted to Siberia, peri-Siberia, and Alaska); NC-S, North Chinese–Siberian (species restricted to North China, Siberia, and peri-Siberia); NC-SA, North Chinese–Siberian–Alaskan (species known from North China, Siberia, peri-Siberia, and Alaska). L?, taxon known from province but may be more widespread paleogeographically.

*Dumoulin and Harris (1994) considered phragmodid elements assigned by Moskalenko (1983, fig. 4W, X) to *P. undatus* Branson and Mehl, likely equivalent to *Phragmodus* n. sp. of Barnes, 1974. Consequently, they characterized the faunal affinities of this species as Siberian–northern North American (Laurentian-Siberian as used herein). Because Moskalenko (1983) did not figure the complete appartus of the species, we are uncertain if her specimens are the same as *P.* n. sp. of Barnes, 1974. Thus, we herein consider the faunal affinities of the Barnes (1974) and Dumoulin and Harris (1994, pl. 2, figs. 20–24) *Phragmodus* as Laurentian.

†Species not found east of the central Brooks Range.

TABLE 2. DISTRIBUTION OF LATEST CAMBRIAN AND ORDOVICIAN CONODONT TAXA OF MIXED FAUNAL AFFINITIES IN NORTHEASTERN RUSSIAN AND THE FAREWELL TERRANE, SEWARD PENINSULA, AND BROOKS RANGE, ALASKA

Taxon	Northeastern Russia	Farewell terrane, central Alaska	Seward Peninsula	Western Brooks Range	Central and eastern Brooks Range
Acanthodina sp. indet.	SA	SA			
Acanthocordylodus sp. indet.	SA	SA	SA	SA	
Belodina? repens Moskalenko	SA	SA	SA		
Clavohamulus n. sp. cf. *C.* n. sp. A of Repetski, 1982	LS				
Diaphorodus sp.			LS		
Evencodus sibericus Moskalenko		SA			
Fryxellodontus? n. sp. (= *Acodina? bifida* Abaimova)		SA	SA	SA	
Histiodella n. sp. 2 of Harris et al., 1979	LS			LS	
Loxodus? spp.		LS			
Oistodus multicorrugatus Harris	LS	LS			
Parapanderodus? consimilis (Moskalenko)	LS			LS	
Plectodina? cf. *P.? dolboricus* (Moskalenko)				SA	SA (central Brooks Range only)
Scolopodus kelpi Repetski	LS		LS		
Stereoconus corrugatus Moskalenko		SA	SA	SA	
Tangshanodus tangshanensis An	NC-SA			NC-SA	
Tasmanognathus sishuiensis Zhang	NC-S				

Note: Thus far, latest Cambrian and Ordovician conodonts with Siberian affinities have not been found in the eastern Brooks Range. Abbreviations of conodont faunal affinities: LS, Laurentian-Siberian (species occur in Laurentia, peri-Laurentia, Siberia, and peri-Siberia); SA, Siberian-Alaskan (species restricted to Siberia, peri-Siberia, and Alaska); NC-S, North Chinese–Siberian (species restricted to North China, Siberia, and peri-Siberia); and NC-SA, North Chinese–Siberian–Alaskan (species known from North China, Siberia, peri-Siberia, and Alaska).

Peninsula and the central Brooks Range (Dumoulin and Harris, 1994, and references therein; Potter, 1984). Carbonate strata in thrust sheets of the De Long Mountains subterrane contain Middle Devonian brachiopods with Siberian affinities (Baxter and Blodgett, 1994) as well as Devonian (Pragian?) corals known elsewhere only from peri-cratonal North America (Road River Formation, Yukon Territory, Canada; W.A. Oliver, 1993, written commun.). Mississippian plants found in chert and sandstone of the De Long Mountains subterrane (Kelly River and Picnic Creek allochthons) have "uniquely Angaran" (Siberian) affinities (Spicer and Thomas, 1987, p. 355).

Deep-water faunas from both siliciclastic and carbonate facies in northern Alaska are mainly cosmopolitan and only rarely provide specific biogeographic information. For example, conodonts from Lower and Middle Ordovician basinal strata in the Brooks Range and the Seward Peninsula are chiefly cosmopolitan deep- and/or cool-water species of the protopanderodid-periodontid biofacies (Dumoulin and Harris, 1994). However, shallower-water Siberian-Alaskan and Laurentian elements such as *Plectodina?* cf. *P.? dolboricus* and *Prattognathus rutriformis* occur as rare postmortem hydraulic additions in this biofacies in the central and western Brooks Range.

Siberian faunal components appear to decrease in number from present-day west to east across northern Alaska. Siberian elements are most abundant and diverse in lower Paleozoic collections from the western Seward Peninsula and western Brooks Range (Table 2), but even these collections contain some Laurentian province forms. Our Ordovician conodont collections show that the ratio of Laurentian province to Siberian-Alaskan species increases across northern Alaska (Table 1), from 1.75 on Seward Peninsula to 4.5 in the western Brooks Range to 5 in the central and eastern Brooks Range. Certain Siberian faunal elements (such as the pentamerid brachiopod *Tcherskidium*) occur throughout northern Alaska and are found as far north and east as the Shublik Mountains (Fig. 2; Blodgett et al., 1992, and this volume; Blodgett, 1998). At least part of the apparent eastward decline in Siberian forms reflects changes in depositional environment. Shallow-water facies of Early and Middle Ordovician age contain notable numbers of Siberian taxa (particularly conodonts), but these facies are rare or absent in the central Brooks Range, where Ordovician basinal strata are best developed. Basinal strata, as noted here, contain largely cosmopolitan forms, and the central Brooks Range intraplatform basin may have blocked the dispersal of Siberian taxa into shallow-water environments of the northeastern Brooks Range.

In summary, both Siberian and Laurentian faunal elements occur at various times and in various fossil groups across northern Alaska. Siberian influences are noted from at least Middle Cambrian through Mississippian time. This pattern of mixed faunal influences is strikingly similar to that seen in the Nixon Fork subterrane in central Alaska (Dumoulin et al., 1998b), which is further discussed in the following.

CENTRAL ALASKA

Unmetamorphosed lower Paleozoic rocks that formed in both shallow- and deep-water environments are widely distributed across central Alaska, and a complex and contentious nomenclature designates these strata. Chiefly shallow-water facies of Late Proterozoic through Devonian age in the Medfra Quadrangle and adjacent areas have been considered part of the Nixon Fork terrane (Patton et al., 1994; Silberling et al., 1994). Coeval deep-water strata in this area have been called the Minchumina terrane to the north and the Dillinger terrane to the south. Shallow- and deep-water facies in both terranes are overlain by heterogeneous, Devonian through Cretaceous lithologies of the Mystic terrane. Decker et al. (1994) established the Farewell terrane, which they interpreted as a coherent, but locally highly deformed, continental margin sequence, to include all of these units. This interpretation has been widely accepted, but which continent the sequence formed along remains the subject of much debate. Some have suggested that the Farewell terrane is a displaced fragment of the North American continental margin (Decker et al., 1994), whereas others believe that it rifted away from the Siberian craton (Blodgett, 1998).

In this chapter we follow the usage of Bundtzen et al. (1997) and Blodgett (1998). We use "Nixon Fork subterrane" for Ordovician through Devonian rocks in the Nixon Fork terrane of Patton et al. (1994), as well as broadly coeval shallow-water strata (Holitna Group) exposed to the south, employ "Dillinger subterrane" for the lower Paleozoic deep-water facies that crop out to the east and southeast of the Nixon Fork rocks, and use "Mystic subterrane" for the Devonian through Cretaceous strata that overlie both older subterranes (Fig. 4). We agree with Decker et al. (1994) that these three subterranes are depositionally related, but retain the subterrane terminology herein because there is no workable stratigraphic nomenclature that encompasses all the rocks under discussion. New and previously published lithologic and faunal data that bear on the origin of the Farewell terrane are summarized in the following.

Lithofacies

Shallow-water rocks of the Nixon Fork subterrane have many similarities with coeval strata in northern Alaska. Lithologic details presented here are from Dutro and Patton (1982), Dumoulin et al. (1999, 2000b), Decker et al. (1994), Measures et al. (1992), and our own observations (Fig. 3, column 7). Rocks considered basement to Farewell terrane Paleozoic strata (Patton et al., 1980, 1994) are exposed in the northeastern Medfra Quadrangle and consist of amphibolite to greenschist facies metasedimentary and metavolcanic rocks. Rhyolitic metatuff and granitic orthogneiss yielded U-Pb zircon ages of 979 +8/–3 Ma and 850 ± 1 Ma, respectively (McClelland et al., 1999). The next-youngest parts of the terrane are exposed in the McGrath and Sleetmute Quadrangles to the south. These rocks are oolitic dolostones and redbeds of probable Late Proterozoic age overlain by mudstones with rare limestone interbeds that contain a rich Middle Cambrian trilobite fauna (Babcock et al., 1993, 1994; St. John and Babcock, 1997).

The Ordovician through Devonian section in the Nixon Fork subterrane is best exposed in the Medfra Quadrangle. Some 5400 m of strata represent a shallow-water platform carbonate succession interrupted by intervals of deeper-water sedimentation in the Silurian and Devonian (Fig. 3) (Dutro and Patton, 1982; Dumoulin et al., 1999, 2000b). Lower Lower Ordovician rocks (Novi Mountain Formation; 900 m thick) weather orange and contain locally abundant argillaceous material, quartz and feldspar silt, ooids, intraclasts, and peloids. Decameter-scale cycles shallow upward from open-marine shales to ooid or intraclast grainstones deposited in nearshore shoals. Upper Lower, Middle, and Upper Ordovician strata (Telsitna Formation; 2000 m thick) are largely micrite and peloidal packstone deposited in middle to inner shelf settings with locally restricted circulation.

Nixon Fork subterrane sections south of the Medfra area contain some similar shallow-water rocks of Early, Middle, and Late Ordovician age, but these facies are intercalated with deeper-water mudstones and limestones (Decker et al., 1994); the percentage of deep-water strata increases to the south. In the Medfra area, deep-water facies first interfingered with shallow-water sediments during the Late Ordovician. Calcareous turbidites, calcitized radiolarite, and lesser shale occur locally in the upper part of the Telsitna Formation and make up all of the succeeding Paradise Fork Formation. The Paradise Fork is ~1000 m thick (Dutro and Patton, 1982) and largely of late Early Silurian (Wenlock) age; the upper part of the unit interfingers with Upper Silurian shallow-water facies. Uppermost beds in the Paradise Fork are extremely condensed and at least as young as Early Devonian (Dumoulin et al., 1999).

Upper Silurian and Devonian shallow-water facies in the Medfra Quadrangle comprise 1000–1500 m of limestone and dolostone (Whirlwind Creek Formation) deposited in a range of subtidal settings with locally restricted circulation. The unit is characterized by decameter-scale cycles of algal laminite that grade up into peloidal and then fossiliferous limestone; notable fossils are ostracodes, gastropods, brachiopods, stromatoporoids, and corals (Dutro and Patton, 1982). Coeval strata to the south include a distinctive algal-sponge mound complex as thick as 500 m that formed a barrier reef along the outer platform margin (Clough and Blodgett, 1985, 1989).

The Dillinger subterrane and related rocks (Minchumina terrane of Patton et al., 1994), exposed southeast of the Nixon Fork subterrane, consist of as much as 1500 m of deep-water strata deposited from Late Cambrian through Early Devonian time (Churkin and Carter, 1996). Hemipelagic shale and fine-grained limestone turbidites predominate in these sections, but coarser-grained turbidites of mixed composition (e.g., the Terra Cotta Mountains Sandstone of late Early–Late Silurian age) occur locally. These coarser turbidites consist chiefly of quartz, feldspar, and calcareous clasts and include notable mica and volcanic lithic clasts. Discrete ash layers are intercalated with the

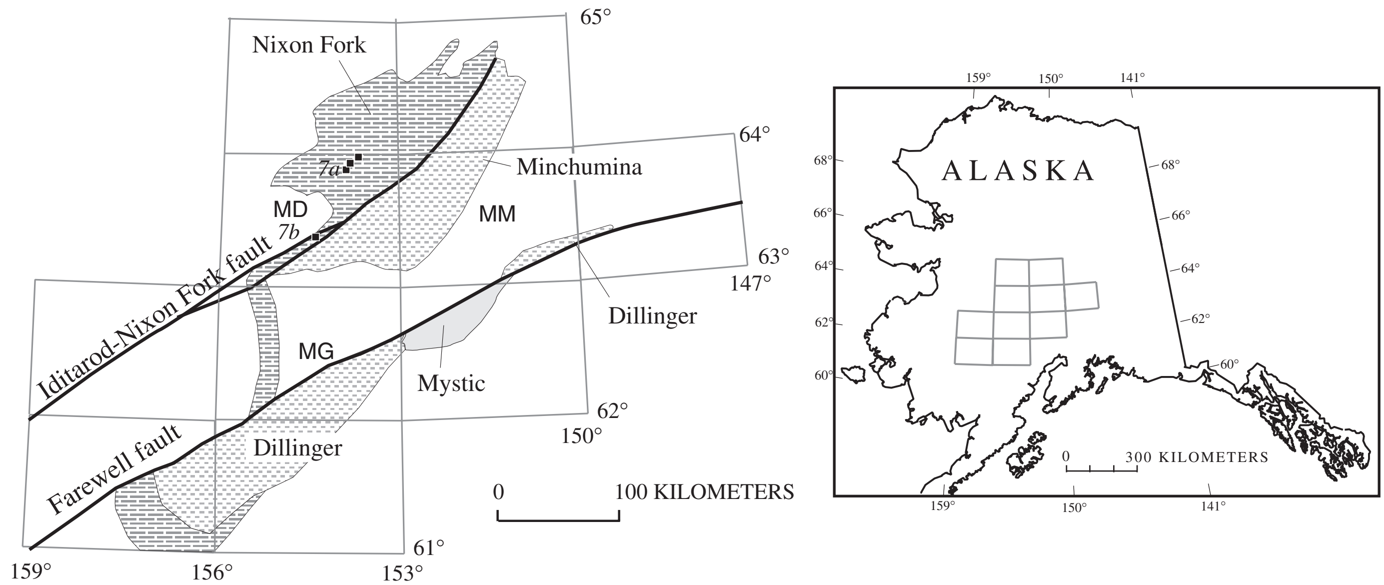


Figure 4. Location of Dillinger, Minchumina, Mystic, and Nixon Fork tectonostratigraphic subterranes in central Alaska. All subterranes shown were included in Farewell terrane of Decker et al. (1994). Dillinger and Nixon Fork south of 63° are modified from Decker et al. (1994) and Silberling et al. (1994); Nixon Fork north of 63° and Minchumina are from Patton et al. (1994); Dillinger north of 63° and Mystic are from Wilson et al. (1998). Selected quadrangles: MD, Medfra; MG, McGrath; MM, Mount McKinley. 7a and 7b are locations of stratigraphic sections shown as column 7 in Figure 3.

Silurian turbidites in both the McGrath and Mount McKinley Quadrangles (Dumoulin et al., 1998a).

Paleobiogeography

Fossil assemblages from the Farewell terrane, like those from northern Alaska, have affinities with both the Siberian and Laurentian paleobiogeographic provinces; ties to faunas from the Urals, Baltica, and terranes of northeastern Russia are also indicated. Early Ordovician conodont collections from the Novi Mountain Formation contain chiefly tropical cosmopolitan forms with lesser Laurentian elements; some Siberian-Alaskan and Laurentian-Siberian components occur in coeval, slightly shallower water strata from the southern part of the Nixon Fork subterrane. Conodont species associations from the Telsitna Formation are also dominated by cosmopolitan forms, but include lesser, roughly equal numbers of tropical cosmopolitan, Laurentian province, and Siberian-Alaskan elements. Siberian-Alaskan elements are most abundant in late Early–Middle Ordovician Telsitna Formation faunas and in Late Ordovician collections from unnamed carbonate rocks at Lone Mountain in the McGrath Quadrangle. Ordovician conodonts from the Farewell terrane have a ratio of Laurentian province to Siberian-Alaskan species of 1.66 (Table 1), which is comparable to, but slightly lower than, the lowest ratio found in northern Alaska (1.75, Seward Peninsula).

Mixed biogeographic affinities are also indicated by a variety of Farewell terrane megafossils. Middle Cambrian trilobites from the southern part of the Nixon Fork subterrane are most like coeval faunas of the East Siberian platform (Palmer et al., 1985; St. John and Babcock, 1997; Kingsbury and Babcock, 1998), and the Mystic subterrane contains Early Permian plants that belong to the Angaran floral province of Siberia (Mamay and Reed, 1984). Other fossils with Siberian or Old World (non-Laurentian) affinities include Middle–Late Ordovician stromatoporoids, gastropods, and brachiopods and late Early Devonian (Emsian) brachiopods, ostracodes, and rugose corals (Dutro and Patton, 1982; Rohr and Gubanov, 1997; Blodgett, 1998; Blodgett et al., this volume; C.W. Stock, 1998, written commun.). Northern Laurentian faunal ties are suggested for other Farewell biota, however, including Middle–Late Ordovician brachiopods (Potter, 1984; Rohr et al., 1992) and early Middle Devonian (Eifelian) trilobites and corals (Blodgett, 1983). Distinctive aphrosalpingid sponges like those in the Silurian reef complexes of the southern Nixon Fork subterrane are known elsewhere only from the Alexander terrane in southeastern Alaska (Fig. 1) and the Ural Mountains (Rigby et al., 1994; Soja, 1994; Soja and Antoshkina, 1997).

COMPARISON OF LITHOFACIES AND PALEOBIOGEOGRAPHY BETWEEN NORTHERN AND CENTRAL ALASKA

Late Proterozoic through Middle Devonian lithofacies and biogeography of the North Alaska carbonate platform correlate remarkably well with those of the Farewell terrane in central Alaska. Sedimentary successions in both areas appear to be built on metamorphosed basement of Late (and locally older?) Proterozoic age, and are characterized by Late Proterozoic ooid-rich dolostones; Middle Cambrian outer shelf deposits; and Ordovician, Silurian, and Devonian shallow-water platform facies. Specific lithologic similarities are numerous and include Lower Ordovician impure limestones rich in detrital material, ooids, and intraclasts; Middle and Upper Ordovician peloidal micrites formed in inner shelf or platform settings with locally restricted circulation; and decameter-scale shallowing-upward cycles in Ordovician, Silurian, and Devonian strata. Deeper-water facies of Middle Ordovician age like those in northern Alaska do not occur in the Medfra Quadrangle but are exposed to the south in the White Mountain area of the McGrath Quadrangle, where they overlie and underlie shallow-water platform strata (Decker et al., 1994). The Silurian deep-water incursion so prominent in the Nixon Fork subterrane has not been seen in platform carbonate rocks of northern Alaska, but isolated sections of Silurian carbonate turbidites crop out adjacent to the platform on Seward Peninsula and in the central Brooks Range.

Biotic similarities between northern and central Alaska are also striking. Ordovician conodont faunas with both Siberian and Laurentian elements are a distinctive feature of both the North Alaska carbonate platform and the Farewell terrane, and Siberian-Alaskan conodonts occur during the same time intervals in both areas and include many of the same species. Middle Cambrian trilobites of Siberian aspect are found in both successions and may include some conspecific forms (Palmer et al., 1985). Ordovician megafossils in the two areas also correlate well (Dutro and Patton, 1981); identical species of gastropod and pentamerid brachiopod (*Tcherskidium*) occur at Lone Mountain (southern Nixon Fork subterrane) and in the York and Shublik Mountains (Blodgett et al., 1992, and this volume; Blodgett, 1998). Middle Ordovician graptolite faunas in the Dillinger subterrane correspond well with those in the Baird Mountains and share strong ties with coeval faunas in Australia and New Zealand (Churkin and Carter, 1996; Carter and Tailleur, 1984). Faunal matches between northern and central Alaska continue into the later Paleozoic: conspecific Eifelian brachiopods are found at White Mountain and in the western Brooks Range (Baxter and Blodgett, 1994), and Angaran (Siberian) plant assemblages occur in upper Paleozoic strata of both regions (Mamay and Reed, 1984; Spicer and Thomas, 1987).

NORTHEASTERN RUSSIA

The Siberian craton, also called the Angara craton (Şengör and Natal'in, 1996) and the North Asia craton (Nokleberg et al., 1994, 1998), is flanked to the north and east by numerous terranes that have been variously defined and named by different authors (Fig. 1). In this chapter, we use the terminology of Nokleberg et al. (1994, 1998) unless otherwise stated. Lower Paleozoic carbonate platform sequences occur both on the Siberian craton and on several of the terranes that surround it. The occurrence of Siberian faunal elements in lower Paleozoic strata of northern and central Alaska has led some to propose that these successions are displaced fragments of the Siberian craton (Grantz et al., 1991; Moore et al., 1994; Blodgett, 1998). To test this idea, we compare lithostratigraphy and faunal assemblages of the Siberian craton and various terranes north and east of this craton to those of northern and central Alaska (Fig. 3).

Discussion herein of Russian lithostratigraphy is based largely on relatively detailed Ordovician through Devonian stratigraphic columns compiled by Valentyn Bondarev and colleagues at VNIIOkeangeologiya, Saint Petersburg, in 1992. The columns were prepared as part of the Paleozoic Circumpolar Correlation Project led by Godfrey Nolan, Geological Survey of Canada, and represent several dozen localities across Russia north of lat 65°N. Kanygin et al. (1988) and Oradovskaya (1988) provided excellent summaries (in English) of Ordovician strata of the Siberian platform and northeastern Russia, respectively. Supplementary lithostratigraphic data come from Oradovskaya and Obut (1977), Kos'ko et al. (1990), Nokleberg et al. (1994, 1998), Şengör and Natal'in (1996), and Natal'in et al. (1999). Faunal data include a suite (87 collections) of Ordovician conodonts collected by Gagiev from various parts of the Kolyma-Omolon superterrane and analyzed by Harris and Repetski (see GSA Data Repository, Appendix 1[1]). A single Ordovician conodont collection from the Chukchi Peninsula, collected by Jaime Toro and coworkers, was also examined by Harris. Conodont data from the Ordovician of the Siberian craton were presented by Moskalenko (1970, 1973, 1983) and Abaimova (1975), among others.

Siberian craton

Paleozoic rocks of the Siberian craton overlie unmetamorphosed Middle and Late Proterozoic siliciclastic, carbonate, and volcanic rocks, which in turn overlie an Archean basement of gneiss and schist; two episodes of Proterozoic rifting are documented (Nokleberg et al., 1994). The Bondarev database contains stratigraphic columns for 6 Ordovician, 7 Silurian, and 15 Devonian sections distributed across northern Siberia; a representative composite section for all three systems from the Mojero River area in central Siberia (~lat 67°N, long 105°E) is shown in Figure 3 (column 8). Ordovician strata range from 300 to 1000 m in thickness, formed in shallow-water settings, and are mainly limestone and dolostone with significant siliciclastic interbeds. Gypsum and anhydrite occur locally, particularly in upper Lower Ordovician sections (Kanygin et al., 1988). Shallow-water carbonate rocks predominate in the Silurian (220–750 m thick), but slightly deeper water (outer shelf) graptolitic marl and shaly limestone characterize the early Early Silurian

[1]GSA Data Repository item 2002078, Appendix 1, is available on request from Documents Secretary, GSA, P.O. Box 9140, Boulder, CO 80301-9140, USA, editing@geosociety.org, or at www.geosociety.org/pubs/ft2002.htm, or on the CD-ROM accompanying this volume.

(Llandovery), and evaporitic facies (including gypsum and anhydrite) accumulated during the Late Silurian. Devonian sections (60–1230 m thick; most ≤430 m) contain abundant evaporites and siliciclastic rocks, and subordinate, mainly Givetian, limestone. Alkalic basalt flows accumulated in several major rift basins during Middle Devonian through Mississippian time (Nokleberg et al., 1994).

Several lithologic and faunal features distinguish the Siberian craton succession from the platform successions of northern and central Alaska. The Archean basement, thick sequence of unmetamorphosed Proterozoic strata, and Ordovician shallow-water siliciclastic rocks have no counterparts in the Alaskan successions (Fig. 3). The deeper-water facies of Llandovery age are similar to, but apparently thinner and shorter lived than, the Paradise Fork and coeval strata in the Farewell terrane. The Ordovician and Upper Silurian–Devonian evaporites of Siberia have no analogs in northern or central Alaska. Siberian province conodonts and megafossils link the faunas of Siberia and Alaska, but only a few of the Laurentian conodonts that occur in the Alaskan successions are also found on the Siberian craton (Table 2).

Chukotka

Rocks of the Chukotka Peninsula have long been correlated with coeval strata in northern Alaska, and some have suggested a common origin for both successions. The Arctic Alaska Plate of Halgedahl and Jarrard (1987), for example, is defined as a single crustal block made up of Chukotka, northern Alaska, adjacent continental margins, and a part of the oceanic crust of the Canada basin. The western boundary of this proposed plate is uncertain; the South Anyui suture zone, adjacent to the Kolyma River Delta, is favored by some workers, but others extend the block west to the Laptev Sea (see discussion in Rowley and Lottes, 1988). The Laptev Sea boundary was favored by Şengör and Natal'in (1996) and Natal'in et al. (1999), who included rocks of northeastern Russia (from Chukotka west through Wrangel and Kotelny Islands) and northwestern Alaska (Seward Peninsula and Hammond subterrane of the Arctic Alaska terrane) in their Bennett-Barrovia crustal block and considered all lower Paleozoic carbonate strata in this region to be part of their Novosibirsk carbonate platform.

Few lower Paleozoic rocks crop out on the Chukotka Peninsula and adjacent regions to constrain tectonic reconstructions of this area. The composite lithostratigraphic section from the Chegitun River area (Fig. 3, column 9) is taken from the Bondarev database; additional lithostratigraphic and faunal data are provided by Oradovskaya and Obut (1977) and Natal'in et al. (1999). These strata were considered part of the Seward terrane by Nokleberg et al. (1994, 1998). A Proterozoic metamorphic complex of gneiss, migmatite, amphibolite, marble, and schist (K-Ar and Rb-Sr ages of 1.6 Ga and 1.9 Ga, respectively) is overlain by schist, carbonate, and quartzite of presumed Late Proterozoic age (Nokleberg et al., 1994); Cretaceous metamorphism has obscured the older history of these rocks (Bering Strait Geologic Field Party, 1997). The lower Paleozoic section is variably metamorphosed and comprises Middle to Upper Ordovician shallow-water carbonate rocks (600–700 m thick) that contain a varied fauna of corals, brachiopods, trilobites, and conodonts; Lower Silurian (upper Llandovery–Wenlockian) deeper water graptolitic black shale and limestone (<100 m), and Upper Silurian–Lower Devonian shallow-water carbonate rocks (450–600 m). The Middle Devonian Tanatap Formation (350–475 m), which consists of polydeformed, greenschist facies phyllites, carbonate turbidites and debris flows, and rare tuffs, structurally overlies the older rocks (Natal'in et al., 1999).

Paleozoic rocks also occur on Wrangel Island, but Paleozoic strata older than Late Silurian have not been documented here. The Paleozoic section overlies Upper Proterozoic clastic and metavolcanic rocks intruded by granite with a U-Pb zircon age of 699 ± 2 Ma (Cecile et al., 1991), which is closely comparable to the U-Pb zircon ages of 676 ± 15 Ma and 681 ± 3 Ma determined for Seward Peninsula orthogneisses (Patrick and McClelland, 1995). Stratigraphic columns in the Bondarev database indicate that Upper Silurian–lower Lower Devonian, shallow-water, carbonate and siliciclastic strata are overlain by deeper water, Lower–Middle Devonian siliciclastic facies, which are in turn overlain by Upper Devonian evaporites and mafic volcanic rocks; the clastic strata in this sequence include both arkosic and quartz-rich layers (Nokleberg et al., 1994).

In general aspect, the lower Paleozoic succession in Chukotka resembles those in northern and central Alaska. Chukotka lacks the Middle Ordovician basinal facies found on Seward Peninsula and in the Brooks Range, but contains deeper-water strata of Silurian age that are precisely coeval with, but apparently thinner than, the Paradise Fork Formation in the Nixon Fork subterrane. A single Ordovician conodont collection from Chukotka (Appendix 1, no. 88; see footnote 1) contains Siberian-Alaskan elements like those found in northern and central Alaska, but includes none of the Laurentian forms that are common in the Alaskan rocks. Megafossils suggest ties between Chukotka and the Alaskan successions; *Tcherskidium* occurs in all three areas (Blodgett et al., 1992) and monorakid trilobites, found on the Siberian craton, Kotelny Island, Omulevka, and Taimyr, are also identified in the York Mountains (Ormiston and Ross, 1976).

Kotelny and Bennett Islands

Kotelny Island (one of the New Siberian Islands; Fig. 1) contains Paleozoic carbonate rocks that have been correlated with those on Chukotka (part of the Novosibirsk carbonate platform of Şengör and Natal'in, 1996) or, alternately, considered part of the Siberian platform (Fujita and Newberry, 1982). Deep-water rocks exposed to the east on Bennett Island are generally interpreted as a lateral facies equivalent of the rocks on Kotelny Island (e.g., Kos'ko, 1994; Şengör and Natal'in, 1996), although some consider Bennett Island to be a separate terrane (Nokleberg et al., 1994). Stratigraphic columns for Kotelny and Bennett Islands are included in the Bondarev database, described by Kos'ko et al. (1990), and summarized in Figure 3 (column 10).

No Proterozoic rocks are exposed in this area. On Bennett Island, an ~500-m-thick sequence of argillite, lesser siltstone, and limestone that contains Middle Cambrian trilobites with Siberian affinities in its lower part is overlain by 1000–1200 m of Ordovician argillite, siltstone, and quartz sandstone with soft-sediment slump and flow features and Arenig and Llanvirn graptolites (Kos'ko et al., 1990; Şengör and Natal'in, 1996). The lower Paleozoic succession on Kotelny Island begins with a thick (1400–1800 m) Ordovician section of chiefly shallow-water carbonate rocks; an interval of slightly deeper water limestone, marl, and shale accumulated during the Middle Ordovician (early Caradoc). Silurian strata (750–1700 m thick) comprise a thinner sequence of basinal graptolitic mudstone and limestone to the southwest and thicker, shallow-water carbonate rocks to the northeast; the basinal sequence shallows and becomes increasingly calcareous upward. Chiefly shallow-water carbonate facies (1000–1700 m) continue through the Middle Devonian and are succeeded by as much as 8900 m of Upper Devonian siliciclastic rocks (Kos'ko et al., 1990). Paleozoic strata on Kotelny Island contain a diversified fauna of corals, ostracodes, brachiopods, and gastropods similar to faunas of the Siberian platform (Nokleberg et al., 1994). No conodont faunas from Kotelny Island are described in the literature.

Lower Paleozoic lithofacies on Kotelny and Bennett Islands correlate intriguingly well with coeval strata in northern and central Alaska. Trilobite-bearing Middle Cambrian, chiefly siliciclastic rocks on Bennett Island correspond to Middle Cambrian outer shelf deposits in the central Brooks Range (Snowden Mountain area) and southern Farewell terrane. Ordovician, Silurian, and Lower–Middle Devonian shallow-water facies on Kotelny match those in the North Alaska carbonate platform and the Farewell terrane (Nixon Fork subterrane). Upper Arenig–middle Caradoc deep-water strata on Bennett Island are coeval with, but less calcareous than, intraplatform basin facies in northern Alaska and also correlate, in age and lithofacies, with the lower part of the Post River Formation in the Dillinger subterrane (Churkin and Carter, 1996); Bennett Island strata, however, are much thicker than equivalent rocks in Alaska. Deep-water Silurian rocks on southwestern Kotelny Island correspond in age, facies, and thickness to the Paradise Fork Formation in central Alaska. The Late Devonian siliciclastic influx recorded on Kotelny Island roughly correlates with, but appears to be at least twice as thick as, siliciclastic strata of the Endicott Group in northern Alaska.

Kolyma-Omolon superterrane

Paleozoic rocks are widely but discontinuously exposed east of the Siberian platform in an area called the Kolyma-Omolon superterrane, which includes 13 discrete terranes (Nokleberg et al., 1994). Lower Paleozoic platform carbonate rocks occur in the Omolon, Omulevka, and Prikolyma terranes, and deeper-water strata of Ordovician and Devonian age are found in the Rassokha and Argatas terranes (Fig. 1; Nokleberg et al., 1994).

The Bondarev database contains stratigraphic columns from four of the Kolyma-Omolon terranes: Omolon (2 Ordovician and 11 Devonian columns), Omulevka (3 Ordovician, 4 Silurian, and 4 Devonian columns), Prikolyma (2 Silurian and 3 Devonian columns), and Rassokha (2 Ordovician and 2 Devonian columns). Only the Omulevka terrane contains a continuous Ordovician through Devonian succession (Nokleberg et al., 1994); a representative composite section from the Selennyakh Range is shown in Figure 3 (column 11). Some Ordovician conodont faunas from the Omolon, Omulevka, and Prikolyma terranes are analyzed in Appendix 1 (see footnote 1) and summarized in the following.

The Omulevka terrane, westernmost of the five Kolyma-Omolon terranes discussed herein, comprises several discrete fault-bounded blocks separated by belts of Mesozoic sedimentary, volcanic, and plutonic rocks (chiefly the Jurassic-Cretaceous Indigirka-Oloy assemblage) (Nokleberg et al., 1994). The Omulevka succession begins with presumed Upper Proterozoic marble, schist, and metavolcanic rocks unconformably overlain by a thick sequence (1700 m) of boulder conglomerate, marble with Middle and Late Cambrian fossils, schist, metarhyolite, and quartzite (Nokleberg et al., 1994). Ordovician strata (2200–5700 m thick) consist of Lower–Middle Ordovician limestone and shale deposited in a deepening-upward environment: graptolitic shale, limestone, and local tuff of Llanvirn–early Caradoc age, and Upper Ordovician shallow-water limestone and local evaporites. Deep-water limestone and graptolitic shale (300–1450 m thick) accumulated during the Early Silurian and grade upward into shallow-water dolostone, limestone, and locally abundant siliciclastic rocks of Late Silurian (500–1400 m) and Devonian (1200–2500 m) age. Middle Devonian (Givetian) calcareous sandstones are intercalated with trachybasalt flows along the southeastern border of the terrane, and Famennian (and younger) sedimentary strata include subordinate layers of andesite and basalt tuff (Nokleberg et al., 1994).

Deep-water rocks of early Paleozoic age occur in the Rassokha and Argatas terranes, which form discrete, fault-bounded blocks east of the Omulevka terrane and were interpreted by Nokleberg et al. (1994) as fragments of oceanic crust. Ordovician shale, graywacke, and volcanic rocks occur in the Rassokha terrane (Nokleberg et al., 1994); two stratigraphic columns from this terrane in the Bondarev database contain 1000–3700 m of Ordovician strata, including a Llanvirn–early Caradoc interval of graptolitic shale and marl. These rocks are unconformably overlain by 1670–3700 m of Devonian limestone, dolostone, and lesser siliciclastic strata. The Argatas terrane includes Lower Ordovician shale and minor Devonian limestone and sandstone associated with Devonian ophiolitic rocks (Nokleberg et al., 1994).

The Prikolyma terrane is directly east of the Omulevka terrane and includes amphibolite-grade gneiss and schist of Proterozoic and/or early Paleozoic age (Nokleberg et al., 1994). Riphean, Vendian, and Cambrian shallow-marine clastic and carbonate rocks occur in the central part of the terrane and Ordovician carbonate and Lower Silurian clastic strata crop out in the southwestern area (Nokleberg et al., 1994). A thick Silurian-Devonian succession in the Yasachnaya River basin is documented in the Bondarev database. It consists of 450–600 m of Llandovery deep-water graptolitic shale and some coarser-grained clastic rocks, 500 m of Wenlock-Ludlow limestone and dolostone, 200–700 m of Pridoli chiefly clastic rocks, and 1300–2100 m of Devonian siliciclastic and carbonate strata. Mafic volcanic rocks of Eifelian and Frasnian age occur within this succession.

The Omolon terrane adjoins the eastern boundary of the Prikolyma terrane. Archean to Early Proterozoic, amphibolite to granulite facies crystalline basement (U-Pb ages of 2.8–3.4 Ga) is unconformably overlain by lower-grade Proterozoic siliciclastic rocks that grade upward into carbonate strata and are in turn unconformably overlain by rift-related clastic and volcanic rocks of Cambrian age (Nokleberg et al., 1994). Lower and Middle Ordovician units comprise several small tectonic blocks; stratigraphic columns in the Bondarev database for the Molandzha and Kedon zones indicate 1625 and 400–700 m, respectively, of shallow-water carbonate and lesser clastic rocks of Tremadoc, Arenig, and Llanvirn age. Devonian strata are widespread, unconformably overlie older deposits, and consist of mafic to felsic volcanic rocks and nonmarine and lesser shallow-marine siliciclastic and carbonate strata (Nokleberg et al., 1994); 11 stratigraphic columns in the Bondarev database document 600–4600 m of chiefly Middle and Upper Devonian rocks.

Ordovician conodont collections from the Omulevka, Prikolyma, and Omolon terranes of the Kolyma-Omolon superterrane (Appendix 1; see footnote 1) contain abundant (78%) cosmopolitan and tropical cosmopolitan species, an unsurprising result given that deeper-water strata were preferentially sampled (basinal facies worldwide produce largely cosmopolitan forms). Of the collections from the Omulevka and Prikolyma terranes, 10% include or consist exclusively of Siberian province and/or Siberian-Alaskan species (Appendix 1; see footnote 1). Rare to common Laurentian-Siberian faunal elements occur in 15% of the samples, but are much less diverse than those associated with Siberian-Alaskan conodonts in collections from northern and central Alaska. Laurentian-Siberian species include *Oistodus multicorrugatus, Histiodella* n. sp. 2 of Harris et al. (1979), *Scolopodus kelpi, Clavohamulus* n. sp. cf. *C.* n. sp. A of Repetski (1982), and *"Scandodus" robustus* (Table 2). Megafossils from both the North Alaska carbonate platform and the Farewell terrane have been broadly correlated with coeval forms from the Kolyma-Omolon superterrane (e.g., Blodgett et al., 1992, and this volume; Blodgett, 1998).

Lithologic correlations between terranes of the Kolyma-Omolon superterrane and those of northern and central Alaska are generally weak. The Omulevka succession best matches the Alaskan rocks; specific similarities include metamorphosed basement of presumed Late Proterozoic age and Middle Ordovician basinal deposits underlain and overlain by shallow-water carbonate strata. Early Silurian basinal facies correlate well in age, thickness, and lithology with the Paradise Fork Formation and equivalent rocks in the Farewell terrane. Features of the Omulevka succession that have no equivalent in coeval Alaskan rocks include the Cambrian (?) boulder conglomerate, Upper Ordovician evaporites, and locally abundant siliciclastic strata of Late Silurian–Early Devonian age. Ordovician basinal deposits and volcanic rocks of the Rassokha terrane have some similarities with coeval strata of the central Seward Peninsula, but the Seward Peninsula volcanic sequence was not deposited on oceanic crust. Lower Silurian deep-water facies in the Prikolyma terrane correlate broadly with the Paradise Fork, but too few data are available on Cambrian-Ordovician strata in Prikolyma to permit a comparison with Alaskan rocks. The Omolon succession includes Ordovician siliciclastic strata that have no counterpart in Alaska and lacks Silurian rocks. All three terranes of the Kolyma-Omolon superterrane that include lower Paleozoic platform carbonates contain volcanic rocks of Middle and Late Devonian age; broadly coeval volcanic rocks occur locally in northern Alaska but are apparently absent from the Farewell terrane.

DISCUSSION

Lithologic and paleontologic data from lower Paleozoic platform carbonate successions in northern and central Alaska and northeastern Russia provide important limitations on models proposed to explain the tectonic evolution of the Arctic region. In this section we explore the broader implications of our stratigraphic and faunal data. We first consider correlation of lower Paleozoic successions within Alaska, and then consider implications of these correlations for the ultimate origin of Alaskan terranes.

Alaskan successions

Strong lithologic and faunal similarities imply that lower Paleozoic carbonate successions on Seward Peninsula and in the western and central Brooks Range are fragments of a single carbonate platform that formed along a continental margin (Dumoulin and Harris, 1994). Carbonate platform strata in the northeastern Brooks Range (Shublik-Sadlerochit Mountains) may also have been part of this margin, but these rocks differ in several respects from coeval platform rocks to the west.

Lower Paleozoic carbonate strata in the northeastern Brooks Range are the most cratonic sequence known in the range; they overlie a thick (>2500 m) Late Proterozoic passive-margin succession (Clough, 1989; Clough and Goldhammer, 1995) and were deposited almost exclusively during transgressive maxima (Harris et al., 1995). The succession contains numerous disconformities—most strikingly, one spanning the entire Silurian and part of the Early Devonian—and lacks evidence of any deeper-water incursions during the early Paleozoic. Laurentian faunal affinities are strong in Shublik-Sadlerochit strata, and Siberian affinities relatively weak. Upper Cambrian and Ordovician rocks in this area contain mainly tropical cosmopolitan conodont species such as *Oepikodus communis* and *Juanognathus variabilis* and Laurentian forms including *Clavohamulus densus, Phragmodus* n. sp. of Barnes, 1974, belodinids and aphelognathids. *C. densus* is widespread in Laurentia, but has not been found elsewhere in Alaska; *Phragmodus* n. sp. is widespread in northern Canada but is unknown west or south of the central Brooks Range in Alaska. Upper Ordovician strata in the Shublik Mountains contain the pentamerid brachiopod *Tcherskidium,* which is characteristic of peri-Siberian terranes; the species found in the Shublik Mountains is new and also occurs in the Farewell terrane (Blodgett, 1998). We provisionally include the Shublik-Sadlerochit succession in our North Alaska carbonate platform, but acknowledge that the lithologic and faunal evidence that ties these rocks to this platform is less robust than that linking the successions of Seward Peninsula and the western and central Brooks Range.

Similarities between carbonate platform successions in northern and central Alaska (North Alaska carbonate platform and Farewell terrane) suggest that these fragments were in mutual proximity during the early Paleozoic, and may even have been joined. Upper Proterozoic through Lower Devonian lithofacies in the two areas correlate well, as do the conodont and megafossil assemblages. Lithologic and faunal ties between northern Alaska and the Farewell terrane diminish after Middle Devonian time. Minor Upper Devonian siliciclastic rocks are reported from the Farewell terrane (e.g., Blodgett and Gilbert, 1992), but there is no equivalent in this area of the thick, largely fluvial siliciclastic strata of the Upper Devonian–Mississippian Endicott Group. Fluvial siliciclastic strata are only locally abundant in the Farewell terrane and appear to be chiefly Permian (Decker et al., 1994).

Other lower Paleozoic carbonate successions in Alaska cannot be definitively linked to those in northern Alaska and the Farewell terrane using lithologic or faunal evidence. Lower Paleozoic carbonate rocks occur in the Jones Ridge area; the Porcupine, Livengood, and White Mountain terranes of east-central Alaska; and the Alexander terrane of southeastern Alaska (Fig. 1; Nokleberg et al., 1994; Silberling et al., 1994). Strata in the Jones Ridge area (Fig. 1, location 15) contain a typical Laurentian fauna of conodonts and megafossils and are part of the ancestral North American continental margin. Lower Paleozoic successions in the Porcupine, Livengood, White Mountain, and Alexander terranes have some lithologic and megafaunal similarities to those of the Farewell terrane and/or the North Alaska carbonate platform, but do not contain Ordovician conodonts of Siberian aspect. Ties appear strongest between the Alexander and Farewell terranes; both contain distinctive Silurian reef complexes with aphrosalpingid sponges, and volcanic rocks of Silurian age (Soja, 1994; Blodgett, 1998; Blodgett et al., this volume; Dumoulin et al., 1998a). Conspecific Middle Devonian (Eifelian) gastropods occur in the Livengood and Farewell terranes (Blodgett et al., this volume) and Ordovician volcanic rocks characterize successions of both the central Seward Peninsula and the White Mountain terrane (Harris et al., 1995). A single specimen of *Tcherskidium* sp., an Ordovician pentamerid brachiopod with Siberian affinities, has been found in the Porcupine terrane, but other Ordovician and Devonian megafossils in this terrane are more similar to forms from cratonal North America (Blodgett et al., this volume).

Fossils with Siberian affinities are reported from Alaskan rocks that formed in several tectonic environments. Cambrian trilobites of Siberian aspect occur at Mount Doonerak in rocks interpreted as a subduction-related magmatic arc complex (e.g., Julian and Oldow, 1998). However, megafossils and microfossils characteristic of the Siberian province are also documented in carbonate platform successions in northern and central Alaska (e.g., Dumoulin and Harris, 1994; Blodgett et al., this volume). Platform environments in both northern Alaska and the Farewell terrane persisted from Proterozoic through Devonian time; such long-lived successions generally form along a continental margin, or on fragments derived from such a margin. We next consider the ultimate origin of these Alaskan carbonate platforms.

Arctic correlations

Metamorphic and isotopic data from basement rocks and lithologic and faunal information from lower Paleozoic strata all help to determine the origin of the carbonate platforms in northern and central Alaska. Metamorphosed strata of Proterozoic age appear to underlie both the North Alaska and Nixon Fork platforms, a feature that distinguishes them from coeval carbonate platforms in western Canada (as pointed out by Patton et al., 1994) and the Siberian craton (Nokleberg et al., 1994), which are underlain by thick sequences of unmetamorphosed Proterozoic rocks. Sparse isotopic ages from Proterozoic basement complex rocks—on the Seward Peninsula (Patrick and McClelland, 1995) and in the Sadlerochit Mountains (McClelland, 1997) in northern Alaska, and in the Medfra Quadrangle (McClelland et al., 1999) in central Alaska—are unlike those from the Canadian Cordillera and Arctic Islands, and suggest that the Alaskan rocks were not derived from western Laurentia.

Lower Paleozoic carbonate platform rocks in northern and central Alaska also differ from coeval carbonate platform rocks in both the Canadian Arctic Islands and the Canadian Cordillera. The carbonate platform in the Arctic Islands has many lithologic and faunal mismatches with the age-equivalent platform in North Alaska (Fig. 3, column 12; Dumoulin et al., 1998c, 2000a). Although lower Paleozoic rocks in the Farewell terrane correlate somewhat better lithologically with the Arctic Islands succession—both areas record widespread drowning of platform facies during Silurian time—Ordovician evaporites in the Arctic Islands have no counterparts in central or northern Alaska. Cambrian through Devonian strata in the Canadian Cordillera have some lithologic similarities to coeval platform facies in northern and central Alaska (cf. Fritz et al., 1991), but faunal evidence distinguishes age-equivalent strata in these areas. Conodonts and megafossils characteristic of the Siberian province that are locally common in lower Paleozoic platform carbonate facies from northern Alaska and the Farewell terrane are absent from coeval facies in the Canadian Arctic Islands and the Canadian Cordillera (Dumoulin et al., 1998c, 2000a). The presence in Alaskan terranes of Siberian forms not seen in well-studied cratonal margin sequences such as the Canadian Rockies and eastern Great Basin suggests that the North Alaska carbonate platform and the Farewell terrane were not attached to Laurentia during the early Paleozoic.

The distribution of Siberian faunal elements in Alaska implies that early Paleozoic carbonate platforms in northern and central Alaska formed in or adjacent to the Siberian faunal province. As noted earlier, however, the Alaskan successions have notable lithologic differences from coeval rocks of the Siberian craton and contain Laurentian faunal elements (both conodonts [Table 1] and megafossils, such as some Ordovician and Devonian corals) that are rare or absent in Siberian craton strata. The lithostratigraphic and megafossil evidence suggests stronger ties between the carbonate platforms in northern and central Alaska and equivalent platforms in terranes north and east of the Siberian craton than between the Alaskan rocks and the Siberian craton. Lower Paleozoic rocks on Kotelny and Bennett Islands, the Chukotka Peninsula, and in the Omulevka terrane have the most compelling lithostratigraphic similarities to the Alaskan successions. Evidence for Early Silurian drowning, like that seen across the Nixon Fork platform and locally, perhaps, along the northern margin of the North Alaska platform, also occurs in the Kotelny, Chukotka, and Omulevka successions; late Early–Middle Ordovician basinal deposits, like those within carbonate platform facies in northern Alaska and the southern part of the Nixon Fork subterrane, are also found in Omulevka and on Bennett Island. Limited Ordovician conodont data from Chukotka and the Kolyma-Omolon superterrane indicate that these "peri-Siberian terranes" contain far fewer Laurentian forms than do coeval Alaskan successions (Tables 1 and 2). Conodont data are not available for Ordovician strata on Kotelny and Bennett Islands.

The faunal data outlined here imply that lower Paleozoic carbonate strata in northern and central Alaska accumulated at or near the juncture of the Siberian and Laurentian faunal provinces. Lithologic and faunal evidence suggests that the Alaskan rocks were not part of the Siberian craton during their deposition, as proposed by Blodgett (1998). The Alaskan strata could have formed on a crustal fragment rifted away from Siberia during the Late Proterozoic (e.g., Şengör and Natal'in, 1996), but more isotopic information is needed from Alaskan, Siberian, and peri-Siberian basement complexes to evaluate this hypothesis. There are intriguing lithologic similarities between the lower Paleozoic successions of northern and central Alaska and those of certain peri-Siberian terranes, most notably Kotelny and Bennett, Chukotka, and Omulevka; additional detailed conodont, megafossil, and lithologic data are needed to test these correlations. Siberian affinities in northern and central Alaskan biotas are notable from at least Middle Cambrian through Early Devonian (Emsian) time, but the lithologic and faunal ties between northern Alaska, the Farewell terrane, and the peri-Siberian terranes of northeastern Russia diminish after the Middle Devonian. Plant fossils of the Angaran floral realm testify that Siberian biotic affinities persisted (or perhaps recurred) as late as Mississippian time in northern Alaska (Spicer and Thomas, 1987) and Permian time in the Farewell terrane (Mamay and Reed, 1984).

CONCLUSIONS

Strong lithologic and faunal ties link Cambrian through Devonian strata of the North Alaska carbonate platform and the Farewell terrane in central Alaska, and rocks in both areas have some similarities to coeval strata of peri-Siberian terranes such as Chukotka, Kotelny, and Omulevka. Megafossil and microfossil assemblages from northern and central Alaska contain both Siberian and Laurentian province elements; the Siberian elements are absent from coeval sequences in Laurentia, and only a few of the Laurentian forms that occur in the Alaskan successions also reached the Siberian craton. These data suggest that carbonate platform successions in northern and central Alaska were in proximity (possibly joined) during the early Paleozoic, and formed at or near the juncture of the Siberian and Laurentian faunal provinces, possibly on a crustal fragment rifted away from the Siberian craton during Late Proterozoic time.

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