CORRELATION OF PRE-CARBONIFEROUS CARBONATE SUCCESSIONS OF NORTHERN ALASKA

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ABSTRACT

Fault-bounded successions of pre-Carboniferous (meta)carbonate rocks occur throughout northern Alaska. Successions studied in detail are those in the York Mountains (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); they are correlated on the basis of lithofacies and conodont biostratigraphy. Available lithologic and biogeographic data are best explained by postulating that these successions accumulated on a single continental margin or platform that had faunal exchange with both Siberia and North America, rather than on a series of discrete platforms juxtaposed by later tectonic events.

INTRODUCTION

Bedrock geology of northern Alaska is dominated by a Mesozoic orogenic belt, which extends eastward more than 1,000 km from the Seward Peninsula through the Brooks Range. Within this belt, rocks of Precambrian through Cretaceous age have been complexly deformed and metamorphosed. Fault-bounded successions of pre-Carboniferous, chiefly metacarbonate rocks occur throughout this area (Fig.1); their original configuration is unknown. Paleogeographic reconstruction of northern Alaska remains contentious, because fundamental tectonic questions are unresolved. In particular, the cause and effects of Devonian orogeny in the Brooks Range, and the position of northern Alaska prior to Mesozoic opening of the Canada basin, are poorly understood (e.g., Nelson et al., in press).

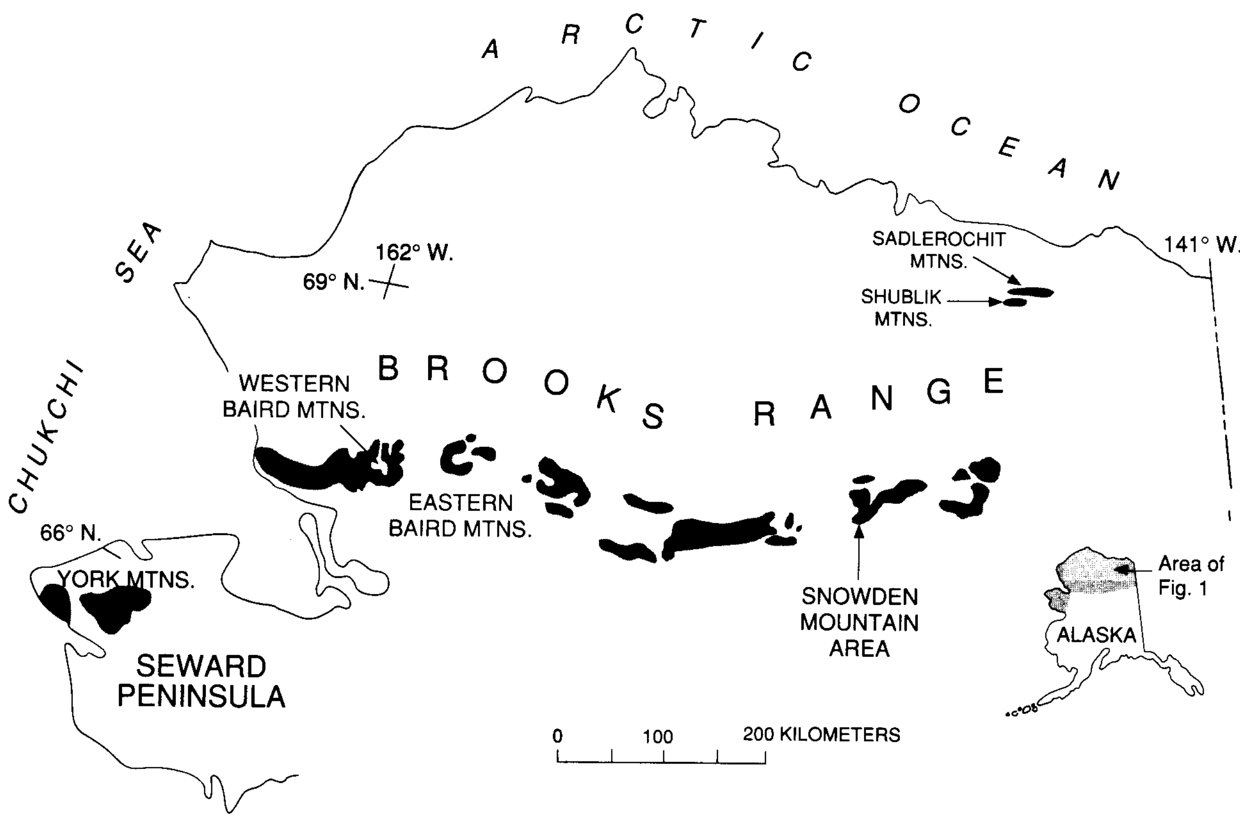

Fig.1. Map of northern Alaska showing general distribution of pre-Carboniferous (meta)carbonate rocks (gray pattern) and geographic names referred to in text.

Most workers interpret pre-Carboniferous carbonate strata of northern Alaska as a platform or continental margin assemblage formed on continental crust, but the Paleozoic position of this crust is poorly constrained (e.g., Sweeney, 1982). Alternatively, pre-Carboniferous strata now found in northern Alaska could have accumulated along several disparate continental margins and then been juxtaposed by later tectonic events. Grantz et al. (1991), for example, suggested the Brooks Range is underlain by Siberian and North American crustal fragments assembled during early Paleozoic convergence.

We used two techniques to test models for the origin of pre-Carboniferous carbonate strata in northern Alaska: (1) microfacies analysis, to assess the degree of lithologic and biotic similarity between individual carbonate successions, and (2) comparison of paleobiogeographic affinities of faunas in these successions.

COMPARATIVE MICROFACIES ANALYSIS

Comparative analysis of microfacies in pre-Carboniferous (meta)carbonate successions can help identify "exotic" continental fragments in northern Alaska. Carbonate strata deposited along the same margin or platform should show similar successions of lithofacies, biofacies, and depositional environments. Coeval rocks formed on separate continents, in contrast, could differ greatly, owing to different sediment sources, paleoclimates, and (or) subsidence histories.

The (meta)carbonate successions of northern Alaska are summarized in Fig.2. Successions for which detailed information is available are the York Mountains (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) (Dumoulin and Harris, in press, and references therein). Rocks in the York and Shublik and Sadlerochit Mountains are unmetamorphosed; those in the western and central Brooks Range are metamorphosed to greenschist and blueschist facies, but sedimentary features are locally well preserved.

Strata of Proterozoic and Cambrian age are thickest in the Shublik and Sadlerochit Mountains but have not been observed in the York and western Baird Mountains. Relatively deep-water facies of Middle Cambrian and older(?) age are known in the eastern Baird and Snowden successions. Relatively shallow-water facies of Late Cambrian age are recognized in the eastern Baird and Shublik-Sadlerochit successions.

Lower Ordovician platform (meta)carbonate rocks are widely distributed in the York, western Baird, and Shublik and Sadlerochit Mountains. The western sections are thicker and differentiated into at least two distinct lithofacies; the Shublik-Sadlerochit section appears relatively uniform. Carbonate platform rocks of Early Ordovician age have not been identified in the eastern Baird or Snowden Mountain areas; instead, this interval contains basinal facies.

Middle Ordovician strata in the eastern Baird and Snowden successions consist chiefly of deep-water slope to basinal facies; both sections contain abundant fine-grained siliciclastic detritus and shallow upward. The Middle Ordovician section in the York Mountains is similar but contains less siliciclastic material and a larger proportion of somewhat shallower facies. Other Middle Ordovician sections are dominated by platform carbonate rocks (Fig.2).

Carbonate strata of Late Ordovician through Middle Devonian age are generally similar across northern Alaska; variations appear to reflect differential erosion during Early Silurian and (or) post-Early Devonian time. Upper Ordovician strata were deposited in a shallowing-upward shelf or platform setting; this pattern has been documented in all successions except the western Baird Mountains, where Upper Ordovician strata are scarce. Lower and Upper Silurian strata occur in all successions except that in the Shublik and Sadlerochit Mountains.

Lower and Middle Devonian (meta)carbonate rocks appear to be rare in the Snowden Mountain area, are rare or absent in the eastern Baird and York Mountains, and are only locally present in the Shublik and Sadlerochit Mountains. The thickest and most widely distributed section of Lower and Middle Devonian metacarbonate rocks occurs in the western Baird Mountains.

Carbonate platform development thus began as early as the latest Proterozoic in at least some parts of northern Alaska and had ended by the Early or Middle Devonian in all the successions discussed above. Clastic influx and (or) Devonian orogeny may have caused the demise of the early Paleozoic carbonate platform(s). Siliciclastic rocks of Middle and Late Devonian age are widely distributed across northern Alaska and are roughly coeval with granitic plutons intruded at about 370 ± 30 Ma (Nelson et al., in press).

PALEOBIOGEOGRAPHY

"Siberian" and "North American" biogeographic affinities have been reported for various fossils from the pre-Carboniferous (meta)carbonate successions described above. The biogeography of Cambrian trilobites has attracted the most attention (e.g., Palmer et al., 1984; Grantz et al., 1991), but provinciality has also been noted in Ordovician trilobites, conodonts, brachiopods, gastropods, and corals. Silurian and Devonian faunas in northern Alaska appear relatively cosmopolitan.

The biogeographic affinities of Cambrian and Ordovician faunas from northern Alaska are summarized in Fig.2. Late Cambrian trilobites in the

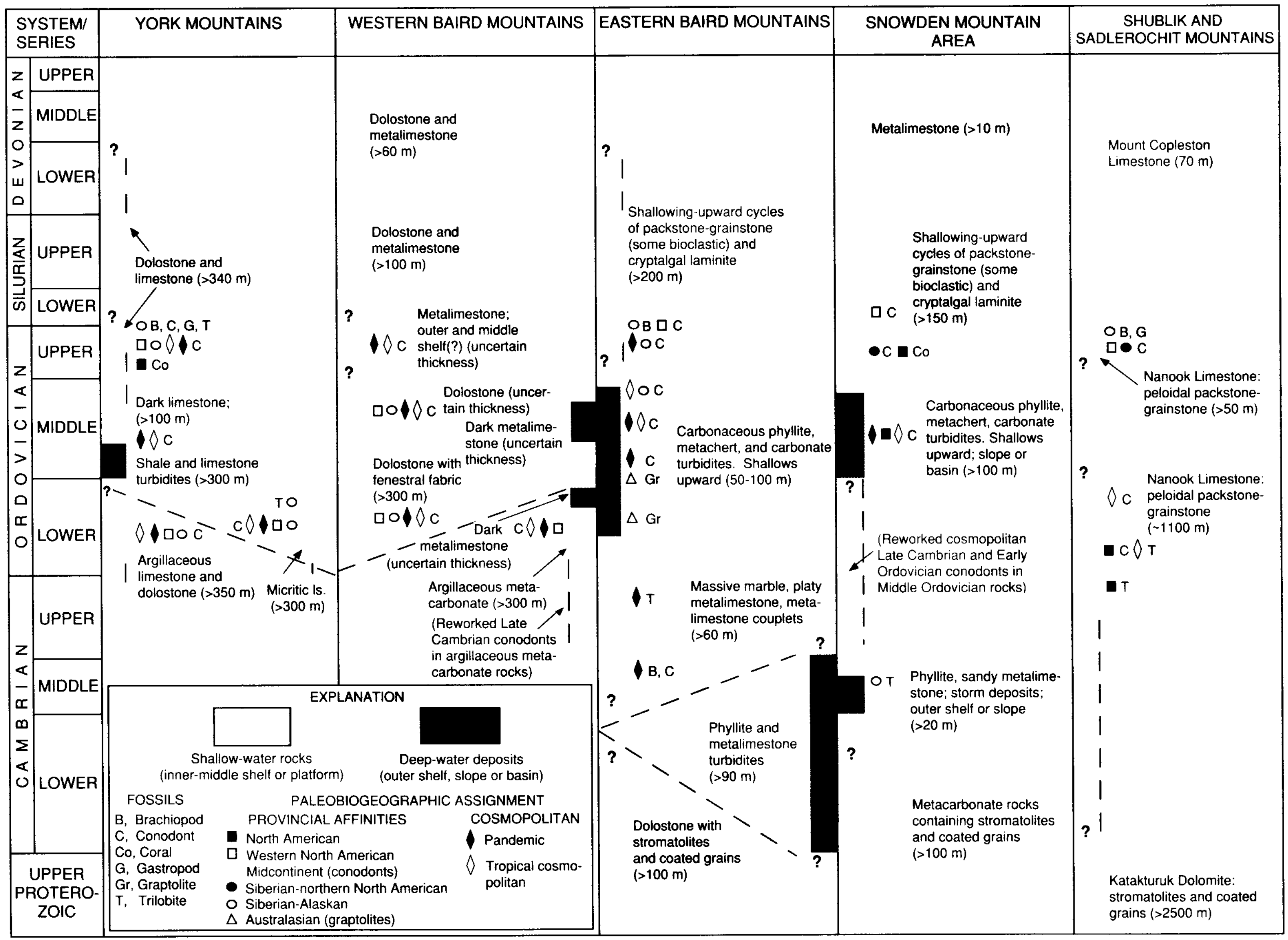

Fig.2. Correlation, depositional environments, and paleobiogeographic affinities of faunas in (meta)carbonate successions in the York, Baird, Snowden, and Shublik and Sadlerochit Mountains. "Siberian" as used here implies affinities with biota from lower Paleozoic rocks of the Siberian platform. Silurian and Devonian faunas are chiefly cosmopolitan. Lithofacies and conodont biostratigraphic analysis from Dumoulin and Harris (in press); lithofacies in Shublik and Sadlerochit Mountains from J.G. Clough and coworkers, Alaska Division of Geological & Geophysical Surveys. Megafossil data from published and unpublished sources cited in Dumoulin and Harris (in press).

Shublik-Sadlerochit succession have North American affinities (Blodgett et al., 1986). Middle Cambrian rocks at Snowden Mountain yield trilobites with Siberian affinities (Palmer et al., 1984). Lower Ordovician strata in the Shublik-Sadlerochit succession produce trilobites with affinities to the low-latitude Bathyurid Province (Blodgett et al., 1986). Early and Late Ordovician trilobites from the York succession have Siberian affinities (Ormiston and Ross, 1976). Late Ordovician brachiopods and gastropods with Siberian affinities occur in the York, eastern Baird, and Shublik-Sadlerochit (meta)carbonate successions (e.g., Blodgett et al., 1988; Blodgett et al., 1992). Some corals from the York Mountains and Snowden Mountain area have North American affinities (Dumoulin and Harris, in press).

Provinciality also characterizes Ordovician conodont faunas from northern Alaska; species typical of the Western North American Midcontinent province (WNAMP) and Siberian-Alaskan province (SAP) have been identified (Dumoulin and Harris, in press). Lower Ordovician strata in the York and western Baird successions yield chiefly tropical cosmopolitan and pandemic species, together with lesser numbers of WNAMP elements. Middle Ordovician rocks in all of the northern Alaskan successions contain chiefly cosmopolitan forms, with the exception of some intervals in the western Bairds. Upper Ordovician strata reveal a relatively complex pattern of conodont faunal affinities (Fig.2). Early Late Ordovician collections in the eastern Baird, Snowden, and Shublik-Sadlerochit successions are dominated by Siberian-northern North American forms, whereas the latest Ordovician faunas in these areas contain WNAMP conodonts. Upper Ordovician strata in the Yorks yield WNAMP and SAP conodonts; the single known locality of Upper Ordovician rocks in the western Bairds produced cosmopolitan conodonts.

Specific elements of the paleobiogeographic pattern outlined above have been used to infer the presence of "exotic" continental fragments in northern Alaska. The occurrence of Cambrian trilobite faunas with Siberian affinities in the Snowden Mountain area, and with North American affinities in the Shublik and Sadlerochit Mountains, has been cited as evidence that the Brooks Range is underlain by both "Siberian" and "North American" crustal fragments (e.g., Grantz et al., 1991). The Siberian affinities of Ordovician trilobites in the York Mountains led Ormiston and Ross (1976, p. 58) to conclude that the Seward Peninsula was part of a "Siberia-Kolyma continent" during the early Paleozoic and was not connected to the rest of Alaska and North America until the Mesozoic.

Long-distance translation of tectonic blocks is not the only mechanism that can produce "anomalous" faunal distributions, however. Modern biogeographic patterns are controlled by many variables, including global circulation, continental configuration, and larval ecology. Recent paleogeographic reconstructions (e.g., Scotese and McKerrow, 1990) have positioned northern Alaska at a moderate angle to the paleoequator during the early Paleozoic, so biotic differentiation in pre-Carboniferous strata may reflect, at least in part, latitudinally controlled ecologic variation.

The most precise biogeographic studies compare fossils of the same age and depositional environment and consider all elements of a given fauna. The "Siberian" trilobites in the central Brooks Range are of early Middle Cambrian age, whereas the "North American" trilobites in the northeastern Brooks Range are Early and Late Cambrian in age. Trilobites of exactly the same age have not been found in the two areas, and conclusions based on non-coeval species may be misleading. Ordovician conodont faunas also show temporal variations in biogeographic affinities; in most north Alaskan successions, "Siberian" faunal elements in lower Upper Ordovician strata give way to "North American" faunal elements in uppermost Ordovician rocks.

It is also important to consider the biogeographic implications of as many fossil groups as possible within a given fauna. For example, the distribution of a variety of Late Ordovician brachiopod and gastropod species led Blodgett et al. (1992) to argue that Arctic Alaska, the Seward Peninsula, and Chukotka formed a single tectonic block in early Paleozoic time, with faunal ties to the Kolyma region.

If northern Alaska represented a collage of distinct crustal fragments, one would expect to find "Siberian" faunas throughout one carbonate succession and "North American" faunas throughout another. This pattern is not observed. Rather, both "Siberian" and "North American" faunal affinities occur at different times and in different fossil groups within all of the (meta)carbonate successions discussed above. "Siberian" influences are particularly noteworthy in Middle Cambrian and early Late Ordovician time. This interpretation agrees well with the Phanerozoic plate tectonic reconstructions of Scotese and McKerrow (1990). They treat northern Alaska-Chukotka as a discrete continental block that lay between Siberia and North America throughout the early Paleozoic. Their reconstructions indicate particular proximity between Siberia and Alaska during Late Ordovician time.

CONCLUSIONS

In our view, available lithologic and paleobiogeographic data from northern Alaska are best explained by postulating that pre-Carboniferous carbonate successions accumulated on a single continental margin or platform that had faunal exchange with both Siberia and North America. During Early and Middle Ordovician time, an intracratonic basin developed along part of the north Alaskan margin (eastern Baird and Snowden successions) while carbonate platform deposition continued elsewhere (York, western Baird, and Shublik-Sadlerochit successions). By Late Ordovician time, shallow-water carbonate deposition had spread again across the north Alaska margin; these conditions persisted, with some interruptions, through at least the Early Devonian.

Thus, our comparisons of the lithology, biofacies, and biogeographic affinities of pre-Carboniferous (meta)carbonate successions across northern Alaska suggest these rocks represent a single carbonate platform or continental margin dismembered by later tectonic events, rather than a collage of "exotic terranes."

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