DEEP-WATER FACIES OF THE LISBURNE GROUP, WEST-CENTRAL BROOKS RANGE, ALASKA

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ABSTRACT

Deep-water lithofacies of the Lisburne Group (chiefly Carboniferous) occur in thrust sheets in the western part of the foreland fold-and-thrust belt of the Brooks Range and represent at least three discrete units. The Kuna Formation (Brooks Range allochthon) consists mostly of spiculitic mudstone and lesser shale; subordinate carbonate layers are chiefly diagenetic dolomite. The Akmalik Chert (Picnic Creek allochthon) is mostly radiolarian-spiculitic chert; rare limy beds are calcitized radiolarite. The Rim Butte unit (Ipnavik River allochthon) consists chiefly of calcareous turbidites, derived from shallow- and deep-water sources, interbedded with spiculitic mudstone. Much of the material in the turbidites came from a contemporaneous carbonate platform and margin, but some fossils and lithic clasts were eroded from older, already lithified carbonate-platform rocks. All three units appear to be roughly coeval in the Howard Pass area and are chiefly late Tournaisian and early Viséan (late Early Mississippian) in age.

Shallow-water lithofacies of the Lisburne Group exposed in the Howard Pass area (Brooks Range allochthon) are mostly of Viséan and younger (Late Mississippian) age. Thus, these carbonate-platform rocks were not the source of the calcareous turbidites in the Rim Butte unit. Rim Butte turbidites could have been derived from older carbonate-platform rocks such as the Utukok Formation of Tournaisian age (Kelly River allochthon) exposed mainly to the west of the Howard Pass quadrangle.

INTRODUCTION

The chiefly Carboniferous Lisburne Group is a dominantly carbonate-platform sequence exposed in the foreland fold-and-thrust belt of the Brooks Range (Fig.1). Deeper water facies (i.e., sediments deposited below the photic zone, probably at depths of 100 m or greater) occur within this group, particularly in the western Brooks Range. In this paper, we describe deep-water Lisburne lithofacies found in the west-central Brooks Range. Previous workers (e.g., Mayfield et al., 1988) considered these facies to be largely **younger** than nearby outcrops of the platform facies, but our work suggests that, in the Howard Pass area, the deeper water facies chiefly are **older** than nearby platform facies.

The deep-water carbonate rocks considered here belong to three units: the Kuna Formation, the Akmalik Chert, and the Rim Butte unit. In the structural framework of Mayfield et al. (1988), the rocks comprising these units were assigned to three discrete structural sequences or allochthons. The allochthons are distinguished on the basis of inferred structural level and differences in lithologic succession; differences are most

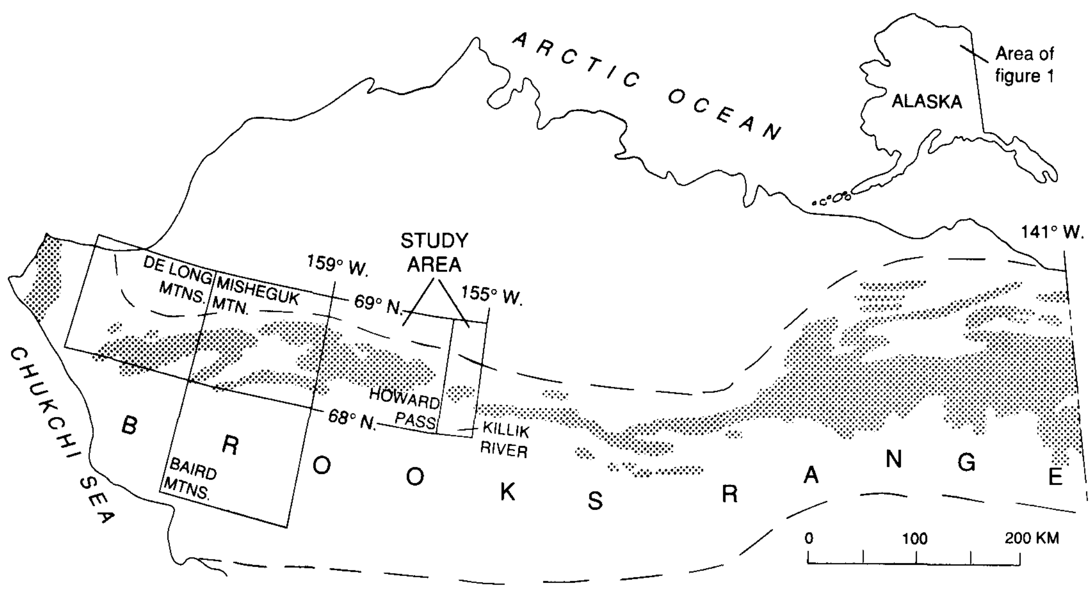

Fig.1. Distribution of the Lisburne Group in northern Alaska (generalized from Armstrong and Mamet, 1978) and location of quadrangles mentioned in text.

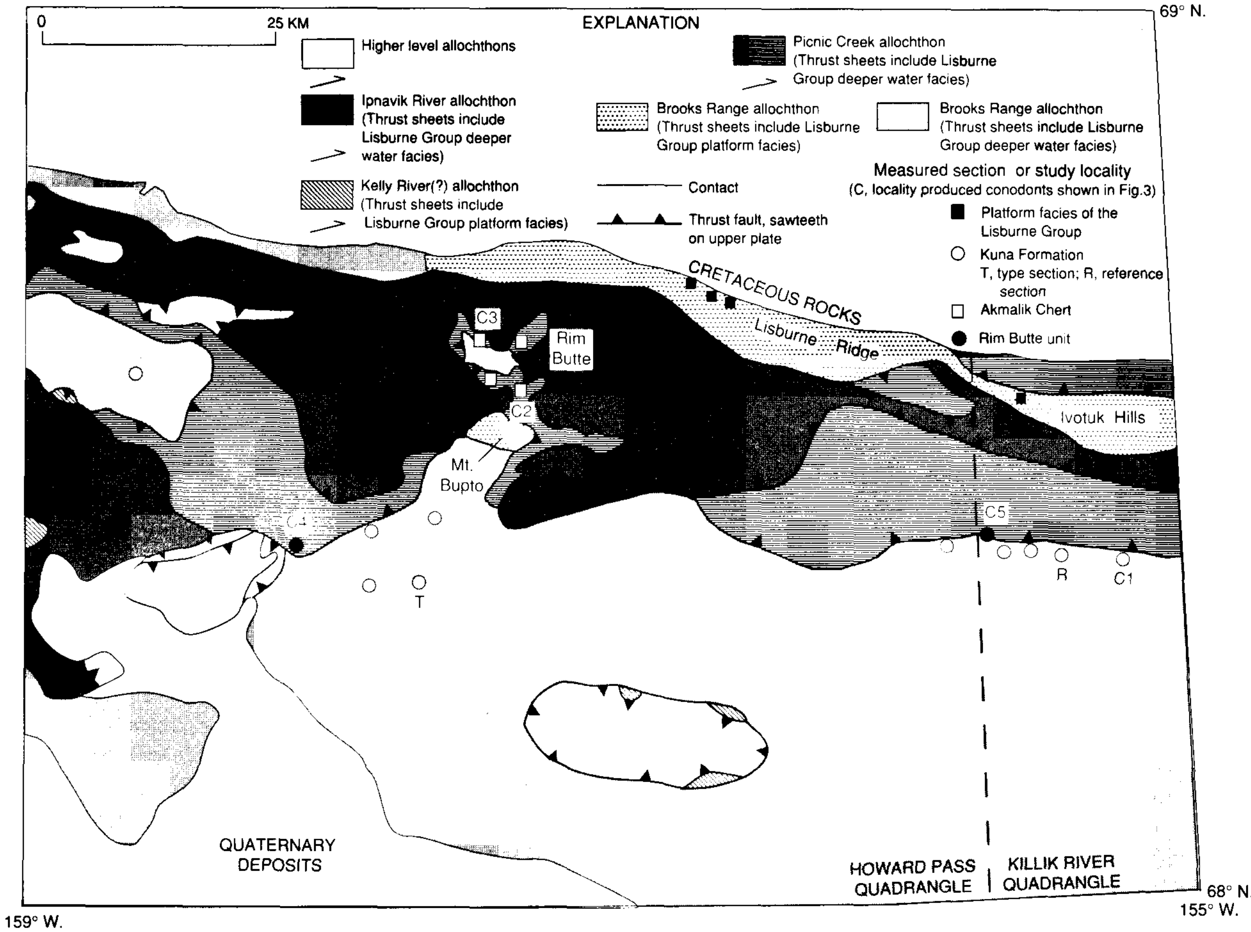

Fig.2. Distribution of allochthons, slightly modified from Mayfield et al. (1988), and location of measured sections and lithologic and fossil collections in the Howard Pass and western Killik River quadrangles. Allochthons may include thrust sheets of other allochthons too small to show at the scale of this map.

pronounced in the Carboniferous facies. The distribution of these allochthons in the study area is shown in Fig.2. Platform facies of the Lisburne Group, as well as deeper water facies of the Kuna Formation, were assigned to the Brooks Range allochthon (equivalent to Endicott Mountains allochthon of the central Brooks Range, e.g., Mull et al., 1987). Chert and limestone equivalent to the Akmalik Chert is part of the Picnic Creek allochthon, and the Rim Butte unit is part of the Ipnavik River allochthon.

The findings described here are based on measured sections and outcrop studies (Fig.2); petrographic descriptions are based on field observations and examination of about 200 thin sections.

KUNA FORMATION

The Kuna Formation was examined across the study area (Fig.2), where it is at most 70 m thick; outcrops investigated include the type section and a reference section established by Mull et al. (1982). The Kuna depositionally overlies the Kayak Shale (lowermost Carboniferous) and generally underlies fine-grained sedimentary rocks of the Etivluk Group (upper Carboniferous to Jurassic). Locally, the upper contact of the Kuna is a fault.

As originally defined (Mull et al., 1982), the Kuna Formation consists of black carbonaceous shale, black chert, fine-grained limestone, and dolostone. In the study area, some Kuna sections consist chiefly of black, carbonaceous, noncalcareous shale. Most sections of the Kuna examined in this study, however, consist primarily of siliceous mudstone with subordinate (5 to 20%) shale. Mudstone beds are even to irregular and 2 to 20 cm thick; shale intervals generally are a few centimeters or less. The thicker beds, called chert by some previous workers (e.g., Mull et al., 1982), are siliceous mudstone, not true chert; they have an earthy rather than vitreous luster and do not fracture conchoidally. In thin section, they contain abundant biosiliceous material, chiefly sponge spicules but also subordinate radiolarians, in a matrix of organic-rich mud.

Fine lamination is the only sedimentary structure visible in most outcrops of the Kuna Formation. Laminae consist of local concentrations of sand- to silt-sized clasts, mostly of mudstone, or alternating concentrations of sponge spicules and mud. Most laminated intervals probably represent distal turbidites, or lags left by bottom currents. Preservation of these laminae, as well as the apparently high organic content of much of the Kuna, suggest that anoxic or dysaerobic bottom-water conditions prevailed during its deposition. Some intervals within the Kuna are burrowed, however, so oxygen levels at the sediment-water interface were locally or periodically high enough to support a bottom fauna.

Carbonate forms 30 percent or less of most outcrops of the Kuna Formation that we studied. Carbonate occurs as concretions or more continuous layers a few millimeters to 30 cm thick. Primary calcareous material such as bioclasts were not seen. Thin-section observations indicate that almost all carbonate now present in the Kuna is of diagenetic origin. Most carbonate layers consist of 80 percent or more euhedral crystals of dolomite in a mudstone matrix; crystals are 16 to 200 μm across. Dolomite is an important component of many organic-rich marine sediments because microbial activity in these sediments reduces sulfate and allows dolomite to form (Baker and Kastner, 1981). Such marine dolomite typically replaces calcite; in the kuna samples, dolomite crystals may have replaced fine-grained calcitic bioclasts and bioclast fragments deposited by turbidity currents. Textural relationships observed in outcrop and thin section indicate that dolomite formed prior to silicification.

Other carbonate occurrences in the Kuna Formation include calcitized radiolarite. Radiolarians generally make up 30 to 80 percent of these samples. Tests occur in a calcite matrix; most tests have been completely replaced by calcite, but concentrations of organic matter and (or) pyrite preserve details of the original test structure. Samples richest in radiolarians are graded and laminated and were probably deposited by turbidity currents.

Fossils other than sponge spicules and radiolarians are rare in the Kuna Formation and include no forms restricted to shallow-water carbonate-platform environments. Concentrations of long-ranging productid brachiopods occur locally and probably represent storm deposits. Some carbonate samples are rich in conodonts, primarily representatives of *Bispathodus utahensis* Sandberg and Gutschick (Fig.3*A*, *B*). This pelagic species probably lived in the more oxygenated upper part of the water column above the dysaerobic to anoxic basin floor. A sample from a concretion 9 m above the base of the type section of the Kuna produced a rich, well-preserved fauna indicative of the lower part of the *anchoralis-latus* Zone (late Tournaisian) (Fig.3*C*-*G*). The highest collection from the type section of the Kuna, 6 m below the contact with the Etivluk Group, contains conodonts of late Tournaisian or early Viséan age (Fig.3*H*).

Conodonts suggest that the Kuna Formation in the Howard Pass area is chiefly late Tournaisian in age (Fig.4), and probably no younger than early Viséan. Radiolarians are poorly preserved and do not refine this age. Conodont faunas of middle and late Tournaisian ages have also been reported from the Kuna in the De Long Mountains quadrangle to the west (Fig.1; e.g., Curtis et al., 1990). However, siliceous strata assigned to the uppermost part of the Kuna in the De Long Mountains may be slightly younger; these strata yield radiolarians of early Viséan(?) to Bashkirian (Late Mississippian to early Middle Pennsylvanian) age (Murchey et al., 1988, Table 32.3). No post-early Carboniferous faunas have been recovered from the Kuna in the Howard Pass area.

AKMALIK CHERT

The Akmalik Chert--defined by Mull et al. (1987) in the Killik River quadrangle--consists of bedded black chert and minor black mudstone, black shale, and dolomitic limestone; it overlies the Kayak Shale and underlies the Etivluk Group. In the central part of the Howard Pass quadrangle (Fig.2), the Akmalik is at most a few tens of meters thick. Much of the unit is true chert; samples are vitreous and contain little argillaceous matter. Siliceous microfossils are abundant, and radiolarians are more common than sponge spicules. Carbonate beds are rare, consist of calcitized radiolarite, and make up at most a few percent of the unit. The abundance of radiolarians relative to sponge spicules and the rarity of mud suggest the Akmalik formed in deeper water than the Kuna Formation or farther from clastic input.

The Akmalik Chert in the central Howard Pass quadrangle contains conodonts of late Tournaisian or early Viséan, probably early Viséan, age (Fig.4; Dumoulin et al., 1993). Conodonts are relatively rare and only a few specimens, such as *Bispathodus utahensis*, *Gnathodus semiglaber* Bischoff (Fig.3*L*), and small fragments of "*Hindeodella*" *segaformis* Bischoff s.f. (an index species of the *anchoralis-latus* Zone) are identifiable (Fig.3*I*-*K*). The conodont assemblage in the Akmalik Chert represents a mixture of shallow-water platform-to-slope biofacies as well as some pelagic elements. Mestognathids and cavusgnathids, among other conodonts (Figs.3*M*, *N*), represent relatively shallow-water platform biofacies, whereas scaliognathids and gnathodids are characteristic of deeper platform and slope biofacies. The preservation characteristics and species composition of the Akmalik conodonts indicate basinward transport by turbidity currents (compare the

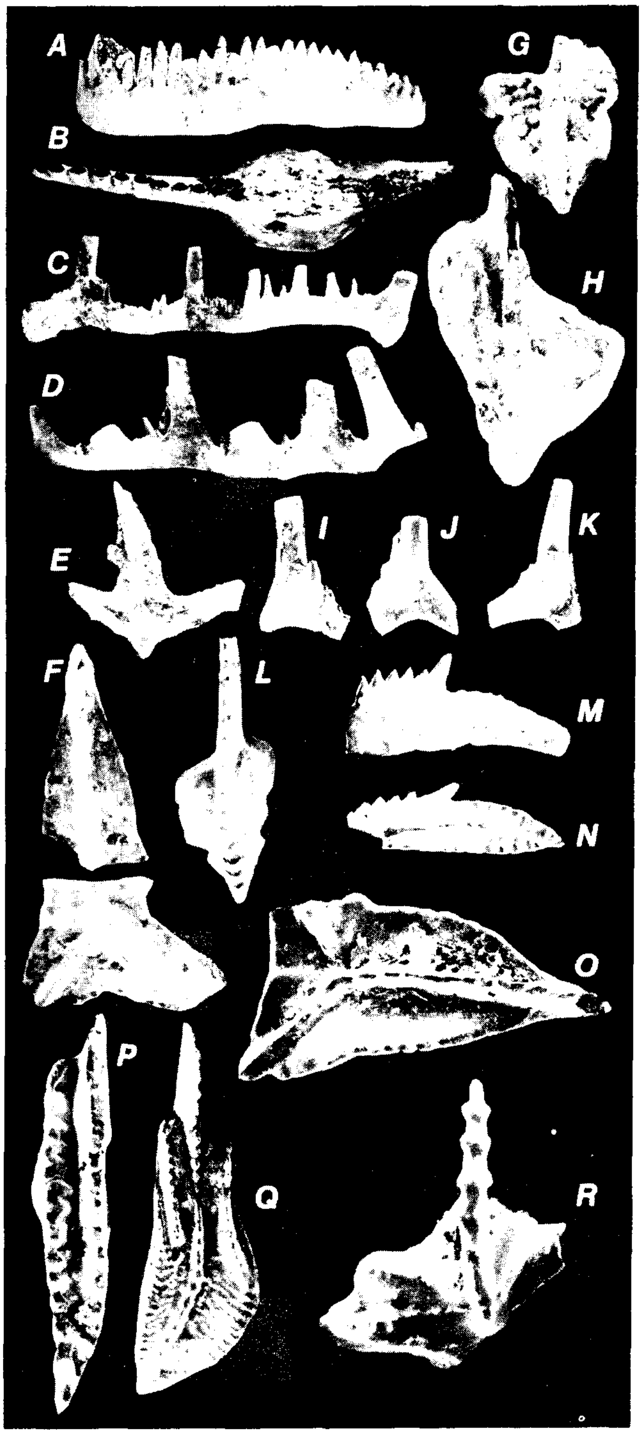

Fig.3. Early Carboniferous conodonts from deep-water facies of the Lisburne Group. Specimens reposited in U.S. National Museum, Washington, D.C. (USNM); all are Pa elements unless otherwise noted.
***A-H*, From the Kuna Formation. *A, B, Bispathodus utahensis* Sandberg & Gutschick, outer lateral and upper views, X30 and X40, USNM 477370, 69, USGS colln. 31738-PC (Fig.2, loc. C1). *C-H*, From type section of the Kuna Formation. *C-G*, 9 m above base of section, USGS colln. 31781-PC, X40, except *F* is X20. The overlapping ranges of species restrict this collection to the lower *anchoralis-latus* Zone. *C, D, "Hindeo-della" segaformis* Bischoff s.f., Sa element and bar fragment, lateral views, USNM 476030, 31. *E, Scaliognathus anchoralis* Branson & Mehl, morphotype 2, lower view, USNM 476032.**
***F, Doliognathus latus* Branson & Mehl, morphotype 3, upper views of two fragments, USNM 476033, 34. *G, Protognathodus cordiformis* Lane, Sandberg & Ziegler, upper view, USNM 476035. *H*, 62 m above base of type section, USGS colln. 31782-PC, *Gnathodus pseudo-semiglaber* Thompson & Fellows, upper view, X40, USNM 476036.**
***I-N*, From Akmalik Chert, X40. *I-K, "H." segaformis*, bar fragments, lateral views, USNM 473783-85, USGS colln. 31722-PC (Fig.2, loc. C2).**
***L-N*, from USGS colln. 31767 (Fig.2, loc. C3). *L, Gnathodus semiglaber* Bischoff, upper view, USNM 473779. *M, N, Mestognathus praebeckmanni* Sandberg and others, inner lateral and upper views, USNM 473781.**
***O-R*, From Rim Butte unit. *O-Q*, middle Viséan conodonts and redeposited middle and late Tournaisian forms from USGS colln. 31753-PC (Fig.2, loc. C4). *O, Doliognathus latus* Branson & Mehl, morphotype 3, upper view, X40, USNM 473792 (redeposited late Tournaisian species). *P, Cavusgnathus unicornis* Youngquist & Miller, upper view, X60, USNM 473790. *Q, Siphonodella isosticha* (Cooper) trans. to *S. obsoleta* Hass, upper view, X40, USNM 473795 (redeposited middle Tournaisian species). *R, Dollymae hassi* Voges, upper view, X60, USNM 473806, USGS colln. 31724-PC (Fig.2, loc. C5).**

nearly complete specimen of *"H." segaformis* from the Kuna Formation to the small fragments of this species in the Akmalik; Figs.3*C, D* versus 3*I-K*).

Mull et al. (1987) considered the Akmalik Chert in the central Killik River quadrangle to be early to early late Carboniferous in age on the basis of plant fossils, radiolarians, and conodonts. No fossils of latest early Carboniferous or younger age have been found in the Akmalik Chert in the Howard Pass quadrangle.

RIM BUTTE UNIT

The Rim Butte unit (Dumoulin et al., 1993) of the Lisburne Group is exposed mainly in thrust sheets of the Ipnavik River allochthon (Fig.2). In the Howard Pass area, this unit consists of 70 to 80 m of fine-grained calcareous and siliceous rocks which are abundantly intruded by 5- to 15-m-thick, locally vesicular, mafic igneous sills. The base of the Rim Butte unit is generally faulted or not exposed, but a gradational contact with the overlying Etivluk Group was observed locally. Mayfield et al. (1988) indicated that rocks here referred to the Rim Butte unit overlie the Kayak Shale.

The Rim Butte unit is distinctively thin bedded and rhythmically color banded. Lighter layers are limestone, and darker layers are siliceous mudstone. The darker layers contain abundant siliceous sponge spicules and are lithologically identical to the siliceous mudstone that forms much of the Kuna Formation. We interpret these layers as the "background" sediment that was accumulating in the Rim Butte and Kuna basin(s).

The limy layers are carbonate turbidites. They consist of complete or base-cut-out Bouma sequences, with sole-marked basal contacts. Lower parts of beds typically are graded and cross-laminated. Upper parts of beds are laminated, and bed-tops generally are bioturbated. The limestone/mudstone ratio varies from outcrop to outcrop and within a single section; limestone comprises 15 to 70 percent of the sections studied and forms beds 80 cm or less in thickness. Redeposited material in these beds consists chiefly of sand- to silt-sized calcareous and lesser siliceous bioclasts. Bioclasts include typically shallow-water forms, such as foraminifers and echinoderm and bryozoan debris, as well as grains of deeper water provenance, such as radiolarians and siliceous sponge spicules. Abundance of specific bioclasts varies from bed to bed. Carbonate turbidites of the Rim Butte unit also contain sedimentary lithic clasts, and some samples include as much as 10 to 15 percent detrital quartz.

Little paleontologic information has previously been reported from these rocks. Our conodont collections indicate that, in the Howard Pass quadrangle, the Rim Butte unit is no older than late Tournaisian to middle Viséan in age (Fig.4). In addition to late Tournaisian conodonts (Fig.3*R*), many Rim Butte turbidites contain some redeposited middle Tournaisian forms, chiefly *Siphonodella* and *Gnathodus* (Fig.3*Q*). These redeposited conodonts indicate that the Rim Butte turbidites were partly derived from erosion of older strata.

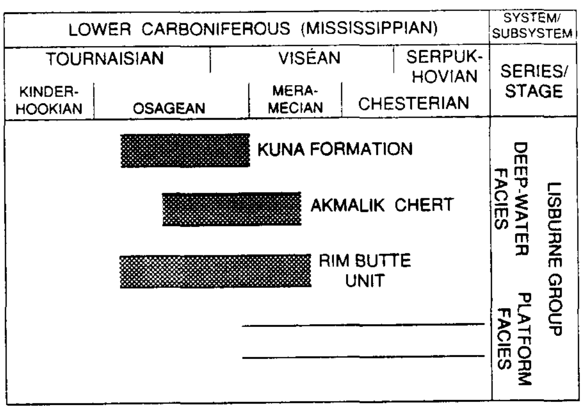

Fig.4. Age range of deep-water and platform facies of the Lisburne Group in the Howard Pass and western Killik River quadrangles on the basis of localities shown in Fig.2.

One turbidite of the Rim Butte unit (the westernmost sample) produced conodonts of no older age than middle Viséan (Fig.3*P*) together with abundant redeposited forms of middle and late Tournaisian age (Fig.3*O*, *Q*). The late Tournaisian conodonts in this younger Rim Butte sample could have been derived from older Rim Butte deposits. The presence of redeposited conodonts in Rim Butte turbidites raises the possibility that none of the conodonts are indigenous and that they merely indicate a maximum possible age.

Conodont-biofacies analysis supports the interpretations of depositional environment outlined above. The late Tournaisian conodonts represent a mixture of forms characteristic of open-marine, moderate-depth, platform-to-slope biofacies, along with a few shallow-water forms. The species diversity and lack of dominance by one or two genera indicate postmortem hydraulic mixing of conodonts from several biofacies and strongly support our interpretation of deposition by turbidity currents in a slope to basinal environment.

DISCUSSION

The age and lithofacies of the deep-water units of the Lisburne Group discussed above offer new constraints for paleogeographic reconstructions of the western Brooks Range. Some previous workers (e.g., Mayfield et al., 1988) interpreted deep-water Lisburne facies in the Howard Pass area as in part coeval with, but chiefly younger than, Lisburne carbonate-platform rocks exposed in the same area and inferred that most Carboniferous successions deepened upward.

Our data suggest a more complicated paleogeography and (or) geologic history for the Howard Pass region. In this area, platform carbonate rocks of the Lisburne Group (included in the Brooks Range allochthon of Mayfield et al., 1988) are exposed at Mount Bupto, Lisburne Ridge, and in the Ivotuk Hills (Fig.2). Megafossil data from Mount Bupto and Lisburne Ridge (Armstrong, 1970) and conodonts from Lisburne Ridge and the Ivotuk Hills (Dumoulin et al., 1993) indicate that these platform sequences are primarily Viséan and locally as young as Serpukhovian in age. That is, they are chiefly **younger** than the deep-water Lisburne facies in the Howard Pass area discussed above (Fig.4). Thus, in at least some parts of the west-central Brooks Range, shallow-water Carboniferous carbonate strata may have been deposited above older, deeper water deposits.

Conodont-age data reported above also indicate that these younger (Viséan) carbonate-platform rocks could not have provided a source for the older (Tournaisian) carbonate material in the Rim Butte unit. Strata of the appropriate age, lithofacies, and biofacies to produce the carbonate turbidites of the Rim Butte unit are exposed in thrust sheets farther west, such as those of the Kelly River allochthon. This allochthon includes a virtually continuous sequence of Middle Devonian through Viséan carbonate-platform rocks (Dumoulin and Harris, 1992), including the Utukok Formation of Tournaisian age. Shallow-water, locally quartzose, carbonate-shelf deposits of the Utukok contain a diverse biota including foraminifers, bryozoans, echinoderms, and conodonts (Dumoulin and Harris, 1992). Both *Siphonodella* and *Gnathodus*, the middle Tournaisian conodonts found in Rim Butte turbidites, occur in the Utukok Formation in the Baird and De Long Mountains quadrangles (Fig.1; Dumoulin and Harris, 1992).

Exposures of carbonate rocks assigned to the Kelly River allochthon are rare in the Howard Pass quadrangle (Fig.2) but are more widely distributed to the west and southwest, in the Misheguk Mountain and Baird Mountains quadrangles (Fig.1; Mayfield et al., 1988; Dumoulin and Harris, 1992). In the Paleozoic paleogeographic and tectonic reconstruction of the western Brooks Range proposed by Mayfield et al. (1988), rocks of the Ipnavik River allochthon are restored to a position immediately south of rocks of the Kelly River allochthon. Paleocurrent data and additional conodont collections over a wider geographic area are needed to test the proposed relationship between the Rim Butte unit and the Utukok Formation. However, the match in age, lithofacies, biofacies, and individual conodont genera between these two units suggests that the Utukok Formation is a likely source for at least some of the carbonate detritus in the turbidites of the Rim Butte unit.

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