

RECONNAISSANCE GEOLOGIC MAP OF THE DE LONG MOUNTAINS A-1 AND B-1 QUADRANGLES AND PART OF THE C-1 QUADRANGLE, ALASKA

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s found relative to the Kelly sequence is shown in figure 3 unconformity at base Locally divided into: ranges from about 30 to 50 m. Base is gradational into the Siksikpuk Formation

KELLY RIVER ALLOCHTHON Amphitheatre sequence Named for characteristic exposures around Amphitheatre Mountain (lat 68°19' N., long 162°34' W.), De Long Mountains B-1 quadrangle. Letter symbols for map units in this sequence include the subscript number 3 to signify that they are part of the Kelly River allochthon. Location of the area where the Amphitheatre sequence Okpikruak Formation (Cretaceous)—Interbedded fine- to medium-grained lithic wacke and mudstone. Early Cretaceous age of unit based on regional stratigraphic correlations. Exposed thickness ranges from 0 to more than 300 m. Depositional thickness is probably variable. Mapped west of upper Wrench Creek and in upper Kelly River drainage, De Long Mountains B-1 and B-2 quadrangles. Has a probable JPe3 Etivluk Group (Jurassic to Pennsylvanian)—Gray chert with minor amounts of shale; weathers to shades of brown, vellow, gray, green, and maroon. Consists of the Siksikpuk and Otuk Formations. Chert contains late Paleozoic radiolarians and, in upper part, Late Triassic pelecypod Monotis in cream-colored beds. Otuk Formation (Jurassic and Triassic)—Gray to dark-gray, well-bedded chert with siliceous shale partings. Contains a few interbedded siliceous limestone beds near top. Weathers to brown, green, yellow, and cream-colored bedding surfaces. Cream-colored zone near top contains Late Triassic pelecypod Monotis. Chert beds contain radiolarians. Uppermost part may be Jurassic based on stratigraphic correlation with similar chert beds that contain identified radiolarians in Puzzle Creek sequence (De Long Mountains A-3 quadrangle) and pelecypods in Howard Pass quadrangle (Mull and others, 1982). Depositional thickness Siksikpuk Formation (Triassic to Pennsylvanian)—Gray radiolarian chert and gray, olive-gray, and maroon siliceous shale. Age based on stratigraphic correlation with this unit in other sequences. Depositional thickness is approximately 40-60 m. Basal contact is sharp and probably conformable on a thin tongue of the Kuna Formation or the Kogruk Formation

Overturned Approximate overturned Strike and dip of foliation

Queried outcrop—Plotted from aerial photographs and not investigated in the field Fossil locality—Listed by number in table 3 Zinc-lead-silver prospect or deposit

RELATIONS OF TECTONOSTRATIGRAPHIC AND LITHOSTRATIGRAPHIC UNITS In Early Cretaceous time, the Brooks Range was created during an orogeny that produced numerous thrust faults with as much as tens of kilometers of displacement. In areas where thrust faults are closely spaced, the structure is so complex that the terrane can be characterized as a "broken formation" (Hsu, 1968). The direction of thrust iuxtaposition was such that upper thrust sheets traveled north relative to the lower sheets. Displacement of rock units across some thrust faults is great enough to superimpose coeval rocks of different sedimentary facies so that rock units in one thrust sheet may be lithologically different from coeval rock units above and below. This is especially evident in Mississippian rocks that appear to have had more complex facies patterns in their original basins of deposition than In order to describe our understanding of the complex stratigraphy and structure in the De Long Mountains quadrangle, most rock units on this map are grouped into both named sequences and allochthons (fig. 2). On this map, the word "sequence" is used as a stratigraphic term, meaning either a distinctive column of sedimentary rocks that were deposited contiguously, or a group of associated and distinctive igneous rocks. Although the assignment of a rock unit to a particular sequence is usually based upon its lithology and stratigraphic relations, its structural position is also important. Thrust sheets that contain the same or similar sequences and occur in the same general structural level are herein grouped together into structural units called "allochthons." In contrast, some previous reports use terms such as "thrust tectonic unit," "structural sequence," or "thrust sequence" for both lithostratigraphic and tectonostratigraphic units. Comparison of the named allochthons in this map with analogous terminology used in other Various parts of the same sequence are commonly juxtaposed several times in adjacent thrust sheets. Faults that bound thrust sheets may occur at any horizon within a sequence, so that each thrust sheet usually contains only part of a complete sequence. Thrust faults that separate thrust sheets containing different sequences are mapped as "intersequence thrust faults," and thrust faults that separate thrust sheets containing the same sequence are mapped as ntrasequence thrust faults. Thrust sheets containing a given sequence almost always occur in the same structural position relative to thrust sheets containing a different sequence. This observation has permitted us to construct the generalized model of the relations between the various allochthons and sequences (fig. 2). This model shows the relative structural positions of the allochthons and the sequence or sequences of rocks within each allochthon. Post-orogenic erosion removed large parts of the upper allochthons from the area, and some were probably never continuous across the quadrangle. The allochthons are usually made up of many large lens-shaped bodies or folded sheets a few hundred meters to tens of kilometers across and a few meters to a kilometer or more in thickness. In most vertical sections some of the allochthons are absent and the sequences in others are internally repeated by intrasequence thrust faults. In addition to the abrupt facies differences across intersequence thrust faults, there are also more gradual changes within the sedimentary rocks that make up certain allochthons. These changes are commonly most noticeable in the Mississippian and Pennsylvanian rocks. Where a facies change in one or more rock units creates regionally significant differences in the stratigraphic column, two similar sequences that occur at the same structural level in different areas are named and described. In such cases, the similar sequences are presumed to have been deposited adjacent to each other and are grouped in the same allochthon. For example, the Amphitheatre and Kelly sequences are lithologically similar and occur at about the same structural level. For this reason, they were probably deposited adjacent to each other, and only a small amount of thrust juxtaposition is inferred between them (see fig. 3 for location of sequences

INTRODUCTION

This map is one of a series of three reconnaissance geologic maps of the southern De Long Mountains 1:250,000-

CRITERIA USED TO DISTINGUISH SEQUENCES The most important criteria used to distinguish one sequence from another are listed in table 2. With the exception of the Bogie sequence, which contains the unique Nuka Formation (Tailleur and others, 1973), there is no single lithology that can be used by itself to distinguish a particular sedimentary sequence. The most distinctive lithologic differences between sequences are usually found in middle and Upper Mississippian rocks. However, lithologic differences in this interval are not great enough to distinguish all sedimentary sequences. Thus, identification of some sequences also may require comparison of the lithologies of the Upper Devonian and (or) older Mississippian rocks that underlie each particular set of Upper Mississippian lithologies. Upper Mississippian (and Lower Pennsylvanian?) rocks in all the sedimentary sequences are overlain by Pennsylvanian to Jurassic chert and shale of the Etivluk Group (Mull and others, 1982), and wacke and mudstone

of the Lower Cretaceous Okpikruak Formation. Generally, we have not seen enough systematic lithologic variation in the Etivluk Group or Okpikruak Formation in the De Long Mountains quadrangle to make either of these two rock units useful for differentiating sequences. UNCERTAIN RELATIONS BETWEEN ALLOCHTHONS AND SEQUENCES A belt of the Okpikruak Formation stretches from the Wulik River to the eastern edge of the De Long Mountains quadrangle through Sheep Mountain (De Long Mountains B-2 quadrangle) and the headwaters of the Kelly River (De Long Mountains B-1 quadrangle). Bordering this large expanse of the Okpikruak Formation are outcrops of the Kelly Sequences, Wulik, Amaruk, Amphitheatre, and Kelly sequences. Because we are not able to determine to which sequence the Okpikruak Formation belongs on the basis of its lithology, we cannot be certain where intersequence faults may cut through the Okpikruak Formation. It is also possible that parts of the Okpikruak Formation may have been deposited shortly after the major faulting had already juxtaposed some allochthons, so that the intersequence faults could be buried under younger sedimentary rocks. These uncertainties permit several interpretations of the structure along the carbonate front north of Inaccessible Ridge and its southwestern extension (De Long Mountains B-1 and B-2 quadrangles) and under the Sheep Mountain trend of the Okpikruak Formation. Some of the thrust sheets mapped as part of the Picnic Creek allochthon may instead belong to a sequence associated with the Brooks Range allochthon. These rocks were assigned to the Amaruk and Wulik sequences on the basis of Carboniferous strata that are similar to black bedded chert and cherty limestones in the Amaruk and Wulik sequences. However, there is structural and stratigraphic evidence that these rocks may be structurally beneath the Key Creek sequence (Moore and others, 1986). Moore and others name these rocks the Wolverine Creek allochthon and suggest a correlation with the Ivotuk sequence of the Brooks Range allochthon (Mayfield and others, 1983). The upper part of the carbonate rocks near Mount Raven (De Long Mountains A-2 quadrangle) contains post-Mississippian brachiopods (fossil loc. 50, De Long Mountains B-2 quadrangle), which are distinctly younger than any known carbonate rocks elsewhere in the Picnic Creek allochthon. The Otuk Formation, which is stratigraphically above the Carboniferous cherty limestones at Mount Raven, contains a shale member and an upper limey cher member that are more commonly developed in sequences in the Brooks Range allochthon than in other structurally higher, allochthons. This combination of characteristics suggests that the thrust sheets near Mount Raven are stratigraphically unlike the rest of the Amaruk sequence, and may instead be part of the Wolverine Creek allochthon On the Wulik River near where it crosses the western boundary of the De Long Mountains A-2 quadrangle, a thrust fault is shown dipping north, thrusting Carboniferous limestone and chert (PMcl2) over the Etivluk Group and Okpikruak Formation on the south side of the fault. This contact may instead be a partially disrupted norma stratigraphic contact dipping south, putting unit PMcl2 structurally beneath, rather than above, the Key Creel sequence. If that is the case, there should be another, unmapped south-dipping intersequence fault between the Wulil River and Ikalukrok Creek that brings the Key Creek sequence over the plate containing unit PMcI<sub>2</sub>. The unit PMcI in this plate would belong to the Wolverine Creek allochthon instead of belonging to the Picnic Creek allochthon. In the north fork of Ferric Creek (De Long Mountains A-3 quadrangle), Carboniferous chert and limestone (PMcl<sub>2</sub>) in the thrust sheet discussed above are mapped as thrust over micritic limestone (Mml<sub>1</sub>) and Kuna Formation (Pmk1) of the Key Creek sequence on the west. This may instead be a thrust fault dipping west, extending down Ferric Creek to the east side of the Ferric Creek prospect. Spiny Ridge (De Long Mountains B-4 quadrangle) is another area where the rocks may belong to either the Picnic Creek allochthon or to a local facies within the Brooks Range allochthon. The rocks at Spiny Ridge were differentiated from the Key Creek sequence because they include Carboniferous chert and limestone (PMc12) and bedded black chert (PMc2) similar to the stratigraphic sequence at Wulik Knot (De Long Mountains B-2 quadrangle), whereas the Mississippian strata of the Key Creek sequence exposed in the Sooner River area (De Long Mountains B-3 quadrangle) east of Spiny Ridge consists entirely of the shaly Kuna Formation ( $\mathbb{P}Mk_1$ ). Cross section C-C', De Long Mountains A-4 and B-4 quadrangles, does not attempt to interpret the structural relation of Spiny Ridge to the Amaruk and Key Creek sequences that are exposed on the northwestern side of the Wulik Peaks south of Spiny Ridge. The Wulik sequence is differentiated from the Key Creek sequence mainly because of fine-grained Mississippian carbonate rocks that are well exposed in the Wulik Knot (De Long Mountains B-2 quadrangle). There are no corresponding carbonates in the Key Creek sequence immediately north of the Wulik Knot. The Wulik sequence can be traced northeastward from the Wulik Knot into the De Long Mountains B-1 and C-1 quadrangles. In this direction the micritic limestone unit (Mml<sub>2</sub>) of the Wulik sequence becomes thin and discontinuous, and the black chert and limestone unit (PMcI<sub>2</sub>) becomes more carbonaceous and shaly, approaching the lithology of the Kuna Formation. The geologic map of the southwestern Misheguk Mountain quadrangle (Curtis and others, 1984) interprets the rocks along strike to the northeast as belonging to the Key Creek sequence of the Brooks Range allochthon. We are not sure whether this reflects a misinterpretation of the rocks in the Misheguk Mountain quadrangle, a facies change within the Wulik sequence, or additional structural complications. Anxiety Ridge (De Long Moutains A-2 quadrangle) is an anticline locally overturned to the north. It was assigned to the Wulik sequence because it contains the combination of fine-grained black chert and limestone (PMcl<sub>2</sub>) and the Kuna Formation (PMk2), similar to some of the thrust sheets in the Wulik Knot. It is possible that the rocks of Anxiety Ridge may have been deposited close to the rocks belonging to the Wolverine Creek allochthon mentioned above rather than with rocks of the Wulik sequence. Two structural interpretations, dependent upon whether Anxiety Ridge belongs to the Wulik sequence of the Picnic Creek allochthon, or to the Wolverine Creek allochthon, are shown on cross section B-B' for the De Long Mountains A-2 map. One possibility is that Anxiety Ridge is part of the Picnic Creek allochthon that was first thrust over the Brooks Range allochthon that lies immediately north of Anxiety Ridge, and then later was overridden from the south by a thrust sheet from the Brooks Range allochthon that contains sandstones of the Endicott Group. The thrust sheets of the Endicott Group are best exposed in the Noatak quadrangle immediately south of the map area. Another possibility, shown in the alternative part of cross section B-B', is that Anxiety Ridge could be a thrust sheet within the Brooks Range allochthon that extends down dip to the north and underlies the Key Creek sequence rocks exposed near the Red Dog zinc-lead-silver deposit. The Nuka Ridge allochthon is represented by only three isolated outcrops of the Nuka Formation, one north and the other two south of the Wulik Peaks (De Long Mountains A-3 and B-3 quadrangles, figs. 1 and 3). Some or all of these outcrops may be olistoliths because they are small, islolated from other Paleozoic sedimentary rocks, and largely surrounded by Cretaceous wacke and conglomerate that may have been deposited on lower sequences. If these exposures of Nuka Formation are olistoliths, they slid into a Cretaceous basin on structurally lower thrust sheets from a thrust sheet of Nuka Formation that once overlaid part of the southern De Long Mountains quadrangle. The

Nuka Ridge allochthon is exposed in the Noatak quadrangle, south of the map area, in its normal structural position above the Ipnavik River allochthon. We believe that the previously accepted Permian age for the upper part of the Nuka Formation, which is based on brachiopod identifications, is suspect. Conodont and foraminifer ages from this unit are consistently Late Mississippian and Early Pennsylvanian(?). The base of the Etivluk Group, which directly overlies the Nuka Formation has not yet been dated by well-preserved index fossils. B.K. Holdsworth (written commun., 1980) has observed radiolarian specimens from chert of the Etivluk Group above the Nuka Formation at Nuka Ridge (Misheguk Mountain quadrangle) that are similar to Albaillella pennata s.s. of earliest Pennsylvanian age. However, these specimens were not preserved well enough for definitive determination. In structurally lower sequences, the base of the Etivluk Group has been dated by radiolarians and conodonts as Early or Middle Pennsylvanian. We see no evidence, either from fossils or from chert lithologies, that the base of the Etivluk Group should be greatly diachronous. Therefore, we SUMMARY OF GEOLOGIC HISTORY Restoration of stratigraphic sequences to their relative positions before the large thrust dislocations that occurred during the Brooks Range orogeny is critical to understanding the geologic history of the De Long Mountains. We believe that the simplest and most reasonable reconstruction requires a consistent unstacking of thrust sheets, with

regard the age of the Nuka as Late Mississippian and Early Pennsylvanian(?) the higher sheets restored to the south relative to the lower sheets (Tailleur and Brosgé, 1970; Martin, 1970) This important premise is based on (1) our interpretation of the probable facies patterns in pre-Cretaceous rocks, and (2) the consistent northward vergence of structures in the De Long Mountains and Misheguk Mountain quadrangles. A palinspastic reconstruction of the sequences, based on the interpretations above, is shown in figure 5. North and south as labeled on the diagram refers to present-day directions. This orientation does not take into account the possible rotation of the entire Arctic Alaskan plate due to rifting in the Canada Basin (Tailleur and Snelson, 1969: ailleur, 1973) or possible crustal bending about the Chukchi syntaxis (Tailleur, 1973; Patton and Tailleur, 1977). The original north-south extent of sequences is difficult to determine because of many factors, so the scale is only approximate. Erosion during the Brooks Range orogeny removed an undetermined amount of the northen edges of the thrust sheets. Erosion after, and possibly during, the orogeny also stripped away an undetermined width of the thrust sheets south of the map area. The amount of shortening caused by folding and thrust faulting within allochthons is not accurately known, although in a few areas it is undoubtedly substantial. The continuity of allochthons in the subsurface, or in their projection above the present surface, is difficult to estimate. In all cases, we have tried to make our estimates as conservative as possible, so that the north-south width of the sequences shown in figure 5 is a During Middle and Late Devonian and Early Mississippian time, two partly coeval groups of sedimentary rocks were deposited in the Arctic Alaska sedimentary basin (Tailleur and Brosgé, 1970), the dimensions of which are unknown due to the compression that disrupted its southern part in the Brooks Range orogeny. The southern part of the basin contained the Baird Group (Tailleur and others, 1967), which is composed of clean, biohermal limestones of the Kelly sequence. Fossil ages from the Baird Group range from Cambrian to Late Devonian (Famennian). Foraminifers from the uppermost part of the Baird Group belong to Mamet zone 6 (B.L. Mamet, written commun. .981) and are latest Devonian or earliest Mississippian in age. In the De Long Mountains quadrangle, fossils older than Devonian have not been collected from the Baird Group. On the continental platform north of the Baird Group, in the Wulik and Key Creek sequences, the Endicott Group of clastic rocks was deposited in an intracratonic basin during Late Devonian and Early Mississippian time. The lower part of the Endicott Group consists of the Hunt Fork Shale. Above this is the Noatak Sandstone and Kanayut Conglomerate, which are composed of shallow-marine and paralic sandstone and some shale and conglomerate (Tailleur and others, 1967; Nilsen, 1981). ughout the Mississippian, sedimentation over the platform was complex. The lower part of the Mississip in all sequences is characterized by intergradational limey siltstone, limestone, and shale. We have mapped the facies that contains mostly sandy limestone as the Utukok Formation, the facies containing mostly shale as the Kayak Shale, and a mostly fine-grained, thin-bedded limestone as the micritic limestone unit. During middle and Late Mississippian and Pennsylvanian time, a complex series of submarine rises and troughs leveloped in the Arctic Alaska basin. The different sedimentary facies of this age are an important key for differentiating stratigraphic sequences. The most prominent rise was in the Kelly sequence where as much as 650 m of cherty carbonate sediments belonging to Mississippian Kogruk Formation were deposited. Tongues of the Kogruk extended to the north into the Wulik sequence and discontinuously into the Key Creek sequence. North and south of the Kelly sequence, interbedded chert and carbonate sediments were deposited in broad troughs in the areas of the Puzzle Creek, Amaruk, and Wulik sequences. North of the Kelly sequence of carbonate rocks, a euxinic basin developed in which the Mississippian and Pennsylvanian Kuna Formation (Mull and others, 1982) was deposited. The Kuna Formation is predominantly black shale, with lesser amounts of radiolarian chert, limestone, and dolomite. The Kuna Formation is best developed in the Key Creek sequence, but it is also present in the Wulik sequence, and some thin tongues of the Kuna Formation probably overlie the Mississippian carbonate rocks in parts of the Amphitheatre and Kelly sequences. A similar black shale unit is also present at the top of the Mississippian and Pennsylvanian black hert and dolomite unit (PMcd4) in the Puzzle Creek sequence. The northern and eastern limits of the Kuna Formation intertongue with and grade into Lisburne Group limestone of the Ivotuk sequence in the Howard Pass quadrangle (Mayfield and others, 1988). Outcrops in the De Long Mountains quadrangle that may be a western equivalent of the Ivotuk sequence, the Wolverine Creek allochthon (Moore and others, 1986) are discussed in the The Nuka Formation is unique among the Carboniferous sedimentary rocks in the western Brooks Range because it contains abundant feldspar grains in sandy limestones. Coeval units in structurally lower allochthons, which formed a belt hundreds of kilometers wide north of the Nuka Formation at this time, contain very little sand-size silicate debris and no feldspar. The source area for the arkose in the Nuka has not been found, but it was probably to the south of the Arctic Alaska basin. The structural position of the Bogie sequence and the arkosic limestone and sandstone in the Nuka Formation are best explained if the Nuka was deposited on the south edge of the Mississippian and Pennsulvanian basin. The depositional environment of the Nuka Formation may have been shallow banks with clastic sources in land areas to the south. It is possible that the granitic source for the arkose began to rift away from the

the red, green, and gray cherts of the Etivluk Group, possibly reflecting a change in the oxidation potential of the seawater at this time. In some exposures of this horizon, yellow or orange clay layers, a few centimeters thick, may Where limestone or interbedded limestone and chert underlies the Etivluk Group, the contact is sharp, although there is commonly an increase in the percentage of chert in the upper 100 m of some of the underlying chert carbonate units and the Kogruk Formation. This cherty interval is partly correlative with the Tupik Formation that has been differentiated in areas to the east of the map area (Sable and Dutro, 1961; Curtis and others, 1984). The contact of the Nuka Formation and Etivluk Group is not exposed in the De Long Mountains quadrangle, but farther east the contact is sharp in places and possibly gradational in others (Tailleur and others, 1973). No compelling evidence from any of the sedimentary sequences shows that the Etivluk Group was deposited on a major unconformity. However, it is possible that future detailed paleontological sampling may substantiate local disconformities at the top of the Kogruk and (or) Nuka Formations. Deposition of the Etivluk Group continued until Middle Jurassic time. In the northern sequences (fig. 5) ithographic limestone, packed with pelecypod Monotis, was deposited in the limestone member of the Otuk Formation of the Etivluk Group during Late Triassic time; most of this limestone was subsequently silicified. In the northern part of the Key Creek sequence, the calcareous Monotis interval is overlain by 5 to 10 m of dark chert and paper shale that resembles the Lower and Middle Jurassic Blankenship Member of the Otuk Formation (Mull and others, 1982). Early Jurassic radiolarians also have been identified near the top of the Etivluk Group in the Puzzle Creek sequence at Punupkahkroak Mountain (De Long Mountains A-3 quadrangle). Pillow basalts and flows of the Copter igneous sequence are not well exposed in the map area, but are similar to the Copter igneous sequence in the Misheguk Mountain quadrangle, where radiolarians from cherts intercalated with pillows have been correlated with radiolarians from the Upper Triassic (Norian) part of the Otuk Formation. The higher structural position of the Copter igneous sequence suggests that it was originally south of the coeval part of the Etivluk Group. The basement onto which Copter basalts were erupted is not known; blocks of Devonian limestone are commonly associated with the Copter igneous sequence and may be part of this basement, but whether the contacts are mainly stratigraphic, intrusive, or tectonic has not been determined. In Late Jurassic and Early Cretaceous time a major change in sedimentation occurred as the old continental shelf

was broken up into large allochthonous sheets. This tectonism, which began the Brooks Range orogeny, progressed from south to north as thrust sheets of southern origin overrode shelf rocks to the north, which were in turn thrust still farther north. The orogeny probably began at the south edge of the Arctic Alaska plate when the Misheguk Mountain allochthon overthrust the Copter igneous sequence. Structurally lower thrust faults then developed beneath the Copter igneous sequence, creating the Copter Peak allochthon. Both allochthons then moved relatively northward over the sedimentary sequences on the old shelf. The leading edges of the allochthons were exposed to erosion and began to shed clastic debris north of the developing mountain range. The petrology of the mafic and ultramafic rocks that make up the Misheguk Mountain allochthon is typical of the lower parts of many ophiolites (Patton and others, 1977; Zimmerman and others, 1981), indicating that this allochthon is probably a remnant of oceanic crust that lay south of the Arctic Alaska continental plate before the Brooks Range orogeny. The basalts and oceanic sediment that may have been on top the gabbro and peridotite have been eroded away and are no longer preserved in the quadrangle. The mechanism of the thrusting is uncertain. We believe the best explanation is that the Arctic Alaska plate, on which the Brooks Range sedimentary sequences were deposited, was subducted toward the (present) south, and allochthonous sedimentary sequences were detached from the upper layers of the subducted plate. In this model, the several hundred kilometers of lower crust on which the sedimentary sequences were deposited are no longer exposed in the De Long Mountains. The suture between the Arctic Alaska plate and the southern oceanic(?) plate is now south of the Baird Mountains. Remnants of the suture plane also may be at the base of the gently folded ophiolitic klippen, mapped as the Misheguk Mountain allochthon. In the northern sequences, which were probably relatively stable during the early parts of the Brooks Range orogeny, the Jurassic and Lower Cretaceous Ipewik unit appear to lie conformably on the Etivluk Group. Some thin tongues of the Ipewik unit possibly extended as far south as the Amphitheatre sequence. The lower part of the Ipewik

unit is commonly present in the Wulik sequence in places where it has not been removed by erosion at the sub-Okpikruak unconformity, and the upper part of the Ipewik unit is best developed in the northern parts of the Key Creek sequence. Coquina beds composed of the pelecypod Buchia, and the clean, well-sorted quartzitic sandstone of the Tingmerkpuk subunit of the Ipewik unit may indicate that the water depth was shoaling toward the northern limits of the presently mapped Key Creek sequence during Valanginian time. The Lower Cretaceous Okpikruak Formation was deposited in a foredeep on the north side of the ancestral Brooks Range during the Brooks Range orogeny. The Okpikruak is mostly graywacke and shale and contains local conglomerate. Features characteristic of turbidity-current deposition are common. Conglomerate clasts are composed of chert of the Etivluk Group, chert and limestone of the Lisburne Group, arkose of the Nuka Formation, limestone of the Baird Group, and gabbro or diabase derived from the known allochthons. Also, many clasts of volcanic and

plutonic igneous rocks are present that have not been recognized within any of the allochthons currently present in the De Long Mountains. Their source is problematical; they may have been derived from the Copter igneous sequence, the upper part of the Misheguk igneous sequence, or from allochthons structurally above the Misheguk Mountain allochthon that now have been entirely removed by erosion (Mayfield and others, 1978b) The base of the Okpikruak Formation is an unconformity in most places, although there may have been continuous deposition in the northern areas where it sits on the Ipewik unit. It is evident from the map pattern that the Okpikruak truncates older units, and in some places rests directly on Devonian rocks, but the angularity of uncation is relatively gradual. Depositional contacts between the Okpikruak and older units seem to be concorda on the scale of an outcrop. If any folding preceded the deposition of the Okpikruak, it probably was relatively gentle. Olistoliths from structurally higher thrust sheets slumped into the foredeep and were incorporated in the Okpikruak sedimentary materials deposited atop lower stratigraphic sequences (Mull, 1979). The olistoliths are mmonly blocks of limestone of the Baird Group or Kogruk Formation, chert of the Etivluk Group, and arkose of the Nuka Formation. In some cases they are surrounded by conglomerate that probably represents submarine channel deposits. Isolated blocks of older, more competent rocks completely surrounded by graywacke and shale of the Okipikruak Formation are common in many areas. Distinguishing olistoliths from tectonically incorporated blocks is difficult in most of these cases. As the thrust sheets moved northward relative to the rocks under them, they overrode parts of the Okpikruak Formation that were deposited earlier, but the Okpikruak continued to be deposited on sequences farther to the north. Thus the depocenter of the Early Cretaceous foredeep migrated northward with time (Snelson and Tailleur, 1968) Some fossil evidence supports this conclusion even though the early orogenic clastic sediments are poorly dated by sparse occurrences of the pelecypod Buchia. In the more northerly (structurally lowest) thrust sheets that are made up of the Key Creek sequence along the Kukpowruk River (De Long Mountains B-2 quadrangle), the base of the orogenic flyschoid sediments, mapped here as the Fortress Mountain Formation, is younger than the well-dated Lower Cretaceous (Valanginian) beds of the Tingmerkpuk subunit of the Ipewik unit (Crane and Wiggins, 1976) on which it was deposited. Near the mountain front 22 km to the southwest in a structurally higher thrust sheet of the Key Creek sequence (fossil locality 9, De Long Mountains B-3 quadrangle), the orogenic flyschoid sediments, mapped here as the Okpikruak Formation, are at least as old as Berriasian, because they contain the pelecypod Buchia okensis. In Valanginian in the northern part of the structurally lowest sequence.

a structurally higher thrust sheet that is part of either the Kelly River, Ipnavik River, or Nuka Ridge allochthon, Curtis and others (1984, fossil locality 48) report a Late Jurassic (Tithonian) pelecypod Buchia fischeriana, from orogenic fluschoid sediments. mapped as wacke and mudstone, in the Misheguk Mountain quadrangle. This fossil evidence shows that the age of the base of the Okpikruak Formation and related orogenic clastic rocks is older in structurally higher sequences than it is in lower sequences. Such a diachronous relation supports the concept of northward prograding flyschoid deposition beginning at least as early as Tithonian in higher sequences and beginning as late as The stacked allochthons that are mapped in the De Long Mountains quadrangle may have been thrust over the south edge of the sequence of rocks present in the subsurface of the North Slope. The evidence for the allochthonous nature of the Brooks Range allochthon, the lowest exposed in the map area, is based on field relations along the north side of the Baird and Schwatka Mountains east of the map area (Mull and others, 1976). The North Slope sequence is not exposed in the De Long Mountains, but it may underlie the entire area at several kilometers depth. With the waning of the large-scale thrusting during mid-Cretaceous time, the foredeep north of the mountain range continued to fill with sediment. The Fortress Mountain Formation, of late Early Cretaceous age, was derived from the Brooks Range and deposited on the northern part of the Okpikruak Formation and Ipewik unit. The character of the graywacke and shale of the southern part of the Fortress Mountain Formation is so similar to the graywacke and shale of the Okpikruak Formation that its southern extent is not easily differentiated from the Okpikruak. Northsouth compression in the Late Cretaceous and early Tertiary caused folds with east-west trends and some minor thrust aulting in the Fortress Mountain Formation and also created broad folds in the stacked allochthons. The De Long Mountains have probably remained a topographic high since Fortress Mountain time, because no rocks younger than

CRETACEOUS KJi<sub>1</sub> Kit<sub>1</sub> KJi<sub>2</sub> JURASSIC OR JURASSIC(?) PENNSYLVANIAN PENNSYLVANIAN(?) DEVONIAN DESCRIPTION OF MAP UNITS [Only allochthons and rock units that appear on this map are colored. Those that are not colored appear on Kuna Formation (Pennsylvanian and Mississippian)—Black, carbonaceous, calcareous shale and subordinate the adjacent maps of this series interbedded fine-grained limestone. Age based on stratigraphic correlation with the Kuna Formation in SURFICIAL DEPOSITS Active alluvial deposits (Quaternary)—Unconsolidated silt, sand, and gravel that is actively reworked during conformable on the Kogruk Formation stream floods. Surfaces marked by sparse vegetation in most places Mko<sub>3</sub> Kogruk Formation (Mississippian)—Light-gray-weathering, medium-grained limestone containing as much as Terrace deposits (Quaternary)-Inactive alluvial deposits composed of silt, sand, and gravel at or above 25 piercent black chert nodules and lenses. Common fossils are Late Mississippian corals, crin brachiopods, and foraminifers of Mamet zone 11 or younger (Armstrong and Mamet, 1977). Depositional present high-water stage. Surface covered by stable vegetation thickness is greater than 600 m. Base is gradational into the micritic limestone unit Glacial outwash deposits (Quaternary) Glacial moraine deposits (Quaternary) Surficial deposits, undivided (Quaternary)—Includes alluvium, colluvium, lacustrine, and glacial deposits **AUTOCHTHONOUS ROCKS** [Rocks that have undergone minor thrust displacement relative to underlying rocks] and is inferred from regional stratigraphic relations. Locally, lower part is divided into: Fortress Mountain Formation (Cretaceous)—Exposed in northern part of map in foothills of De Long Mountains. Variable depositional thickness is probably more than 1 km in some places at north edge of map. Age is Early Cretaceous. Divided into: Wacke and mudstone member-Commonly more than 50 percent fine- to medium-grained wacke that is Baird Group, upper part (Devonian)—Consists of: isually calcareous, well bedded, and locally conglomeratic. Some wacke beds have numerous shale chips. Commonly weathers medium to light brown on hill slopes where some soil and rock fragments have encrustations of caliche. Contains Albian pelecypod Inoceramus. Base rests on either Valanginian part of the Ipewik unit in northern part of map area or the Okpikruak Formation in more southern exposures Wacke and conglomerate member-Brown-weathering, gray and grayish-green wacke and granule- to correllation with similar limestone in thrust slices at base of Kelly sequence that are Middle and Late pebble-wacke conglomerate interbedded with subordinate siltstone and mudstone. Texturally and Devonian in age. Exposed thickness is as much as 25 m; basal contact is a thrust fault ompositionally immature; contains clasts of quartz, limestone, chert, diabase, and shale. Mapped only at Mount Kelly, De Long Mountains B-3 quadrangle AUTOCHTHONOUS OR ALLOCHTHONOUS ROCKS B-1 quadrangle. Letter symbols for map units in this sequence include the subscript number 3 in their map Fortress Mountain and Okpikruak Formations, undivided (Cretaceous)—Interbedded wacke and mudstone. Age based on Early Cretaceous palynomorphs and pelecypods sequence is found relative to the Amphitheatre sequence is shown in figure 3 **ALLOCHTHONOUS ROCKS** Okpikruak Formation (Cretaceous)-Interbedded fine- to medium-grained lithic wacke and mudstone with BROOKS RANGE ALLOCHTHON Key Creek sequence rocks that may be olistoliths from higher allochthons. Lower part may possibly be Late Jurassic in age. Named for characteristic exposures along Key Creek (lat 68°08' N., long 162°29' W.), De Long Mountains A-1 quadrangle. Letter symbols for map units in this sequence include the subscript number 1 to signify that they uncomformity at base. Locally divided into: are part of the Brooks Range allochthon Okpikruak Formation (Cretaceous)-Interbedded gray mudstone and fine- to medium-grained wacke. granitte, and basalt. Ranges in thickness from 0 to approximately 20 m Contains Early Cretaceous pelecypods Buchia sublaevis and Buchia okensis. Locally contains blocks of Etivluk Group (Jurassic to Pennsylvanian)—Gray, black, brown, and maroon radiolarian chert with siliceous older rocks that are possible olistoliths from higher allochthons. Exposed thickness may exceed 300 m. shale partings. Consists of the Siksikpuk and Otuk Formations. Locally divided into: Depositional thickness is probably variable. In some areas base may be gradational into the Ipewik unit; Otuk Formation (Jurassic and Triassic)—Gray and maroon well-bedded chert with siliceous shale partings. in other areas it is an unconformity. Age of unit is Early Cretaceous. Locally divided into: Cream-colored zone near top has a few limestone beds and contains Late Triassic pelecypod Monotis Conglomerate member-Wacke conglomerate with rounded boulders and pebbles that consist of chert, limestone, granite, dacite, diabase, and gabbro. Distribution is sporadic; thickness ranges from 0 to approximately 30 m Ipewik unit (Cretaceous and Jurassic)—Maroon and gray shale, coquinoid limestone, siltstone, and clean quartz sandstone. This unit was termed the "Ipewik Formation," for exposures on the Ipewik River, in an (De Long Mountains A-3 quadrangle) and pelecypods in Howard Pass quadrangle (Mull and others, 1982). Depositional thickness about 30–50 m. Base is gradational into the Siksikpuk Formation abstract by Crane and Wiggins (1976), but was misspelled "Ipewick". Shale locally contains sparse wellrounded pebbles that consist of quartz, chert, gabbro, and granite. Shale contains local light-weathering clay beds (bentonite?) and volcanic rocks of intermediate composition at one location on a tributary of upper Kukpuk River, De Long Mountains B-3 quadrangle. Variable depositional thickness ranges from 0 to 50 member of the Kogruk Formation or a thin discontinuous tongue of the Kuna Formation m. Early Cretaceous pelecypod Buchia sublaevis commonly occurs in red-weathering limestone coquina beds in upper part. Basal contact appears to be conformable on the Otuk Formation. Age of unit is Jurassic and Early Cretaceous. Locally divided into: Tingmerkpuk subunit (Cretaceous)-Fine- to medium-grained, massive to thick-bedded, clean quartz lower sequence. Exposed thickness is about 10 m andstone. Unit name is for exposure near Tingmerkpuk Mountain, De Long Mountains C-1 quadrangle. Locally interbedded with red shale that has concretions and shell beds containing Early Cretaceous (Valanginian) pelecypod Buchia sublaevis. Age of unit is Early Cretaceous. Thickness ranges from 0 to chert nodules and lenses. Locally contains subordinate thin zones of dark-gray, micritic carbonate rocks with lenses of black chert. Common megafossils are mid- and Late Mississippian corals, crinoids, and JPe1 Etivluk Group (Jurassic to Pennsylvanian)—Gray chert with minor amounts of shale; weathers brown, yellow, ate Mississippian (Chesterian) in age. Foraminifers are Late Mississippian and range from approximatel gray, green, and maroon. Consists of the Siksikpuk and Otuk Formations. Contains Pennsylvanian to riassic radiolarians; in upper part, Late Triassic pelecypod Monotis is common. Age of unit is Pennsylvanian to Middle Jurassic. Locally divided into: from about 200 to 600 m. Base is gradational into the Utukok Formation. Locally divided into: Otuk Formation (Jurassic and Triassic)—Light- to dark-gray chert with thin siliceous shale partings. Upper part weathers to cream-colored or light-brown and green bedding surfaces and contains a few siliceous limestone beds that contain Late Triassic pelecypod Monotis. Middle part is well-bedded, gray, brown, or Mountains A-3, A-4, and B-3 quadrangles. Probably grades laterally into the Tupik Formation as mapped dark-gray chert containing rarely preserved Triassic pelecupods Halobia in shaly layers, Lower part which in Misheguk Mountain quadrangle (Curtis and others, 1984, Sable and Dutro, 1961). Locally contains is locally present, is gray shale with a few carbonate beds that contain Early Triassic conodonts. Chert also crinoids but otherwise is sparsely fossiliferous. Late Mississippian age of unit based on foraminifer collections (Marmet zones 14 to 15) from De Long Mountains A–3 quadrangle. Depositional thickness is approximately contains numerous Mesozoic radiolarians. Uppermost part may be Jurassic based on stratigraphic correlation with similar chert beds that contain identified radiolarians from Puzzle Creek sequence (De Long 30-75 m. Base is gradational into less cherty limestone of the Kogruk Formation Mountains A-3 quadrangle) and pelecypods in the Howard Pass quadrangle (Mull and others, 1982). Utukok Formation (Mississippian)—Buff-weathering limestone, sandy limestone, and fine-grained sandstone. Depositional thickness is approximately 30-50 m. Base appears to be gradational into the Siksikpuk Interbedded gray shale may comprise as much as 50 percent in lower part west of Wulik River. Early Formation. Age of formation is Early Triassic to Middle Jurassic Siksikpuk Formation (Triassic to Pennsylvanian)—Gray chert and gray, olive-gray, and maroon siliceous shale. Middle part of unit is mostly shale that grades both up and down into well-bedded chert with thin lississippian, approximately Mamet zone 12. Exposed thickness is as much as about 1,000 m; depositional siliceous shale partings. Mammillary bedding structures locally common especially near base. Bottom of contact on the limestone unit of the Baird Group is not exposed and is inferred from regional stratigraphic section contains indefinitely dated Late Mississippian to Early Pennsylvanian radiolarians. Top of section elations. Locally divided into: is difficult to precisely determine in outcrop but appears to contain Mesozoic radiolarians. Depositional thickness is approximately 40-80 m. Base appears to be gradational into the Kuna Formation. In places, the gradational zone at base contains yellow-weathering clay beds (bentonite?). Age of formation is Pennsulvanian to Early Triassic Kuna Formation (Pennsylvanian and Mississippian)—Black carbonaceous shale with subordinate interbedded black chert, except in top 10 m where chert predominates. Contains a few dark-gray, fine-grained limestone interbeds. A few beds of calcareous granule sandstone are found west of Wulik River. Shale surfaces shale member or the sandstone member commonly acquire a bluish-silver sheen on weathering. Lower part contains Osagean to Chesterian Sandstone member-Interbedded buff-weathering, fine-grained sandstone, calcareous sandstone, sandy conodonts and probable early Meramecian brachiopods. Upper part contains Late Mississippian to Early or Middle Pennsylvanian radiolarians. Limestone contains rare corals. Depositional thickness is approximately 40-70 m. Basal contact is either sharp on the Kogruk Formation or gradational into the micritic limestone unit or Kayak Shale. Age of formation is Early Mississippian to Early or Middle thickness approximately 200-400 m. Basal contact is commonly a thrust fault PMv<sub>1</sub> Intermediate to mafic volcanic rocks (Pennsylvanian or Mississippian)—May include hypabyssal intrusive shale. May contain a few calcareous sandstone beds. Only mapped west of Wulik River. Exposed thickness rocks. Andesite or basalt composed of plagioclase, augite, biotite, apatite, and ilmenite(?) that is partly is approximately 200 m. Basal contact is not exposed altered to chlorite, kaolinite, calcite, and leucoxene. Only found in small outcrops near Deadlock Mountain Baird Group, upper part (Devonian)—Divided into: and east of middle part of Wulik River (De Long Mountains A-2 quadrangle). Occupies uncertain Limestone-Light-gray, medium- to coarse-grained limestone. Found as isolated blocks along thrust faults at stratigraphic position but probably interfingers with upper part of the Kuna Formation Kogruk Formation (Mississippian)—Gray, medium-grained limestone with as much as 25 percent black chert nodules and lenses, locally dolomitic. Contains crinoids and brachiopods that have not been studied in indefinitely dated Silurian to Devonian corals and stromatoporoids and Middle to Late Devonian detail. Unit is considered late Early and Late Mississippian in age based on stratigraphic position between brachiopods and conodonts. Exposed thickness ranges from 0 to 70 m. Basal contact is a thrust fault the Kuna Formation and Kayak Shale. Outcrops appear to be discontinuous, and depositional thickness Limestone and shale—Gray shale interbedded with light-gray- to buff-weathering limestone. Most limestone ranges from 0 to 20 m. Base is gradational into the Kayak Shale is fine grained and weathers to platy and flaggy fragments. Shale is locally carbonaceous. Mapped above Mml<sub>1</sub> Micritic limestone (Mississippian)—Dark-gray, light-weathering, thin-bedded limestone with subordinate a thrust fault on east side of Punupkahkroak Mountain, De Long Mountains A-3 quadrangle. Age of unit interbedded black shale, middle and Late Mississippian age based on stratigraphic position between the is presumably Devonian based on lithologic similarity to the shale and limestone unit in Puzzle Creek Kuna Formation and Kayak Shale south of lower part of Puzzle Creek, De Long Mountains A-3 quadrangle. Probably laterally gradational into the Kogruk Formation. Depositional thickness ranges from IPNAVIK RIVER ALLOCHTHON 0 to approximately 30 m. Base is gradational into the Kayak Shale Puzzle Creek sequence Kayak Shale (Mississippian)—Black to dark-gray shale with interbedded rusty-weathering fossiliferous limestone and pyritic ironstone concretions. Locally contains a few siltstone and sandstone beds. Common fossils include probable Early Mississippian crinoids, brachiopods, bryozoans, and conodonts. Depositional Named for characteristic exposures in the hills around the upper part of Puzzle Creek (lat 68°10′ N., long 163°33′ W.), De Long Mountains A-3 quadrangle. Letter symbols for map units in this sequence include the thickness is approximately 10-40 m. Base is gradational into the Utukok Formation. Age of unit is Early subscript number 4 to signify that they are part of the Ipnavik River allochthon Mu<sub>1</sub> Utukok Formation (Mississippian)—Buff-weathering, light-gray, coarse-grained limestone with interbedded local wacke conglomerate. Upper part is presumably Early Cretaceous in age based on stratigraphic clean, fine-grained quartz sandstone, siltstone, and shale. Locally contains numerous Early Mississippiar correlation with fossiliferous parts of the Okpikruak Formation in other sequences. Lower part may possibly crinoid, bryozoan, coral, and brachiopod fossils. Exposed only in De Long Mountains A-1, A-2, and A-3 be Late Jurassic. Locally contains blocks of older rocks that are possible olistoliths from higher allochthons quadrangles. Intertongues with uppermost part of the red-brown siltstone unit in De Long Mountains A-1 Exposed thickness ranges to more than 200 m. Depositional thickness is probably variable. Has a probable quadrangle. Age of formation is Early Mississippian. Locally divided into: unconformity at base. Locally divided into: Limestone and shale member—Consists of 75 percent buff-weathering limestone interbedded with 25 chert, limestone, granite, and basalt. Thickness ranges from 0 to approximately 50 m percent gray calcareous shale. Contains numerous Mississippian crinoid, brachiopod, gastropod, and coral fossils, and upper part has Late Mississippian foraminifers of Mamet zone 11 or younger. Exposed thickness JPe<sub>4</sub> of 100-300 m may be, in part, structurally repeated. Basal contact is not exposed shale partings. Locally divided into: Sandstone member-Buff-weathering, fine- to medium-grained clean quartz sandstone interbedded with sandy limestone and subordinate gray shale. Common fossils are crinoids and brachiopods that have not been studied in detail. Mapped only in De Long Mountains A-1, A-2, and A-3 quadrangles. Exposed age from Triassic to Early Jurassic (Toarcian to late Pliensbachian). Depositional thickness is approximately thickness is less than 40 m; basal contact is a thrust fault 30-50 m. Base is gradational into the Siksikpuk Formation Red-brown siltstone (Mississippian)—Mostly reddish-brown-weathering siltstone, locally calcareous, with subordinate amounts of sandstone and shale. Ironstone concretions are locally abundant in shaly intervals. Crossbeds and ripple marks are common features in sandy beds. Common fossils include crinoids, brachiopods, and gastropods, which have not been studied in detail. Equivalent beds in Noatak guadrangle mestone unit, or the black chert and dolomite unit contain Early Mississippian conodonts (A.G. Harris, written commun., 1982). Exposed thickness ranges from 0 to 200 m. Base is gradational into the light-brown-weathering, thicker-bedded undivided Noatak Sandstone and Kanayut Conglomerate Mountains A-3 quadrangle Noatak Sandstone and Kanayut Conglomerate, undivided (Mississippian and Devonian)—Mostly lightbrown- to reddish-brown-weathering, well-indurated, fine- to coarse-grained sandstone with interbeds of conglomerate, siltstone, and maroon and gray shale. Sandstone is locally calcareous. Exposed thickness is probably greater than 300 m. Base is gradational into the Hunt Fork Shale. Age of the Kanayut Conglomerate is Late Devonian and Early Mississippian(?). Overall age of unit is Late Devonian and Early Hunt Fork Shale (Devonian)—Shale, slate, and phyllite with lesser amounts of interbedded siltstone and sandstone. Mapped only in southern part of De Long Mountains A-1 and A-2 quadrangles. Thickness is into the black chert and limestone unit on Punupkahkroak Mountain (De Long Mountains A-3 quadrangle) greater than 300 m. Base is not exposed in map area. Age of unit is Late Devonian PICNIC CREEK ALLOCHTHON Wulik sequence Named for characteristic exposures along the tributaries of the upper part of the Wulik River (lat 68°21' N. limestone unit or the black chert and dolomite unit long 163° W.), De Long Mountains B-2 quadrangle. Letter symbols for map units in this sequence include the subscript number 2 to signify they are part of the Picnic Creek allochthon. Location of the area where the Wulik sequence occurs relative to the Amaruk sequence is shown in figure 3 Okpikruak Formation (Cretaceous)-Interbedded brown-weathering, fine- to medium-grained wacke and contact on the Kayak Shale gray mudstone. Contains Early Cretaceous pelecypod Buchia sublaevis. Locally contains blocks of older rocks that are possible olistoliths from higher allochthons. Exposed thickness ranges from 0 to more than 700 m. Depositional thickness is probably variable. In some areas base may be gradational into the Ipewik unit; in other areas, it is an unconformity. Locally divided into: into the black chert and the black chert and limestone units. Maximum exposed thickness is approximately Conglomerate member-Wacke conglomerate with rounded boulders and pebbles of chert, limestone, granite, dacite, diabase, and gabbro. Distribution is sporadic and thickness ranges from 0 to approximately KJi<sub>2</sub> | Ipewik unit (Cretaceous and Jurassic)—Maroon and gray shale. Depositional thickness ranges from 0 to 10 m. Basal contact appears to be conformable on the Otuk Formation the limestone unit of the Baird Group is not exposed but is inferred from regional stratigraphic relations Etivluk Group (Jurassic to Pennsylvanian)—Gray chert with minor amounts of shale; weathers to shades of Utukok Formation (Mississippian)—Divided into: brown, yellow, gray, green, and maroon. Consists of the Siksikpuk and Otuk Formations. Chert contains numerous late Paleozoic and Mesozoic radiolarians and upper part contains Late Triassic pelecypod Otuk Formation (Jurassic and Triassic)—Light- to dark-gray chert with thin siliceous shale partings. Upper part contains Triassic pelecypod Monotis, weathers to cream-colored or light-brown and green bedding surfaces, and commonly contains a few carbonate beds. Chert contains Triassic radiolarians. Top is presumably Jurassic based on stratigraphic correlation with similar chert beds that contain identified radiolarians in Puzzle Creek sequence (De Long Mountains A-3 quadrangle) and pelecypods in the exposed but is inferred from regional stratigraphic relations Howard Pass quadrangle (Mull and others, 1982). Depositional thickness is approximately 30-50 m. Base Baird Group, upper part (Devonian)—Divided into: is probably gradational into the Siksikpuk Formation Siksikpuk Formation (Triassic to Pennsylvanian)—Gray and maroon chert and siliceous shale. Chert contains radiolarians that have not been studied in detail. Age based on stratigraphic correlation with equivalent unit in Key Creek sequence. Depositional thickness is approximately 40-60 m. Basal contact as about 200 m. Basal contact is commonly a thrust fault appears to be sharp and conformable on the black chert unit or the black chert and limestone unit Black chert (Pennsylvanian? and Mississippian)—Well-bedded black chert with a few siliceous black shale partings. Local white-weathering rind on bedding surfaces. Chert contains radiolarians that have not been studied in detail. Age based on stratigraphic correlation with uppermost part of the Kuna Formation in Key Creek sequence. Depositional thickness ranges from 0 to 50 m. Basal contact is sharp on the micritic limestone unit, or is gradational into the Kuna Formation Black chert and limestone (Pennsylvanian? and Mississippian)—Approximately equal amounts of interbedded black chert and micritic limestone. Locally may have a few dolomitic beds. Sparse fossils in NUKA RIDGE ALLOCHTHON limestone include crinoids, bryozoans, and Late Mississippian brachiopods. Age of upper part is based on Bogie sequence stratigraphic correlation with the black chert and limestone unit in the Amaruk sequence. Depositional thickness ranges from 0 to 200 m. Base is gradational into the Kuna Formation or the micritic limestone Kuna Formation (Pennsylvanian and Mississippian)—Black carbonaceous shale with subordinate black chert beds. Locally contains numerous thin beds of micritic limestone. Lower part contains middle Osagean conodonts and upper part contains indefinitely dated Late Mississippian to Early Pennsylvania most other exposures of the Nuka Ridge allochthon in the western Brooks Range brachiopods and gastropods. Depositional thickness ranges from 0 to 35 m. Base is gradational into the Nuka Formation (Pennsylvanian? and Mississippian)—Light-gray- to buff-weathering, coarse-grained arkose, micritic limestone unit or the Kayak Shale Micritic limestone (Mississippian)—Dark-gray, fine-grained limestone; weathers light gray. Beds 0.5-5 cm thick commonly weather flaggy to platy. As mapped, locally contains a few beds of medium-grained crinoidal limestone, containing black chert nodules, that probably represent a thin tongue of the Kogruk Formation (not distinguished as a discrete map unit in this sequence). Contains Late Mississippian (Meramecian) foraminifers and indefinitely dated late Osagean to early Chesterian conodonts. Megafossils include Late Mississippian brachiopods. Depositional thickness ranges from 0 to 80 m. Base is gradational into the Kayak Shale or the Utukok Formation Mk<sub>2</sub> Kayak Shale (Mississippian)—Gray fissile shale with interbedded light-gray- to buff-weathering limestone and local rusty-weathering ironstone concretions. Local bioclastic limestone beds contain crinoid buttons Pennsylvanian(?) and Late Mississippia Exposed thickness ranges from 5 to 40 m; may be locally absent south of Inaccessible Ridge (De Long Mountains B-1 quadrangle). Base is probably conformable on the Utukok Formation COPTER PEAK ALLOCHTHON Utukok Formation (Mississippian)—Interbedded sandy limestone and calcareous sandstone. Contains crinoid Copter igneous sequence and brachiopod fossils that have not been studied in detail. Early Mississippian age of unit based on Named for characteristic exposures at Copter Peak (lat 68°30' N., long 161°18' W.), Misheguk Mountain stratigraphic correlation with the Utukok Formation in Amaruk and Kelly sequences. Stratigraphic relation quadrangle. Letter symbols for the map unit in this sequence include the subscript number 6 to signify that it to the Kayak Shale is uncertain but is probably both laterally and vertically intergradational. Exposed is part of the Copter Peak allochthon thickness is approximately 30 m and basal contact is a thrust fault south of Inaccessible Ridge (De Long Mountains B-1 quadrangle). Locally absent at Anxiety Ridge (De Long Mountains A-2 quadrangle) Basalt (Jurassic? and Triassic)—Locally has pillow structures. Poorly exposed in southern part of De Long Mountains A-3 and A-4 quadrangles. Basal contact is a thrust fault. Triassic age based on lithologic correlation with similar rocks in Misheguk Mountain quadrangle, which contain intercalated Triassic cherts Noatak Sandstone (Mississippian and Devonian)-Calcareous, medium-brown to buff-weathering, wellindurated, fine- to medium-grained sandstone and siltstone. Contains a few ironstone concretions, and that have been dated by radiolarian fossils. Jurassic(?) age is based on possibility that gabbroic rocks of abundant siltstone beds are present in upper part. Mapped only on Anxiety Ridge (De Long Mountains Jurassic age, similar to those exposed in the Misheguk igneous sequence, may have been source for some A-2 quadrangle) and east of map area in Misheguk Mtn. quadrangle (Curtis and others, 1984). Exposed thickness is about 50 m, and base is not exposed. Age of unit is Late Devonian and Early Mississippian MISHEGUK MOUNTAIN ALLOCHTHON Amaruk sequence Named for characteristic exposures along the upper tributaries of the Amaruk River (lat 68°14'30" N., long 163°38′ W.), De Long Mountains B-3 quadrangle. Letter symbols for map units in this sequence include the Named for characteristic exposures at Misheguk Mountain (lat 68°15′ N., long 161°05′ W.), Misheguk Mountain subscript number 2 to signify that they are part of the Picnic Creek allochthon. However, some of the rocks quadrangile. Letter symbols for map units in this sequence include the subscript number 7 to signify that they here mapped as Amaruk sequence may instead belong to the Wolverine Creek allochthon of Moore and others are part of the Misheguk Mountain allochthon 1986). Location of the area where the Amaruk sequence is found relative to the Wulik sequence is shown on Gabbro (Jurassic)-Medium- to coarse-grained. Predominant minerals are plagioclase, clinopyroxene orthopyroxene, homblende, and olivine. Locally banded with plagioclase- and pyroxene-rich layers, and locally includes small dikes of peridotite, pyroxenite, and homblende-plagioclase pegmatite. Age based on potassium-argon dates on homblende from similar rocks in Misheguk Mountain quadrangle (Patton and Ko<sub>2</sub> Okpikruak Formation (Cretaceous)—Interbedded gray-brown, fine- to medium-grained wacke and gray mudstone. Early Cretaceous age of unit based on stratigraphic correlation with similar beds that contain the pelecypod Buchia sublaevis, in this unit in adjacent sequences. Locally contains blocks of older rocks others, 1977). Mapped only in southeastern part of De Long Mountains A—1 quadrangle and southern part that are possible olistoliths from higher allochthons. Exposed thickness ranges from 0 to more than 1200 of De Long Mountains A-4 quadrangle m. Depositional thickness is probably variable. Has a possible unconformity at base. Locally divided into: Ultramafic rocks (Jurassic)—Predominantly orange-weathering peridotite and partly serpentinized dunite with Conglomerate member-Wacke-matrix conglomerate with rounded boulders and pebbles of chert, minor amounts of pyroxenite in small dikes. Basal contact is a thrust fault. Mapped only in De Long limestone, granite, dacite, and diabase. Deposited locally with thickness that ranges from 0 to approximately Mountains A-1 and A-4 quadrangles. ROCKS NOT ASSIGNED TO A SPECIFIC THRUST SEQUENCE Etivluk Group (Jurassic to Pennsylvanian)—Gray chert with minor amounts of shale; weathers to shades of Okpikruak Formation (Cretaceous)—Greenish-gray lithic wacke and gray mudstone. Contains Early Cretaceous brown, yellow, gray, green, and maroon. Consists of the Siksikpuk and Otuk Formations. Chert contains late Paleozoic and early Mesozoic radiolarians and in upper part, Late Triassic pelecypod Monotis. Locally pelecypod, Buchia. In some areas where this unit was deposited upon Kelly or Puzzle Creek sequences, its lower part may possibly be Late Jurassic in age. Locally divided into: Otuk Formation (Jurassic and Triassic)—Light- to dark-gray chert with thin siliceous shale partings. Upper Conglomerate member-Wacke conglomerate with rounded cobbles and pebbles that consist of chert, part contains cream-colored bed surfaces and Late Triassic pelecypod Monotis. Lower part, which is seldom limestone, granite, and mafic igneous rocks exposed, is mostly shale with a few limestone beds that contain Early Triassic conodonts. Triassic Inewik unit (Cretaceous and Jurassic)—Thin-bedded maroon and gray shale. Depositional thickness ranges radiolarians are common in chert. Uppermost part is presumably Jurassic based on stratigraphic correlation from 0 to 10 m. Mapped at mountain front east of upper Saksot Creek and along upper Kelly River (De with similar chert beds that contain identified radiolarians in Puzzle Creek sequence (De Long Mountains Long Mountain B-1 quadrangle). Base appears to be conformable on the Otuk Formation A-3 quadrangle) and brachiopods and pelecypods in Howard Pass quadrangle (Mull and others, 1982). Etivluk Group (Jurassic to Pennsylvanian)—Gray radiolarian chert with siliceous shale partings. Locally Depositional thickness is about 30-50 m. Base is gradational into the Siksikpuk Formation Siksikpuk Formation (Triassic to Pennsylvanian)—Olive-gray and maroon chert and siliceous shale. Chert Otuk Formation (Jurassic and Triassic)-Light- to dark-gray radiolarian chert with thin siliceous shale contains radiolarians that have not been studied in detail in this sequence. Age based on stratigraphic correlation with this unit in Key Creek sequence. Depositional thickness ranges from about 40-80 m. Basal contact is probably conformable on the black chert unit, the black chert and limestone unit, or the black partimgs. Upper part weathers to cream-colored or light-brown and green bed surface Siksikpuk Formation (Triassic to Pennsylvanian)—Maroon and gray radiolarian chert and siliceous shale chert and dolomite unit Black chert (Pennsylvanian? and Mississippian)—Well-bedded black chert with a few black siliceous shale lack chert (Pennsylvanian? and Mississippian)—Well-bedded black chert with a few black shale partings and less than 10 percent gray- or brown-weathering carbonate beds. Probably laterally gradational into the Black chert and limestone (Pennsylvanian? and Mississippian)—Occurs as isolated olistoliths(?) and (or) black chert and limestone unit or the black chert and dolomite unit. Age based on stratigraphic correlation thrust slices in the Okpikruak Formation in De Long Mountains A-3 and B-2 quadrangles with the black chert and limestone unit and the Kuna Formation of Key Creek sequence. Depositional Kuna Formation (Pennsylvanian and Mississippian)—Black carbonaceous shale and subordinate black chert. Contains a few thin, fine-grained limestone beds. Age is based on correlation with the Kuna Formation in thickness ranges from 0 to 60 m. Sharp basal contact on sandstone member of the Utukok Formation Black chert and limestone (Pennsylvanian and Mississippian)—Approximately equal amounts of interbedded Kev Creek sequence. Contains Late Mississippian foraminifers and pelecypods on north side of Inaccessible black chert and fine-grained gray limestone. In some areas limestone beds are pervasively silicified. Ridge (De Long Mountains B-1 quadrangle) Limestone contains sparse crinoids and brachiopods. Uppermost part contains brachiopods of probable Kogruk Formation (Mississippian)—Light-gray limestone with black chert nodules and lenses. Crops out as a thrust block on west edge of Avgun Hills (De Long Mountains A-1 quadrangle) and as olistoliths in the Pennsylvanian or Permian age near Mount Raven (De Long Mountains A-2 quadrangle). Lower part contains Late Mississippian corals and foraminifers. Laterally gradational into the black chert unit and the Okpikruak Formation (De Long Mountains A-3 and B-2 quadrangles) black chert and dolomite unit. Depositional thickness ranges from about 70 to 200 m. Base is gradational into the Kogruk Formation or sharp on the Kayak Shale or the Utukok Formation Kayak Shale (Mississippian)-Dark-gray shale with a few interbeds of rusty-weathering limestone. Shale contains ironstone concretions. Occurs in small isolated outcrops on west edge of the Avgun Hills (De Long PMcd<sub>2</sub> Black chert and dolomite (Pennsylvanian? and Mississippian)—Approximately equal amounts of Mountains A-1 quadrangle) and north of Punupkahkroak Mountain (De Long Mountains A-3 quadrangle) interbedded black chert and fine-grained, gray- or brown-weathering dolomite. Laterally gradational into the black chert unit and the black chert and limestone unit. Depositional thickness is about 50-150 m. Base Limestone (Mississippian or Devonian)—Light-gray-weathering, medium- to thick-bedded limestone. Locally is either gradational into the Kogruk Formation or is sharp on the Utukok Formation and the Kayak Shale ncludes a few dark-gray chert nodules. Outcrops may be thrust slivers and (or) olistoliths. As mapped may locally include parts of the Kogruk Formation or the limestone unit of the Baird Group Micritic limestone (Mississippian)—Dark-gray, fine-grained limestone; weathers light-gray with flaggy to platy beds. Only exposure recognized in this sequence is northeast of Wulik Peaks (De Long Mountains B-3 Baird Group, upper part (Devonian)—Consists of: quadrangle). Exposed thickness ranges from 0 to 10 m; depositional contact on the Kayak Shale or Utukok Limestone—Massive to thick-bedded, light-gray limestone. Age based on lithologic correlation with nearby Formation is not exposed but is inferred from a similar stratigraphic relation in Wulik sequence Devonian limestone. Crops out southeast and northwest of lower part of Wulik River, De Long Mountains Kogruk Formation (Mississippian)—Well-bedded, medium-grained limestone with less than 20 percent black A-3 quadrangle. Thrust slivers and (or) olistoliths locally may belong to Kelly, Puzzle Creek, Bogie, or nodular chert. Contains foraminifers of Mamet zone 11 or slightly younger. Base is mid-Mississippian (late Bastille (Curtis and others, 1984; Ellersieck and others, 1984) sequence. Exposed thickness is as much as Osagean and early Meramecian) based on identification of bryozoans. Commonly contains crinoids. positional thickness ranges from 0 to 20 m. Base is gradational into the Utukok Formation Kayak Shale (Mississippian)—Gray fissile shale with subordinate amounts of interbedded rusty- or buff-Contact—Approximately located; queried where doubtful weathering limestone. Common fossils include crinoids and brachiopods. Probably laterally gradational into the Utukok Formation. Exposed thickness ranges from about 0 to 30 m; basal contact is a thrust fault U, upthrown side Utukok Formation (Mississippian)—Approximately 60-70 percent buff-weathering limestone or sandy Thrust fault—Dashed where approximately located; dotted where concealed; queried where doubtful. Sawteeth limestone and 30-40 percent interbedded shale. Contains Early Mississippian ostracodes and conodonts. on upper plate. Arrows show relative motion in cross sections. Where thrust faults are inferred near outcrop Common megafossils are crinoids, brachiopods, and Early Mississippian gastropods. Probably laterally boundaries, a thrust fault symbol is shown next to Quaternary sedimentary deposits. In such places the gradational into the Kayak Shale. Exposed thickness is less than 30 m; basal contact is a thrust fault. Locally edrock is not thrust over the Quaternary deposits but is thrust over bedrock and under a thin cover of unconsolidated sedimentary material Sandstone member—Buff-weathering, fine- to medium-grained, clean quartz sandstone interbedded with ■ Between allochthons (intersequence thrust fault) sandy limestone and subordinate gray shale. Common fossils are crinoids and brachiopods that have not been studied in detail in this sequence. One locality in De Long Mountains A-2 quadrangle has Early \_\_\_\_\_ Within an allochthon (intrasequence thrust fault) Mississippian foraminifers of Mamet zone 8 or older. Only mapped west of Wulik River in De Long Folds—Showing direction of plunge. Dashed where approximately located Mountains A-2, B-2, and B-3 quadrangles. Exposed thickness is less than 50 m; basal contact is a thrust Overturned anticline - Overturned syncline Strike and dip of beds

CORRELATION OF MAP UNITS

SURFICIAL DEPOSITS

**AUTOCHTHONOUS ROCKS** 

QUATERNARY

**AUTOCHTHONOUS OR** 

ALLOCHTHONOUS ROCKS