GEOLOGICAL SURVEY RESEARCH 1971

Chapter B

GEOLOGICAL SURVEY PROFESSIONAL PAPER 750–B

Scientific notes and summaries of investigations in geology, hydrology, and related fields

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GEOLOGICAL SURVEY RESEARCH 1971

This collection of 46 short papers is the first published chapter of "Geological Survey Research 1971." The papers report on scientific and economic results of current work by members of the Geologic and Water Resources Divisions of the U.S. Geological Survey.

Chapter A, to be published later in the year, will present a summary of significant results of work done in fiscal year 1971, together with lists of investigations in progress, reports published, cooperating agencies, and Geological Survey offices.

"Geological Survey Research 1971" is the twelfth volume of the annual series Geological Survey Research. The eleven volumes already published are listed below, with their series designations.

Geological Survey Research	*Prof. Paper*
1960	400
1961	424
1962	450
1963	475
1964	501
1965	525
1966	550
1967	575
1968	600
1969	650
1970	700

LISBURNE GROUP, CAPE LEWIS–NIAK CREEK, NORTHWESTERN ALASKA

By A. K. ARMSTRONG, B. L. MAMET,[1] and J. THOMAS DUTRO, Jr.,
Menlo Park, Calif., Montreal, Canada, Washington, D.C.

Abstract.—Sections of Lisburne Group, Carboniferous (Mississipian), were measured in structurally complex terrane on rootless allochthonous thrust sheets. Exposures at Cape Lewis exceed 3,100 stratigraphic feet and consist of 1,284 feet of Viséan (lower Chester) shales and carbonates of the Nasorak Formation and 1,864 feet of "Namurian" (middle and upper Chester) carbonates of the Kogruk Formation. An incomplete 215-foot-thick section of the Nasorak Formation at Niak Creek is uppermost Meramec, lowermost Chester equivalent. On an underlying thrust sheet at Niak Creek, an incomplete section of the Kogruk Formation is 715 feet thick and is a Meramec age equivalent. Within these sections six foraminiferal assemblage zones are recognized and tied to the Cordilleran and Eurasian standards. A fauna of 14 taxa of lithostrotionoid carols is also present in the beds of Meramec and earliest Chester age. Corals are rare in beds younger than earliest Chester.

In 1968 Dutro and Armstrong measured and collected samples from five sections of the Lisburne Group on sea cliffs adjacent to the Arctic Ocean in northwestern Alaska (figs. 1 and 2). Carbonate classification used is Dunham's (1962). All the exposures studied are on rootless thrust sheets. The sea cliffs afford excellent exposures of these rocks, whereas inland, on the rubble-covered slopes of the Lisburne Hills, the Lisburne Group is very poorly exposed.

The 3,100-foot-thick composite section at Cape Lewis is formed by three measured sections, 68A–9, 68A–10, and 68A–11. These sections are believed to be one thrust sheet and make up a nearly complete representation of the Lisburne Group. The Cape Lewis section is truncated at its base by structurally complex terrane and tundra cover; the top of the section is tundra cover and a possible thrust fault surface (figs. 3, 4).

The two sections near Niak Creek are incomplete partial sections of the Lisburne Group. Section 68A–12, north of Niak Creek, is 715 feet thick. The base of the section is above a thick tectonic breccia zone and the top is a thrust fault surface (fig. 5*A*). Section 68A–13, south of Niak Creek, is 215 feet thick and is bounded by faults (fig. 5).

A foraminiferal zonation for the Lisburne Group in the central and eastern Brooks Range was established by Armstrong, Mamet, and Dutro (1970). The geographic and biostratigraphic relations of the measured sections on the sea cliffs of northwestern Alaska to the

[1] Université de Montréal.

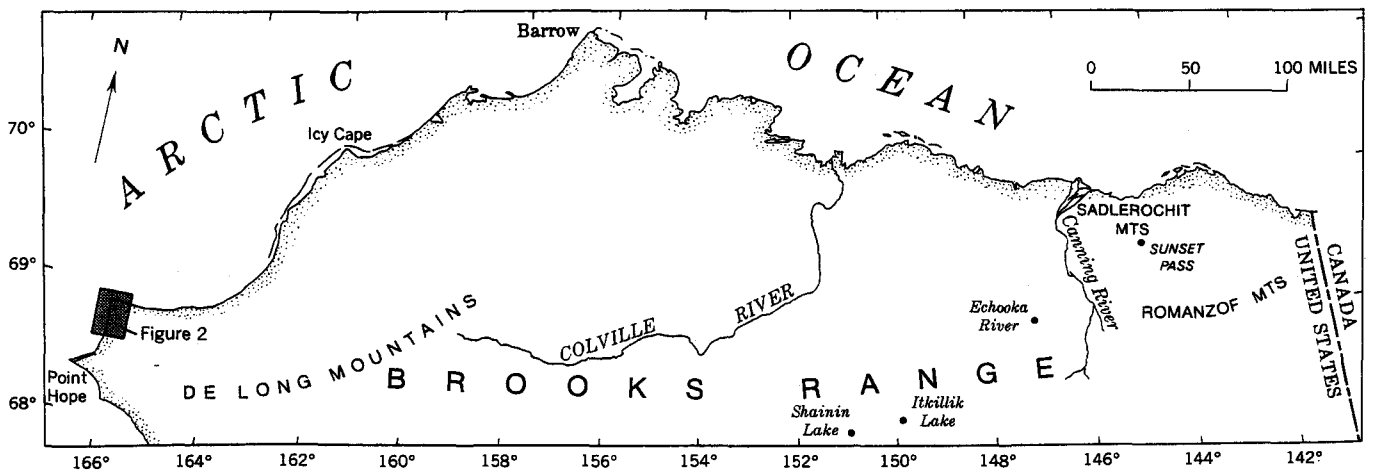


FIGURE 1.—Index map of arctic Alaska, showing location of sections referred to in figures 2 and 6.

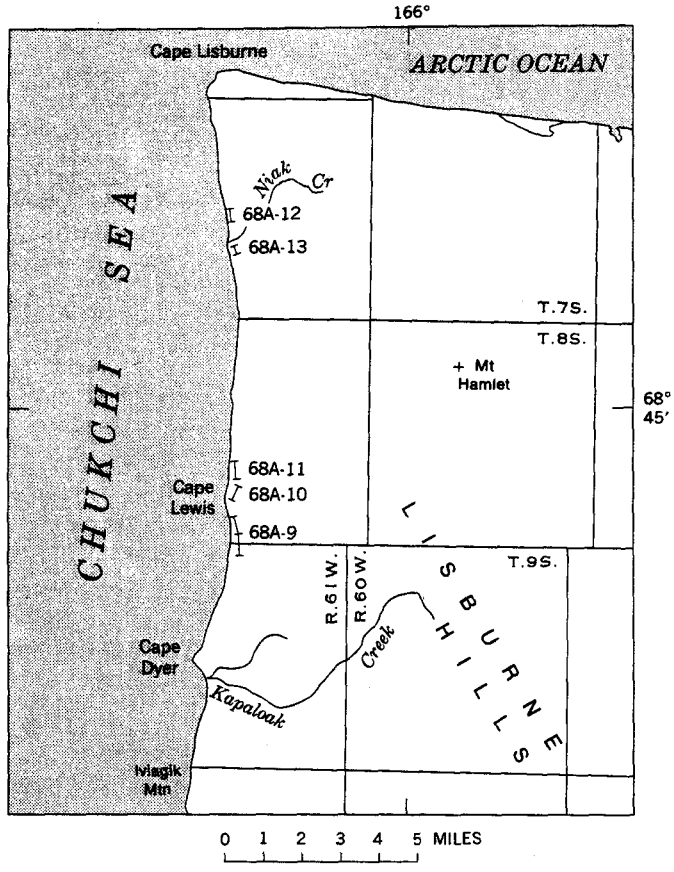


FIGURE 2.—Index map showing location of measured sections described.

Lisburne Group of the central and eastern Brooks Range is shown in figures 1 and 6.

The oldest carbonate rock found in the sea cliff sections is at the base of section 68A–12, north of Niak Creek. These rocks now rest on a thick zone of tectonic breccias. Undoubtedly, there were older carbonates in this section before the tectonic activity that produced the thick breccia zone (fig. 5*A*). The higher beds of section 68A–12 are extensively dolomitized; the Foraminifera present indicate an undetermined Viséan age for this interval.

Section 68A–13, on the south side of Niak Creek, is on a higher thrust sheet which overrides the thrust sheet bearing section 68A–12. Below the base of section 68A–13 is a sequence of paralic sediments: dark-gray shales, coals, siltstones, and sandstones. These sediments appear to be in gradational contact with the marine limestones of section 68A–13. Detailed study of these paralic clastic sediments is difficult because exposures are poor, and there are numerous small folds and faults. The Foraminifera of section 68A–13 are of late zone 15 and represent an age near or equivalent of the Meramec-Chester boundary.

The thick composite section at Cape Lewis comprising sections 68A–9, 68A–10, and 68A–11 is about 3,100 feet thick; microfossils indicate a late Viséan age (early Chester), zone 16_1 at the base and a "Namurian" zone 18 (late Chester) in the youngest exposed beds. As the top of section 68A–11 is covered by soil and tundra, beds younger than zone 18 may be present in the Kogruk Formation.

NASORAK FORMATION

The Nasorak Formation was named by Campbell (1967, p. 7), who designated as its type section a section in a sea cliff adjacent to the mouth of Nasorak Creek near Cape Thompson.

South of Cape Lewis, the Nasorak Formation is exposed in the sea cliffs (fig. 3*A*), where 1,282 feet of the lower part of section 68A–9 was assigned to this formation (figs. 4*A*, *B*). At this locality the Nasorak Formation can be divided into four lithic units.

The base of the measured section begins at or on the beach. Neither the composition nor the age of the underlying rocks is known, but they probably are Mississippian clastic rocks deposited in paralic or continental environments. The lowest unit consists of 355 feet of shales, siltstones, argillaceous limestones, limestones, and minor amounts of sandstones. The limestones and shale beds are generally 1 to 5 feet thick.

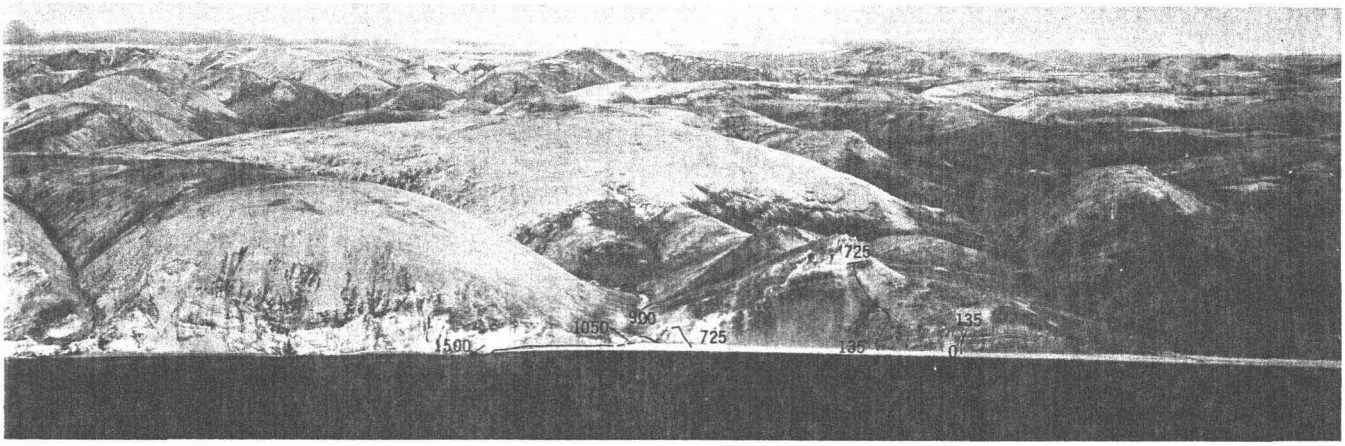
Unit 2, which is 295 feet thick, is composed primarily of dark-gray shales with lesser amounts of siltstone and sandstone. A massive limestone, about 15 feet thick, occurs near the middle of the unit. This limestone is overlain by gray to medium-brown calcareous shales that have a gradational contact with the massive cherty limestones of unit 3 (fig. 4*A*).

This dark-gray carbonaceous shale zone could possibly, under proper conditions, be a source bed for petroleum.

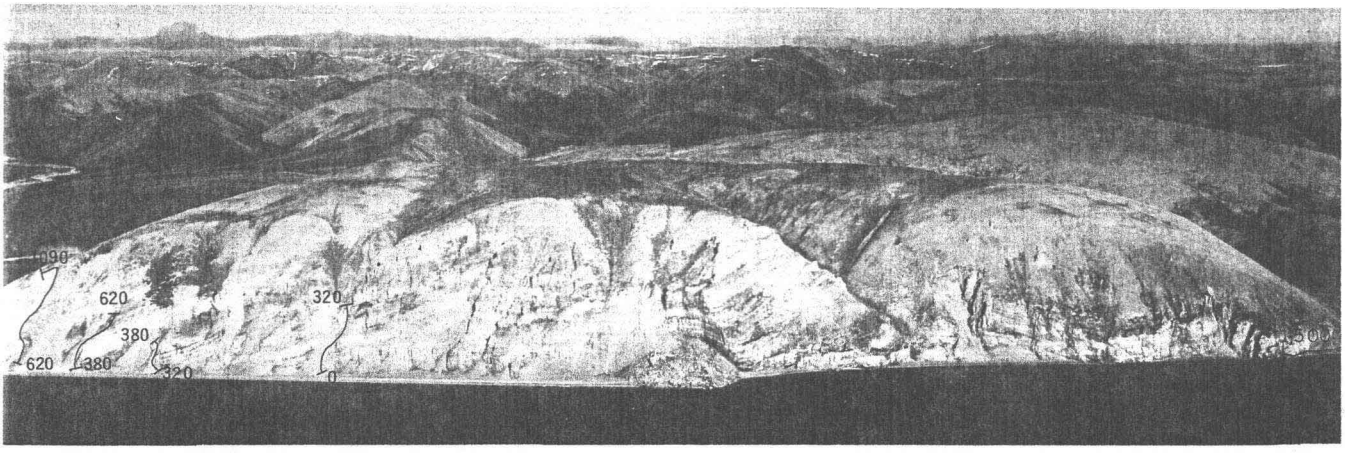
Unit 3 consists of 250 feet of massive-bedded light-gray to gray echinoderm-bryozoan packstone. Two covered intervals, 15 and 35 feet thick, are present (fig. 4*A*). The top of unit 3 is marked by a creek bed. The highest 20 feet of the unit contains a large number of lithostrotionoid corals. The gravel and soil associated with the creek bed covers some 150 stratigraphic feet of section.

Unit 4 is 232 feet thick. The base, exposed on the north side of the creek, is a 15-foot-thick sequence of thin-bedded gray limy mudstones and gray calcareous shales. The next 51 feet is covered. This is followed by 164 feet of shales, calcareous gray shales, and thin-bedded argillaceous lime mudstones.

The top of the Nasorak Formation at Cape Lewis was picked at the occurrence of the first massive gray



A



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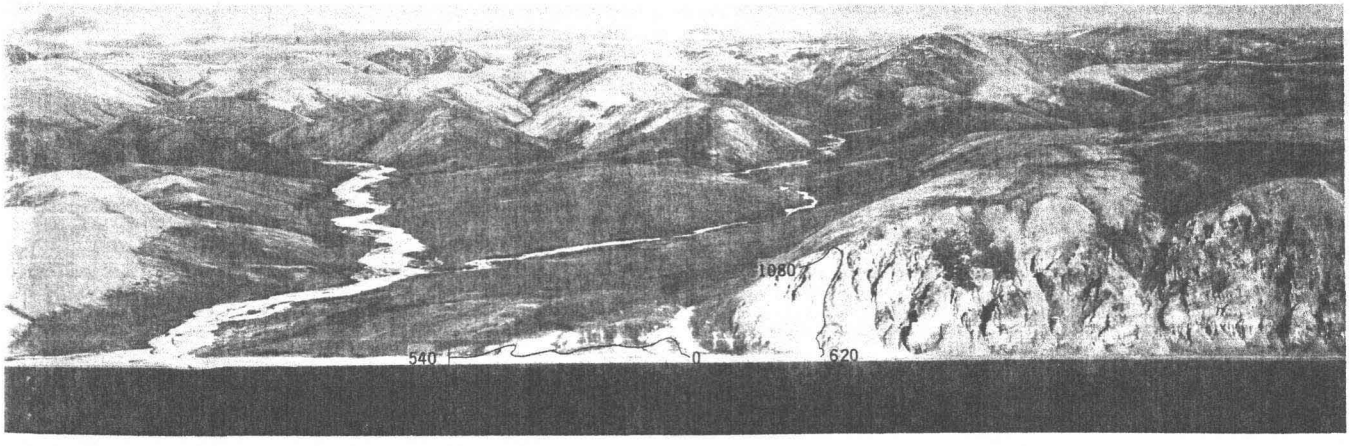

C

FIGURE 3.—Cape Lewis, oblique view to the east.

A, South end of sea cliff, showing location of section 68A–9.
B, Middle part of sea cliff, showing location of section 68A–10.
C, North end of sea cliff, 0–540, showing location of section 68A–11. The section marked "620–1090" is the upper part of section 68A–10 (See *B*).

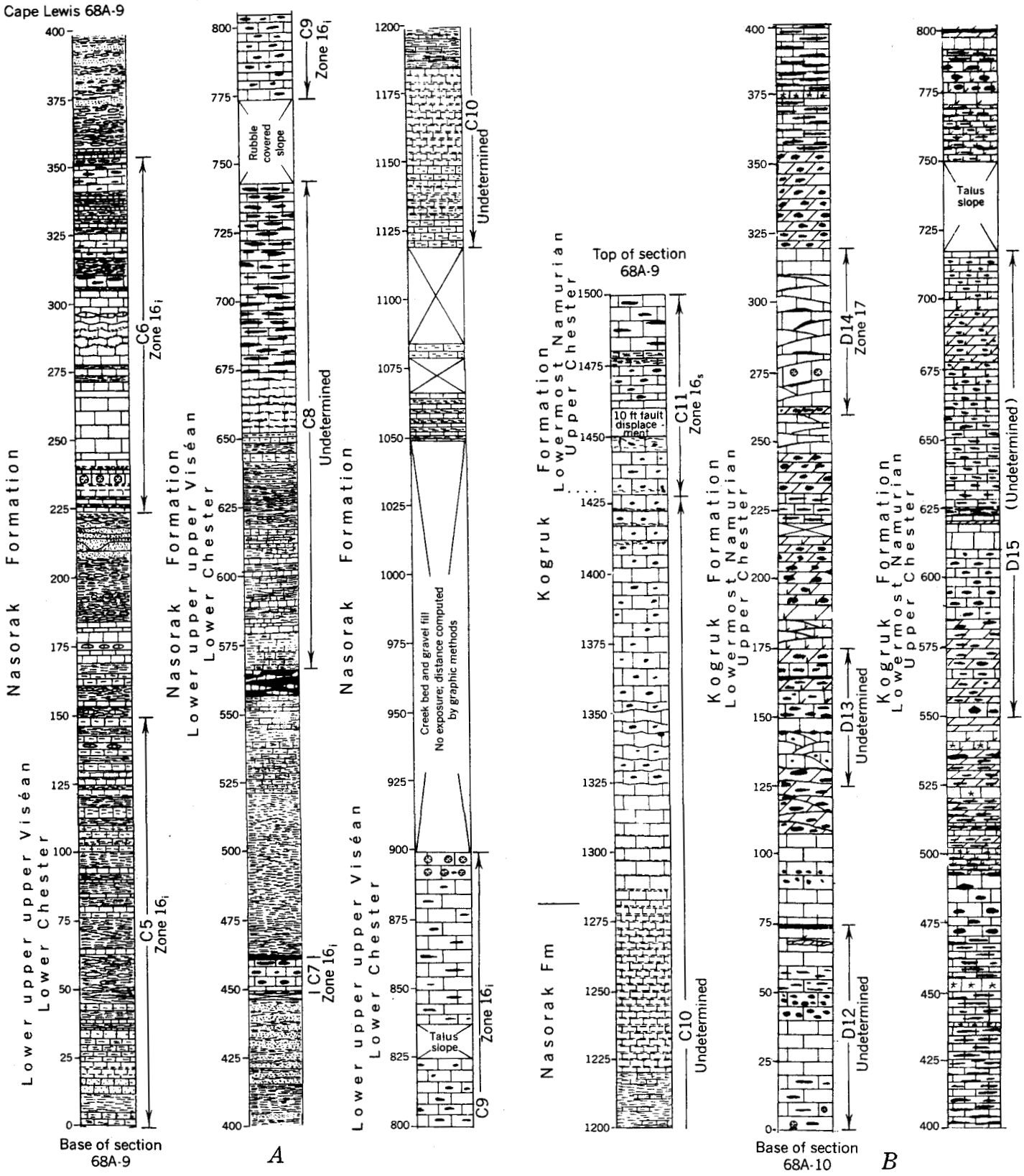

FIGURE 4.—Stratigraphic sections at Cape Lewis. Microfossil collections C5 to E17 shown in the section "Microfossil Lists."
A, Stratigraphic section 68A–9, Nasorak Formation.
B, Stratigraphic section 68A–9, continued; section 68A–10, Nasorak and Kogruk Formations.
C, Stratigraphic section 68A–10, continued; section 68A–11, Kogruk Formation.

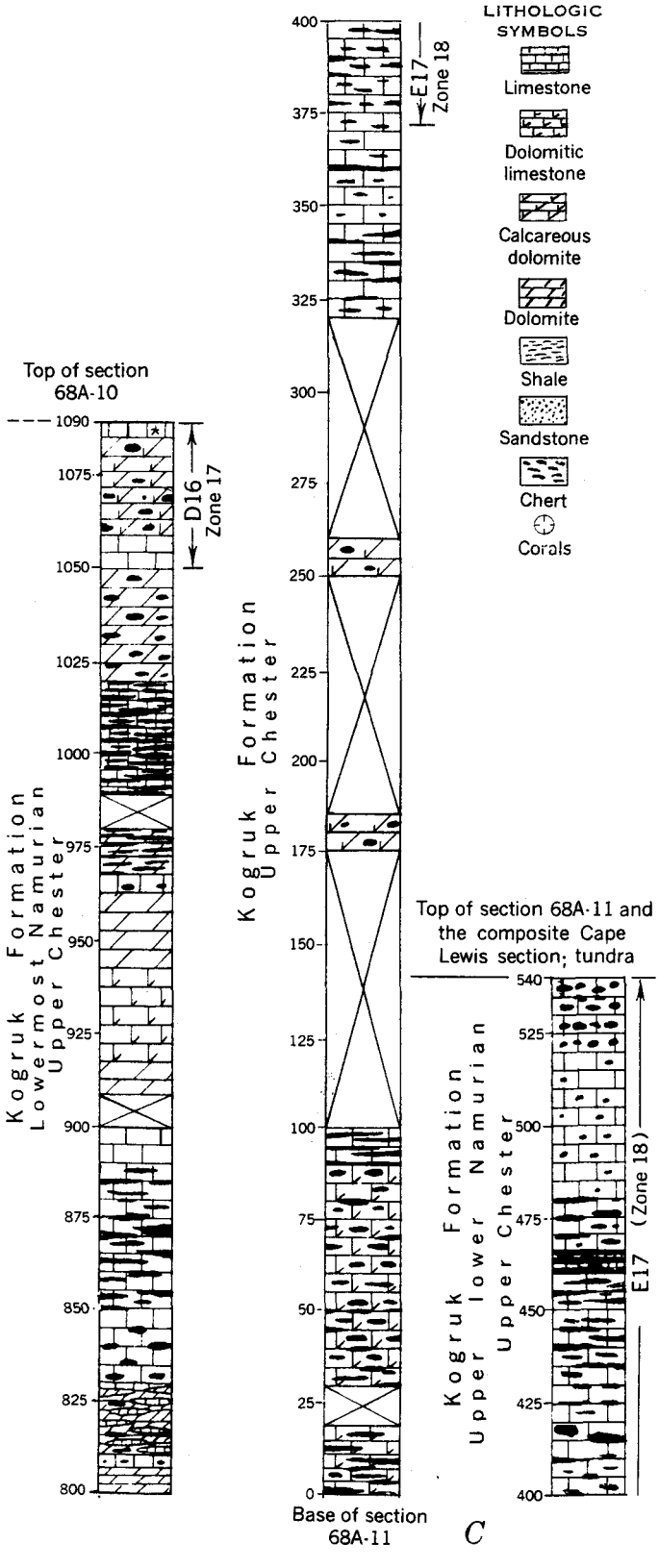

FIGURE 4.

echinoderm-bryozoan wackestones and packstones (figs. 3*A* and 4*B*) not followed by another cycle or sequence of shale or argillaceous limestone.

The section 68A–13, south of Niak Creek, is only 215 feet thick and is a partial representation of the lower part of Nasorak Formation. The section (fig. 5*A*, *B*) is a rhythmic sequence of dark-gray calcareous shales, argillaceous limestones, and 1- to 5-foot beds of medium- to dark-gray bryozoan-echinoderm wackestones and packstones. Dark-gray nodular chert is common, and commonly the limestones are slightly dolomitized. Dolomite is common as scattered rhombs within the micrite matrix.

KOGRUK FORMATION

Sable and Dutro (1961, p. 592) named the Kogruk Formation for the thick sequence of Carboniferous (Mississippian) limestone in the western DeLong Mountains. The Kogruk Formation in the Cape Lewis sections is more than 1,864 feet thick. The lower 232 feet of the Kogruk Formation is in the upper part of section 68A–9. These beds are massive, light-gray to gray, crossbedded echinoderm-bryozoan packstones and wackestones. An inaccessible interval, possibly 100 to 200 feet thick, that forms a cliff separates the top of section 68A–9 from the base of section 68A–10 (fig. 4*B*). Section 68A–10, which is 1,090 feet thick, is composed of massive carbonates. The lower 247 feet is a series of shallow-water cyclic carbonates. The cycles, each of which may be 20 feet thick or may exceed 120 feet, are formed by a series of 1- to 50-foot-thick beds which range in composition from grainstone formed by rounded bioclasts of bryozoans and echinoderms upward into packstones and wackestones that are capped by fine-grained siliceous and cherty dolomites. A 63-foot-thick light-gray, crossbedded echinoderm-bryozoan packstone-grainstone (fig. 4*B*) is present from 247 to 320 feet above the base of 68A–10. From 360 to 470 feet is a massive sequence of medium- to thin-bedded brownish-gray to brownish-black lime mudstone to well-sorted fine-grained bryozoan-echinoderm packstone. The unit contains 1- to 3-inch-long bodies of irregular-shaped grayish-black to black chert (fig. 7). From 570 to 1,090 feet is a sequence consisting of thin- to medium-bedded, gray to medium-gray cherty echinoderm grainstones that grade upward into lime mudstones and dolomites.

The base of section 68A–11 (fig. 4*C*) is believed to be within a few tens of feet stratigraphically from the top of 68A–10. Section 68A–11 is approximately 542 feet, thick, and the top is marked by tundra and soil cover. The nature of the beds that overlie this section is

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unknown. Section 68A–11 is composed of light-gray to gray limestone and dolomites containing light-gray to gray nodular chert. The limestones are primarily echinoderm-bryozoan wackestones and packstones. The beds tend to be massive.

Section 68A–12, north of Niak Creek (fig. 5*A*, *B*), is 715 feet thick and is an incomplete section of the Kogruk Formation bounded at its top and bottom by fault surfaces.

The bottom 45 feet of the section (fig. 8) is dark-gray argillaceous wackestones containing abundant colonial corals. The remaining 670 feet is composed of light- to medium-gray limestones and dolomites with nodular chert in varying amounts. The rock types are wackestones to echinoderm-bryozoan grainstones. Dolomitization is common. The beds from 35 to 225 feet above the base are light-brown-gray dolomites. The remainder of the section is a series of beds composed of lime mudstones, echinoderm-bryozoan packstones, and grainstones showing varying degrees of dolomitization.

BIOSTRATIGRAPHY

Microfaunal assemblage zones

Microfaunal assemblage zones are used in this study. These zones have been used by Mamet and Gabrielse (1969), Mamet and Mason (1968), and Mamet (1968) to correlate the Carboniferous of western Canada with the Carboniferous of the northern Cordilleran of the United States (Sando and others, 1969). Armstrong, Mamet, and Dutro (1970) used these microfaunal assemblage zones to correlate the Lisburne Group of the eastern and central Brooks Range.

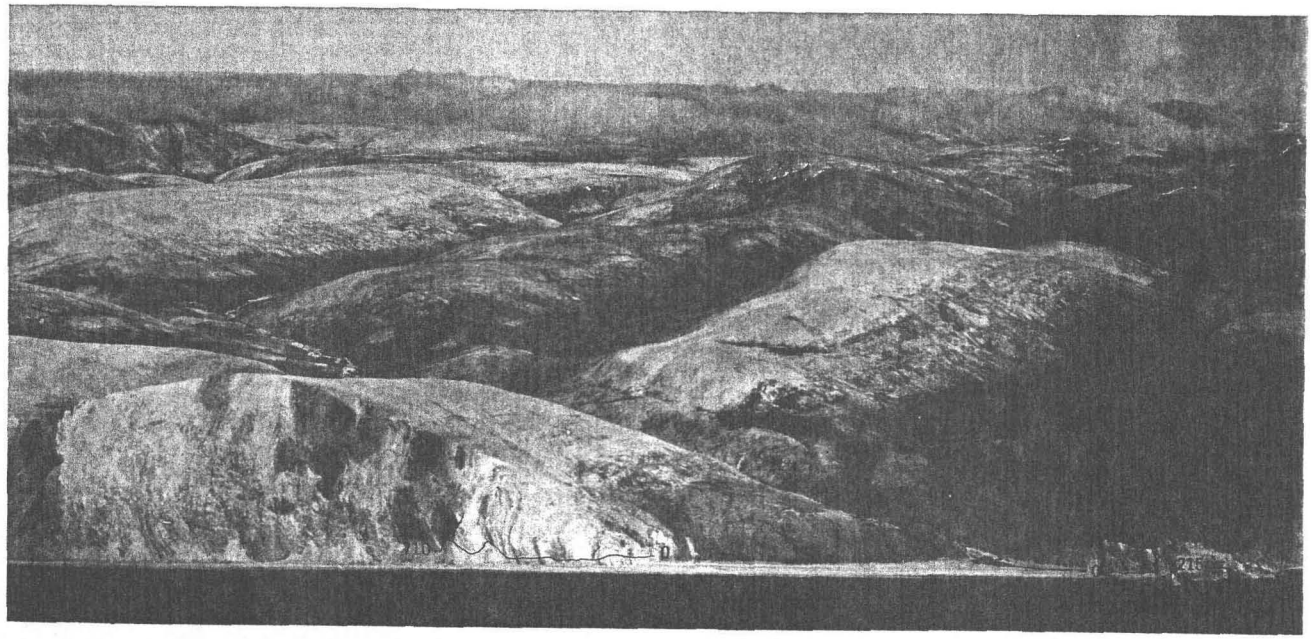
The microfacies of Alaska, as in most of the Taimyr-Alaska foraminiferal realm (Mamet, 1962; Mamet and Belford, 1968), are generally poor in foraminifers and algae. Within the sections of the Lisburne Group studied in the sea cliffs of northwestern Alaska, six foraminiferal assemblages can be recognized and tied to the Cordilleran and Eurasiatic Carboniferous zonations (Sando and others, 1969).

The middle Viséan zone 13 is identified on the presence of archaediscids (*Archaediscus* of the Group *A. krestovnikovi* Rauzer-Chernoussova), endothyrids (*Eoendothyranopsis* of the group *E. pressa* Grozdilova *in* Lebedeva), *Globoendothyra* sp., eoforschiids (*Eoforschia*), and primitive bradyinids (*Endothyranopsis*).

No characteristic assemblage zone 14 has been found.

The top of zone 15 is recognized on the basis of endothyrids, and the $15/16_1$ boundary is placed at the extinction of *Eoendothyranopsis-Eoforschia; Endothyra* sensu stricto and *Zellerina* become an important element of the microfauna.

Zone 16_1 is poorly represented throughout the entire Cape Lewis 68A–9 section; the microfauna is reduced to scarce small endothyrids, archaediscids, and tetrataxids.



A

FIGURE 5.—Stratigraphic sections on Niak Creek. Microfossil collections A1 to B4 shown in the section "Microfossil Lists."
A, North Niak Creek section, 68A–12, and south Niak Creek section, 68A–13. Oblique view to the east.
B, Stratigraphic section 68A–12, north Niak Creek, and section 68A–13, south Niak Creek.

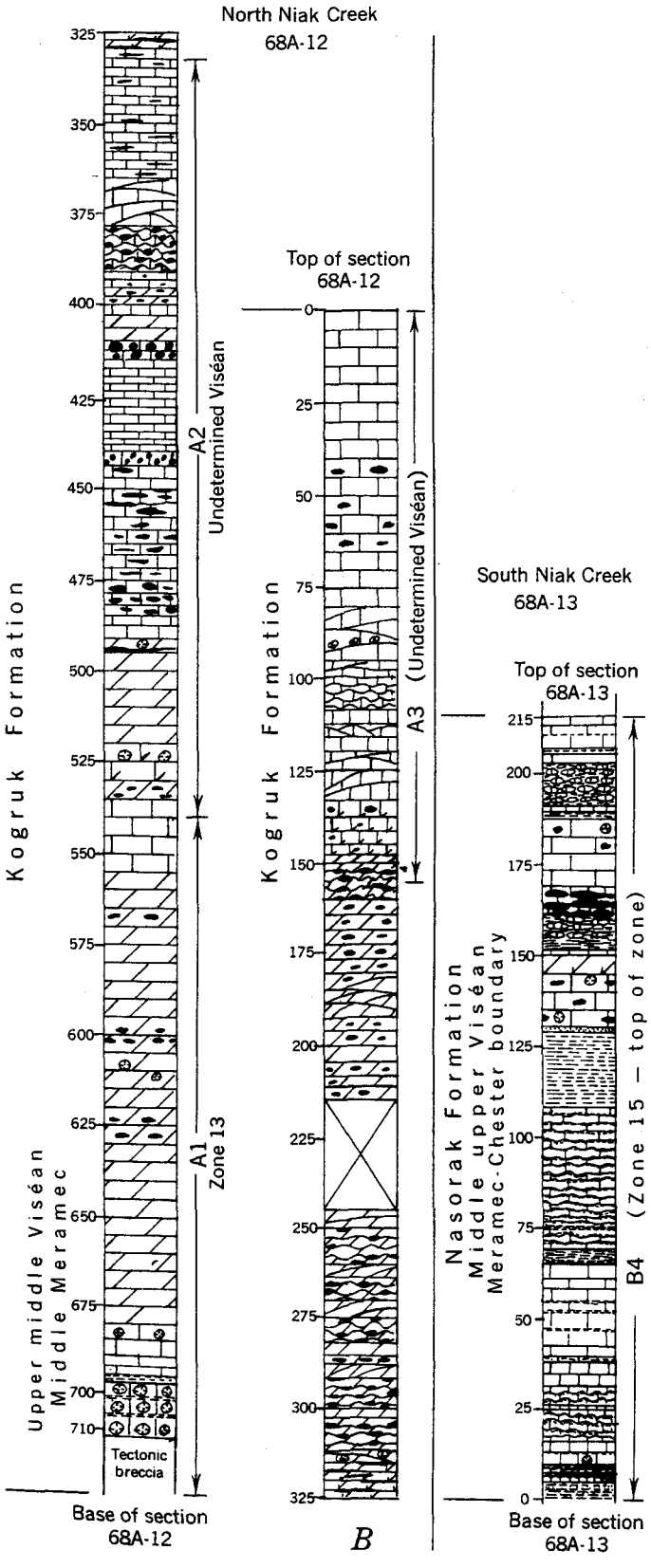


FIGURE 5.

Zone 16_s is characterized by the outburst of *Neoarchaediscus Planospirodiscus*, and zone 17 by the appearance of *Asteroarchaediscus*.

The youngest Carboniferous zone identified in this report is in the late early "Namurian" (*Eumorphoceras* equivalent) zone 18, identified on the presence of *Globivalvulina*? of the group *G. parva* Chernysheva mixed with very abundant *Asteroarchaediscus* and *Planospirodiscus*.

Microfossil lists (stratigraphic location shown on figs. 4 and 5)

A1 (0–220 feet)
Microfacies
Archaediscus sp.
Archaediscus of the group *A. krestovnikovi* Rauzer-Chernoussova.
Brunsia sp.
Calcisphaera sp.
Calcisphaera laevis Williamson.
Calcisphaera pachysphaerica (Pronina).
Earlandia, sp.
Earlandia clavatula (Howchin).
Earlandia vulgaris (Rauzer-Chernoussova and Reitlinger).
Endothyra sp.
Endothyra? of the group *E.*? *prisca* Rauzer-Chernoussova and Reitlinger.
Endothyranopsis sp.
Endothyranopsis compressa (Rauzer-Chernoussova and Reitlinger).
Eoendothyranopsis sp.
Eoendothyranopsis of the group *E. pressa* (Grozdilova *in* Lebedeva).
Eoendothyranopsis? *redwalli* (Skipp).
Eoforschia sp.
Globoendothyra sp.
Globoendothyra of the group *G. tomiliensis* (Grozdilova).
Palaeotextularia sp.
Parathurammina sp.
Age: zone 13, late middle Viséan, St. Louis equivalent.

A2 (220–400 feet)
Microfacies
Archaediscus sp.
Archaediscus of the group *A. krestovnikovi* Rauzer-Chernoussova.
Brunsia sp.
Calcisphaera sp.
Calcisphaera laevis Williamson.
Calcisphaera pachysphaerica (Pronina).
Endothyra sp.
Endothyra of the group *E. bowmani* Phillips *in* Brown.
Globoendothyra sp.
Age: undetermined Viséan zone.

A3 (600–710 feet)
Microfacies
Archaediscus of the group *A. krestovnikovi* Rauzer-Chernoussova.
Endothyra of the group *E. bowmani* Phillips *in* Brown.
Age: undetermined Viséan zone.

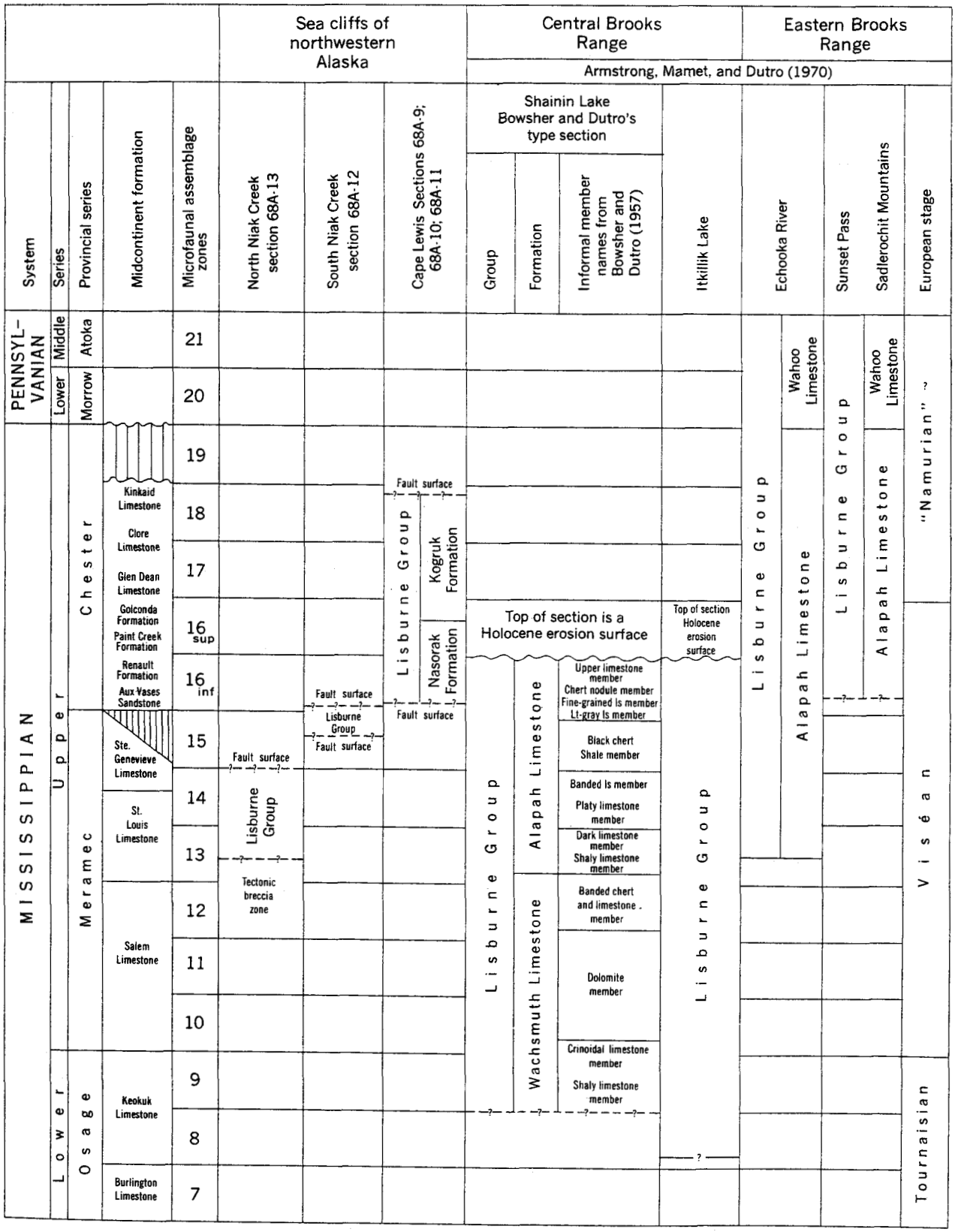


FIGURE 6.—Regional stratigraphic correlation chart for the Lisburne Group of northwestern Alaska with the Lisburne Group of the central and eastern Brooks Range.

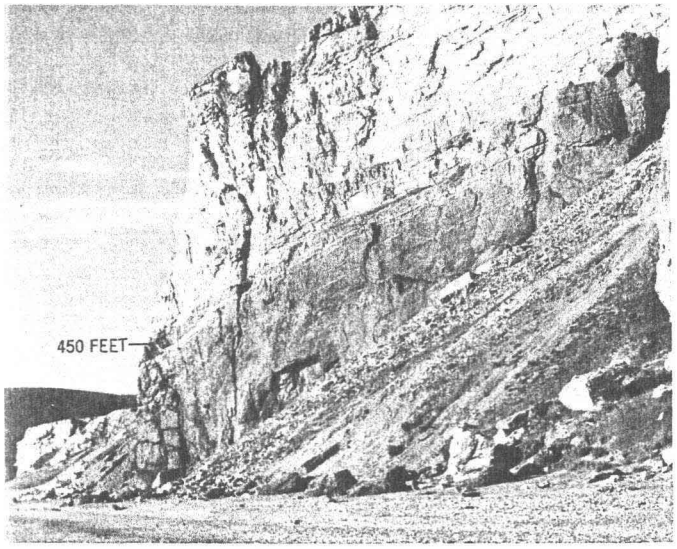


FIGURE 7.—Sea cliff showing the massive, thin-bedded dark-brownish-gray limestone present in section 68A–10, from 375 to 450 feet above the base. These beds are overlain by light-gray bryozoan-echinoderm wackestones and packstones.

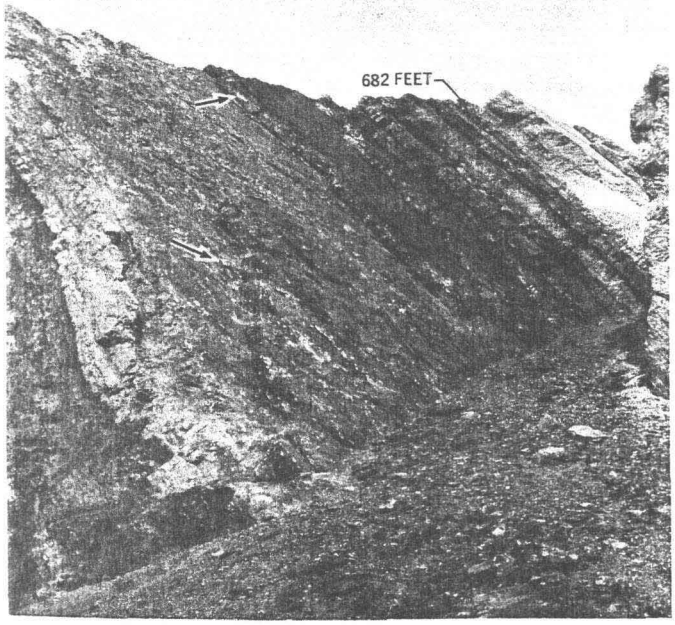


FIGURE 8.—View of the sea cliff at the base of section 68A–12, north of Niak Creek. Below the 715-foot level is a thick zone of tectonic breccia. The arrows point to two lithostrotionoid coral colonies. The bedding surface and the sides of the bed contain numerous coralla. Although coralla are very abundant, only 5 taxa are present.

B4 (0–215 feet)
Microfacies
Calcisphaera sp.
Calcisphaera laevis Williamson.
Calcisphaera sp.
Earlandia of the group *E. clavatula* (Howchin).
Earlandia of the group *E. vulgaris* (Rauzer-Chernoussova and Reitlinger).
Endothyra sp.
Endothyra of the group *E. bowmani* Phillips *in* Brown.
Endothyranopsis sp.
Endothyranopsis cf. *E. crassa* (Brady).
Eoendothyranopsis sp.
Eoendothyranopsis of the group *E. pressa* (Grozdilova *in* Lebedeva).
Globoendothyra sp.
Tetrataxis sp.
Age: zone 15 (top of the zone), middle late Viséan, Meramec-Chester boundary equivalent.

C5 (0–150 feet)
Microfacies
Archaediscus sp.
Calcisphaera laevis Williamson.
Cornuspira sp.
Endothyra sp.
Endothyra of the group *E. bowmani* Phillips *in* Brown.
Globoendothyra sp.
Tetrataxis sp.
Tetrataxis of the group *T. angusta* Vissarionova.
Tetrataxis of the group *T. conica* Ehrenberg *emend* von Möller.
Zellerina sp.
Age: zone 16_1, early late late Viséan, early Chester.

C6 (225–355 feet)
Microfacies
Calcisphaera sp.
Cornuspira sp.
Earlandia sp.
Endothyra sp.
Endothyra of the group *E. bowmani* Phillips *in* Brown.
Endothyra? of the group *E.? prisca* Rauzer-Chernoussova and Reitlinger.
Globoendothyra sp.
Tetrataxis sp.
Tetrataxis of the group *T. angusta* Vissarionova.
Tetrataxis of the group *T. conica* Ehrenberg *emend* von Möller.
Age: zone 16_1, early late late Viséan, early Chester equivalent.

C7 (450–460 feet)
Microfacies
Calcisphaera sp.
Earlandia sp.
Earlandia vulgaris (Rauzer-Chernoussova and Reitlinger).
Endothyra sp.
Endothyra of the group *E. bowmani* Phillips *in* Brown.
cf. *Neoarchaediscus* sp.
Tetrataxis sp.
Age: zone 16_1, early late late Viséan, early Chester equivalent.

C8 (575–740 feet)
Microfacies
Age: undetermined.
Earlandia sp.
Earlandia sp.
Endothyra sp.

C9 (770–900 feet)
Microfacies
Calcisphaera sp.
Earlandia sp.
Earlandia vulgaris (Rauzer-Chernoussova and Reitlinger).
Endothyra sp.
Endothyra of the group *E. bowmani* Phillips *in* Brown.
Endothyra? of the group *E.*? *prisca* Rauzer-Chernoussova and Reitlinger.
Globoendothyra sp.
Tetrataxis sp.
Tetrataxis of the group *T. angusta* Vissarionova.
Tetrataxis of the group *T. conica* Ehrenberg *emend von Möller.*
Age: zone 16_1, early late Viséan, early Chester equivalent.

C10 (1,120–1,415 feet)
Microfacies
Calcisphaera sp.
Earlandia sp.
Endothyra sp.
Age: undetermined

C11 (1,415–1,500 feet)
Microfacies
Archaediscus sp.
Archaediscus krestovnikovi Rauzer-Chernoussova.
Brunsia sp.
Diplosphaerina sp.
Earlandia sp.
Endothyra sp.
Neoarchaediscus sp.
Planospirodiscus sp.
Pseudoglomospira? sp.
Age: zone 16_2, latest Viséan, early Chester equivalent.

D12 (0–75 feet)
Microfacies
Archaediscus sp.
Archaediscus krestovnikovi Rauzer-Chernoussova.
Brunsia sp.
Calcisphaera sp.
Cornuspira sp.
Endothyra sp.
Kamaena sp.
Pseudoglomospira sp.
Stacheoides sp.
Age: undetermined.

D13 (125–175 feet)
Microfacies
Archaediscus sp.
Archaediscus krestovnikovi Rauzer-Chernoussova.
Brunsia sp.
Calcisphaera sp.
Cornuspira sp.
Endothyra sp.
Stacheoides sp.
Age: undetermined.

D14 (260–320 feet)
Microfacies
Archaediscus sp.
Archaediscus of the group *A. chernoussovensis* Mamet.
Archaediscus of the group *A. moelleri* Rauzer-Chernoussova.
Archaediscus krestovnikovi Rauzer-Chernoussova.
Asteroarchaediscus sp.
Brunsia sp.
Endothyra sp.
Age: zone 17, earliest "Namurian," Glen Dean equivalent of the Chester Series.

D15 (550–715 feet)
Microfacies
Calcisphaera sp.
Earlandia sp.
Eostaffella sp.
Age: undetermined.

D16 (1,050–1,090 feet)
Microfacies
Archaediscus sp.
Archaediscus of the group *A. chernoussovensis* Mamet.
Archaediscus krestovnikovi Rauzer-Chernoussova.
Archaediscus of the group *A. moelleri* Rauzer-Chernoussova.
Asteroarchaediscus sp.
Endothyra sp.
Endothyra of the group *E. bowmani* Phillips *in* Brown.
Eostaffella sp.
Palaeotextularia sp.
Planospirodiscus sp.
Age: zone 17, earliest "Namurian," Glen Dean equivalent of the Chester Series.

E17 (375–525 feet)
Microfacies
Archaediscus sp.
Archaediscus krestovnikovi Rauzer-Chernoussova.
Asteroarchaediscus sp.
Calcisphaera sp.
Cornuspira sp.
Endothyra sp.
Globivalvulian? of the group *G.*? *parva* Chernysheva.
Planospirodiscus sp.
Pseudoendothyra sp.
Stacheoides sp.
Age: zone 18, late early 'Namurian," late Chester equivalent.

Lithostrotionoid coral zones

The known stratigraphic distribution of lithostrotionoid coral species within the Lisburne Group (Mississippian) of the Lisburne Hills and sea cliff exposures and species from DeLong Mountains (Armstrong, 1970b) are shown in figure 9.

The base of the North Niak Creek section **68A–12** contains the oldest coral fauna known in the region. Although a large number of lithostrotionoid corals were collected, thin-section studies reveal only four species: *Lithostrotion* (*Siphonodendron*) *warreni* Nelson, *Lithostrotionella banffensis* (Warren), and two new and undescribed species of *Lithostrotionella.* This coral fauna is found in association with a middle Viséan (middle Meramec), late zone 13 microfauna.

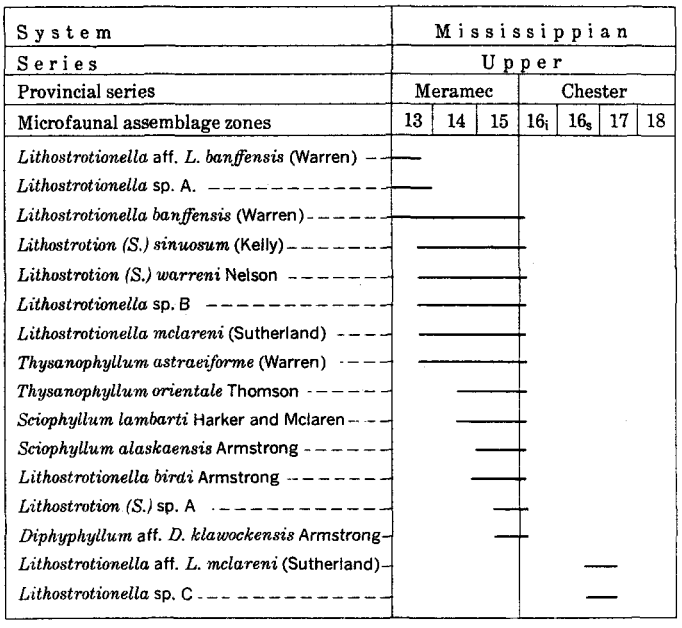


FIGURE 9.—Stratigraphic range of lithostrotionoid corals in the Lisburne Group of northwestern Alaska.

The South Niak Creek section 68A–13, which is at the zone 15–16 boundary, contains a prolific fauna of lithostrotionoid corals, *Lithostrotion* (*Siphonodendron*) *sinuosum* (Kelly), *L.* (*S.*) *warreni* Nelson, a new and undescribed species of *Lithostrotion* (*Siphonodendron*), *Diphyphyllum* aff. *D. klawockensis* Armstrong, *Lithostrotionella banffensis* (Warren), *L. birdi* Armstrong, *L. mclareni* (Sutherland), *Thysanophyllum astraeiforme* (Warren), *Sciophyllum lambarti* Harker and McLaren, and *S. alaskaensis* Armstrong.

The lower 900 feet of the Cape Lewis section 68A–9 is equivalent to the basal Chester, zone 16_i as indicated by the Foraminifera, and has a lithostrotionoid coral fauna of *Lithostrotion* (*Siphonodendron*) *sinuosum* (Kelly), *L.* (*S.*) *warreni* Nelson, a new species of *Lithostrotion* (*Siphonodendron*), *Diphyphyllum* aff. *D. klawockensis* Armstrong, *Lithostrotionella banffensis* (Warren), *L. birdi* Armstrong, *L. mclareni* (Sutherland), *Thysanophyllum astraeiforme* (Warren), and *Sciophyllum lambarti* Harker and McLaren.

Many of the species collected from the Lisburne Hills sea cliffs are known to occur in the Kogruk Formation of the DeLong Mountains. Armstrong (1970b) reports the following species of coral from the Meramec zones 14 and 15 of the Kogruk Formation of the DeLong Mountains: *Lithostrotion* (*Siphonodendron*) *sinuosum* (Kelly), *L.* (*S.*) *warreni* Nelson, *Lithostrotionella banffensis* (Warren), *L. birdi* Armstrong, *L. mclareni* (Sutherland), *Thysanophyllum astraeiforme* (Warren), *Sciophyllum lambarti* Harker and McLaren, and *S. alaskaensis* Armstrong.

A middle to late Meramec coral fauna that is associated with a Foraminifera fauna is reported by Armstrong (1970a) from the northwestern coastal regions of the Prince of Wales Island, southeastern Alaska. This coral fauna has in common with the fauna of this report the following species: *L.* (*S.*) *warreni* Nelson, *Diphyphyllum klawockensis* Armstrong, *L. banffensis* (Warren), *L. birdi* Armstrong, *T. astraeiforme* (Warren), and *S. alaskaensis* Armstrong.

Comparison of the coral faunas of the Lisburne Group with the four coral assemblages of Macqueen and Bamber (1968) from the Mount Head Formation of southwestern Alberta suggests that the extinction of *L.* (*S.*) *warreni* Nelson, *Thysanophyllum astraeiforme* (Warren), and *Lithostrotionella mclareni* (Sutherland) could be slightly later in Alaska than in Alberta, Canada.

Foraminifera suggest that the Lisburne Group coral fauna at the north of the Niak Creek section (68A–12) is a time equivalent of Macqueen and Bamber's faunal assemblage 2 from the Mount Head Formation and of Sando, Mamet, and Dutro's coral zone E from the northern Cordillera of the United States. The coral fauna from South Niak Creek section 68A–13 and the lower 900 feet of the Cape Lewis section 68A–9 is an equivalent of Macqueen and Bamber's fossil assemblage 4 and of the upper part of Sando, Mamet, and Dutro's (1969) coral zone F.

The limitations encountered in attempting to compare the coral fauna of northwestern Alaska with those of Alberta are greatly magnified when comparisons are made with coral faunas of the northern Cordillera of the United States. Sando, Mamet, and Dutro's list of fossil corals (1969, p. E7) from the Cordilleran region of the United States shows no species in common with the Lisburne Group faunas.

The microfossil assemblage (fig. 9) indicates that the prolific Kogruk Formation coral fauna straddles the Meramec-Chester boundary and extends into the lower Chester. Field studies in the Cape Lewis–Niak Creek region, and also across the Brooks Range, indicate that this coral assemblage became extinct during the early part of zone 16_i.

Above zone 16_i, colonial corals are relatively rare. Specimens of two new species of lithostrotionid corals were collected in the carbonates of zone 16_s at Cape Lewis. A few solitary corals were the only corals found at Cape Lewis in the upper Chester limestones of zones 17 and 18.

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PALEOCENE MOLLUSKS FROM THE GULF OF ALASKA TERTIARY PROVINCE—A SIGNIFICANT NEW OCCURRENCE ON THE NORTH PACIFIC RIM

By WARREN O. ADDICOTT and GEORGE PLAFKER,
Menlo Park, Calif.

Abstract.—Marine mollusks of Paleocene age occur near the base of a sequence of continental and marine strata mapped as the Kulthieth Formation in the foothills of the St. Elias Mountains, southern Alaska. The gastropod *Turritella merriami brevitabulata* Merriam and Turner indicates correlation with the upper Paleocene "Meganos Stage" of the Pacific coast of the conterminous United States. The fossils from the Malaspina district (lat 60° N.) provide evidence of the oldest marine strata thus far recorded from the Gulf of Alaska Tertiary province, the oldest previously known strata being of middle or late Eocene age. They also record the first occurrence of marine Paleocene from north of California (lat 40° N.). Accordingly, Paleocene seas were not of restricted distribution but in fact extended over broad areas along the North Pacific rim.

One of the more puzzling aspects of the paleogeographic history of the North Pacific basin has been the apparent constriction of marine deposition during the Paleocene in contrast to the widespread occurrence of marine strata of Late Cretaceous and Eocene age. Marine Eocene strata, for example, occur along the west coast of the conterminous United States, Canada, and southern Alaska, but rocks of Paleocene age have previously been reported only from low latitudes—no farther north than northern California near lat 40° N. (fig. 1).

In this paper we report the first documentation of marine strata of Paleocene age from the north Pacific margin near lat 60° N. The new record is based upon the gastropod *Turritella merriami brevitabulata* Merriam and Turner (1937). The collection was made in 1968 by George Plafker in a remote part of the rugged southern foothills of the St. Elias Mountains within the Gulf of Alaska Tertiary province (fig. 2).

STRATIGRAPHIC OCCURRENCE

The *Turritella* and indeterminate fragments of mollusks, including a nuculanid, were collected from a hard, massive sandstone near the base of a sequence of

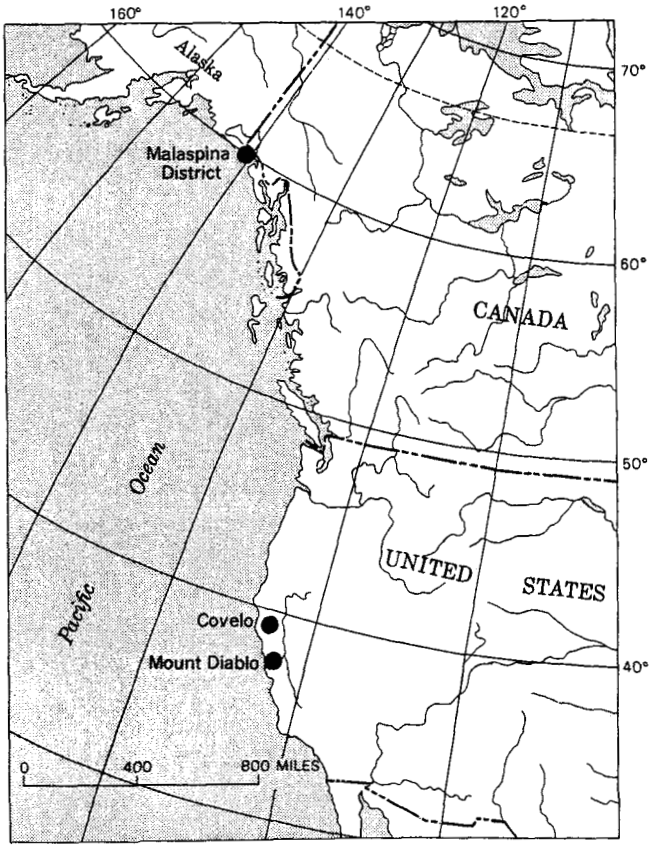

FIGURE 1.—Index map of the northeastern part of the Pacific Basin, showing Paleocene occurrences of *Turritella Merriami brevitabulata* Merriam and Turner.

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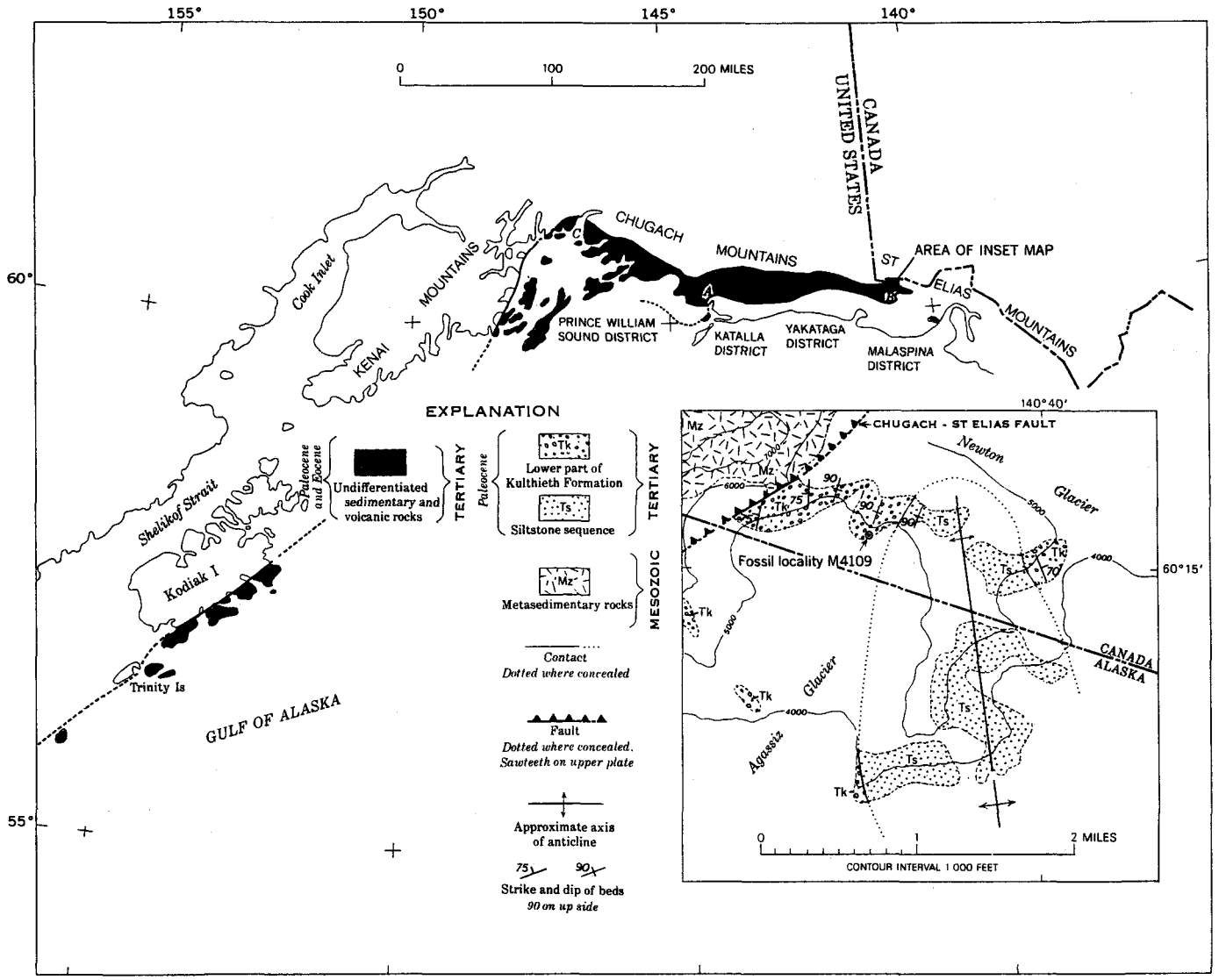

FIGURE 2.—Index map of the northern Gulf of Alaska region, showing the approximate outcrop areas of lower Tertiary rocks and localities referred to in the text.

terrestrial and marine strata mapped by Plafker and Miller (1957) as the Kulthieth Formation. The Kulthieth Formation is part of a belt of Paleogene sedimentary and volcanic rocks that fringes the margin of the Gulf of Alaska from the vicinity of Yakutat Bay westward to the Trinity Islands (fig. 2). At the fossil locality (USGS M4109), at least 3,900 feet of the Kulthieth Formation is exposed in a homoclinal section that strikes roughly north and dips between 90° and 75°, with tops to the west (fig. 2). The sequence consists predominantly of uniformly bedded, light-gray to greenish-gray, hard, arkosic sandstone, pebbly sandstone, and sandy pebble conglomerate. Interbedded with the coarse clastic rocks are subordinate amounts of reddish-brown- to orange-weathering, leaf-bearing calcareous sandstone, dark-gray siltstone, and thin beds of sheared bituminous coal.

The Kulthieth Formation is in contact to the east with a highly contorted and sheared sequence of greenish-gray-weathering, gray to dark-gray siltstone containing minor amounts of fine-grained laminated sandstone in thin beds or lenses. These rocks were mapped as an unnamed siltstone sequence by Plafker and Miller (1957). The contact between the two units is crudely conformable but is marked by crumpling and slickensiding indicative of differential fault movement between the Kulthieth Formation and the relatively incompetent siltstone sequence. The general map rela-

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