Preliminary Geologic Map of the Baird Mountains and part of the Selawik Quadrangles, Alaska

by

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Introduction

The Baird Mountains quadrangle lies north of the Arctic Circle between 67° and 68° latitude and between 159° and 162° longitude. The quadrangle covers 14,015 km^2 and is situated in the southwestern Brooks Range between the Noatak and Kobuk Rivers. The earliest geologic investigations of this area were undertaken following the discovery of placer gold in the southern Brooks Range around the turn of the century. Very little gold was recovered from the area of the Baird Mountains quadrangle, however, and consequently very little geologic mapping was done until after World War II when there was increased interest in base metal resources.

A preliminary generalized reconnaissance map of the Baird Mountains quadrangle was published as a USGS Open-File Report by Brosgé and others (1967), and this mapping was incorporated into the 1:1,000,000 scale maps of northern Alaska published by Beikman and Lathram (1976), Grybeck and others (1977), and the 1:500,000 scale map of Mayfield and others (1983a). The current map, at 1:250,000 scale, builds on Brosgé's work and is the result of 4 months of additional fieldwork distributed over 4 years, 1983-1986. The project was funded under the Alaska Mineral Resource Assessment Program (AMRAP), and our fieldwork was focused mainly on the mineral resources of the quadrangle. Because of the limited amount of new fieldwork contributing to this map, and because of limited to poor exposure in much of the map area, this map is considered to be preliminary and reconnaissance in nature.

Stratigraphic Framework

The stratigraphy of the western Brooks Range includes Proterozoic through Upper Cretaceous rocks, and Cenozoic unconsolidated deposits. Pre-Cretaceous rocks have been multiply deformed and metamorphosed; Cretaceous rocks have also been strongly deformed.

The pre-Cenozoic rocks in the western Brooks Range were all involved in the Brookian orogeny and are now components of a fold and thrust belt. The thrust belt is the product of considerable shortening and telescoping of sedimentary facies, such that coeval rocks representing different sedimentary facies are juxtaposed by faults (Tailleur and others, 1966; Ellersieck and others, 1979; Mayfield and others, 1983a).

In the Baird Mountains quadrangle, deposits from distinct sedimentary environments are represented by lithostratigraphic units within seven different stratigraphic sequences. Some lithostratigraphic units are present in more than one stratigraphic sequence, indicating facies overlap between sequences. Facies overlap suggests there is not long-distance transport between sequences. Total shortening is difficult to estimate because the sequences are internally imbricately thrusted as well as being thrust faulted or normally faulted with respect to adjacent sequences. The composition and distribution of the seven stratigraphic sequences are shown on Plate 1 in the Correlation of map units and in the inset map of the Distribution of stratigraphic sequences.

The structurally lowest stratigraphic sequence is the Nanielik Creek sequence, which includes the majority of Precambrian rocks in the map area, Lower Paleozoic carbonate platform deposits, and Middle Paleozoic shallow-marine to fluvial clastic deposits.

The Nanielik Creek sequence is structurally overlain to the south by the Kallarichuk Hills sequence, which consists of Proterozoic and Paleozoic shallow water and basinal deposits with minor interspersed volcanic rocks.

The Nanielik Creek and Kallarichuk Hills sequences are both structurally overlain by the Tukpahlearik Creek sequence, consisting of Lower to Middle Paleozoic basinal facies deposits, and deposits transitional to platform facies deposits.

Overlying the Tukpahlearik Creek sequence is the Nakolik River sequence which contains the Lower Paleozoic Baird Group platform carbonate deposits, and the limestones and clastic rocks of the Nakolik River, also representing carbonate buildups and shallow water facies. Upper Paleozoic to Mesozoic basinal facies shales and cherts stratigraphically overlie the Lower and Middle Paleozoic carbonate and clastic rocks.

The Kivivik Creek sequence structurally underlies the Nakolik River sequence. No Lower Paleozoic rocks are exposed with the Kivivik Creek section; the Middle and Upper Paleozoic rocks and the Mesozoic rocks differ from the Nakolik River sequence only slightly. The Endicott Group rocks are coarser grained in the Kivivik Creek sequence, and a tuffaceous unit (Mlt) which does not occur in any other sequence is present.

Like the Nakolik River sequence, the Eli River sequence structurally overlies the Kivivik Creek sequence. The Eli River sequence includes Lower to Middle Paleozoic platform carbonates of the Baird Group (DOb), but differs from the Nakolik River sequence in that it represents continuous carbonate deposition through the Mississippian: it is missing the Upper Devonian to Lower Mississippian clastic interval that is present in the other sequences.

The Maiyumerak Mountains sequence is separated from the other sequences by a normal fault. It is missing a Lower Paleozoic section, and the Devonian carbonate rocks are distinguished from the other Paleozoic limestones and dolostones in the map area by the presence of feldspar grains. However, the Etivluk Group (JPe) contains radiolarian cherts that lithologically and faunally tie this sequence to the other stratigraphic sequences that contain the Etivluk Group.

A chronologic stratigraphic synthesis for the map area indicates a long history of continental margin deposition with intermittent periods of volcanism.

Proterozoic rocks, in the eastern part of the map area (included in the Nanielik Creek and Kallarichuk Hills sequences), consist of mafic volcanic rocks, limestone, dolostone, and siliceous clastic rocks. The Proterozoic

rocks exposed in the northeastern part of the map area, in the Nanielik Creek sequence, were metamorphosed to amphibolite facies either prior to, or synchronous with, intrusion by granitic and gabbroic rocks at approximately 750±6 Ma (Karl and others, 1989). The Proterozoic rocks in the Kallarichuk Hills sequence may also have undergone this Proterozoic amphibolite facies metamorphism, based on Proterozoic K-Ar ages for actinolite (Turner and others, 1979) and a U-Pb age of 705 ± 35 Ma for zircons from metagranitic rocks,(John Aleinikoff, written commun., Sept. 1989).

The Proterozoic rocks are succeeded by Cambrian to Devonian platform carbonate rocks, with varying amounts of intercalated mafic volcanic rocks. Elsewhere in the quadrangle, the oldest dated rocks are Ordovician, and include platform carbonate rocks and carbonaceous shales and quartzites that were deposited in restricted basins, possibly between the carbonate platforms. Silurian rocks are less common, but present in the carbonate platform sequences.

In Middle to Late Devonian time, the predominant carbonate deposition of the Lower Paleozoic was gradationally succeeded by dominantly siliceous clastic deposition, except in the northwestern part of the map area, in the Eli River and Maiyumerak Mountains sequences. In the Eli River sequence, quartz grains are present in the latest Devonian to earliest Mississippian limestones (MDue), so apparently the siliceous clastic influence did extend to that depositional environment. However the feldspar grains in the Devonian limestone (Dk) in the Maiyumerak Mountains sequence are unique to this unit in the map area, and are not found in any of the Devonian clastic units. Mayfield and others (1983a) have suggested a source terrane for the feldspars in this limestone separate and distinct from the major source that supplied the siliceous clastic material for virtually all of the other Middle and Upper Devonian deposits. Mafic or felsic volcanic rocks are locally intercalated with the siliceous clastic rocks, suggesting local extensional volcanism.

Mississippian time is characterized by a variety of depositional environments, ranging from shallow-water carbonate build-up deposits to black, restricted basin cherts and argillites, and interspersed mafic to felsic volcanic and volcaniclastic deposits.

By Pennsylvanian and Permian time the continental margin subsided, and a more uniform, moderately deep-water depositional environment prevailed. During this time cherts and shales of the Etivluk Group (JPe) began to accumulate, and this type of deposition continued through the Jurassic. Only in the northwestern part of the map area, in the Maiyumerak Mountains sequence, was this quiet water deposition accompanied by mafic volcanism.

In the Maiyumerak Mountains sequence, the Jurassic rocks are overlain by Jurassic to Cretaceous argillites and quartz-wacke turbidites. During this time, the Brookian orogeny was initiated, and the effect of shortening deformation on these rocks was to break the older rocks of the Maiyumerak Mountains sequence into fault blocks and mix them into the argillite and quartz-wacke, forming a tectonic melange. A tectonic melange also formed at the southern edge of the Kallarichuk Hills sequence. These melanges may have originated at thrust-fronts as olistostromes that were subsequently overridden

and tectonized by advancing thrust sheets. During the Brookian orogeny, other rocks in the map area were folded, thrusted, and metamorphosed at blueschist and greenschist facies conditions.

Following the Brookian orogeny, non-marine Late Cretaceous coal-bearing conglomerates and sandstones were deposited. Tertiary rocks have not been recognized in the map area. Quaternary deposits include fluvial, glacial, and eolian sediments.

Structural Framework

The regional geologic history of the western Brooks Range is punctuated by three major deformational events. More deformational events may have occurred, however the Late Mesozoic Brookian orogeny was so dominant that evidence of previous events is difficult to distinguish. The three events recognized in the western Brooks Range are (1) Proterozoic amphibolite facies metamorphism (Mayfield and others, 1982; Armstrong and others, 1986; Till and others, 1988; Karl and others, 1989), (2) the Middle Paleozoic Ellesmerian orogeny represented by relict fold structures in the Ambler River quadrangle, adjacent to the east of the map area (Hitzman and others, 1986), and (3) the Late Mesozoic Brookian orogeny (Tailleur and others, 1966; Mayfield and others, 1983a), which involved major north-vergent regional thrusting that proceeded at least in part under blueschist and greenschist facies metamorphic conditions. Following the Brookian orogeny, east-west compression affected the western Brooks Range (Payne, 1955; Patton and Tailleur, 1977; Grantz and others, 1975, 1981), as far east as the Baird Mountains quadrangle (Karl and Long, 1987). Thrusting was followed by normal faulting, possibly related to isostatic readjustment.

The Baird Mountains quadrangle lies within the western Brooks Range fold and thrust belt, which formed in Late Jurassic to Late Cretaceous time in response to the Brookian orogeny. In the northwestern part of the Baird Mountains quadrangle, the fold and thrust belt consists of Middle and Upper Paleozoic rocks of the Endicott, Lisburne, and Etivluk Groups that have been imbricately thrusted and folded into anticlinal stacks of thrust sheets. Distinctive formations in the Upper Devonian to Mississippian Endicott Group facilitate the recognition of some of the major thrust faults and duplexes in this area, though there are many more fault repetitions of these units than can be represented at the 1:250,000 scale of this map. In the northeastern part of the quadrangle, the thrust sheets are composed of Lower Paleozoic and Proterozoic rocks that have been imbricately thrusted and folded. Detailed biostratigraphy in the carbonate rocks by J.A. Dumoulin and A.G. Harris has identified some of the major thrust faults and repetition of section in this area, although again there are more fault repetitions than can be represented at the scale of this map. Much less work has been done in large areas of relatively homogeneous rocks in the rest of the quadrangle, but it is assumed that the same tectonic style of imbricate fault repetitions applies to these rocks as well, based on age repetitions in a few measured sections by Dumoulin and Harris, and based on the great thickness of the rock units, particularly the Baird and Endicott Groups. There is a possibility that detailed biostratigraphy in the Baird Group (DOb) will lead to identification of major

structures and stratigraphic repetitions within the Baird Group. Due to a lack of marker beds and fossils in extensive units such as the Hunt Fork Shale (Dhf) and the quartz mica schist unit (Pzqms), it has not been possible to identify even the main thrust faults.

Rocks of different fabric and metamorphic grade are also juxtaposed in the fold and thrust belt. Rocks of the Kallarichuk Hills sequence contain biotite and record upper greenschist facies conditions, whereas rocks of the Tukpahlearik Creek and Nanielik Creek sequences contain lower greenschist facies and greenschist-blueschist facies mineral assemblages. Rock fabrics range from brittle to ductile within and between sequences. Within thrust sheets fabric is controlled by protolith. For example in the Tukpahlearik Creek sequence the pelitic rocks are phyllitic to schistose, and the siliceous rocks are quartzites and slates. The extensive quartz mica schists (Pzqms) of the Kallarichuk Hills sequence are isoclinally folded and tightly crenulated. These rocks are thrust over Endicott Group rocks of the Nanielik Creek sequence that locally retain bedding structures. Proterozoic rocks of the Nanielik Creek sequence were ductilely deformed and uplifted through a ductile-brittle transition zone at blueschist-greenschist facies metamorphic conditions during the Brookian orogeny (Till and others, 1988). The ductilely deformed schists of the Kallarichuk Hills sequence and the rocks of the Nanielik Creek sequence are both overprinted by a spaced cleavage resulting from brittle deformation that may represent a late phase of the Brookian orogeny, or may represent a younger deformational event (Karl and Long, 1987).

Contacts are typically very poorly exposed. Where observed, most contacts are faults. In ductiley deformed rocks, mylonitic zones are common at thin-section scale. Cataclastic zones up to several meters thick mark many contacts in less metamorphosed rocks. In many places, rocks that occur in normal stratigraphic order are separated by observed shear zones and faults. Some of these contacts may be faulted unconformities, out-of-sequence thrusts, or bedding controlled normal faults. The two most noteworthy contacts of this nature are (1) the contact of Paleozoic quartz metaconglomerate, metasandstone and phyllite (Pzqs) over Ordovician to Devonian carbonate rocks (DOc) in the northeastern part of the quadrangle, and (2) the contact of the Hunt Fork Shale (Dhf) over phyllite of the Tukapahlearik Creek sequence (DOtp and DOtpg) in the northcentral part of the quadrangle. The unit Pzqs which is characterized by quartz pebble metaconglomerate, quartz metasandstone, and maroon and green phyllite that have yielded no fossils, is lithologically similar to rocks considered to unconformably overly Lower to Middle Paleozoic carbonate and clastic rocks elsewhere in the Brooks Range (Nelson and Grybeck, 1980; Mayfield and Tailleur, 1978; Dillon and others, 1986). Only one sedimentary contact of the unit Pzqs over the unit DOc was recognized in the Nanielik Creek area (Inyo Ellersieck, unpublished field notes); in most places faults were observed. The phyllite of the Tukpahlearik Creek sequence (DOtp) is quite similar to, and apparently gradational to, the overlying phyllite of the Hunt Fork Shale (Dhf). However, where we have observed this contact, it is intensely sheared and faulted. Nevertheless, an original gradational stratigraphic relationship between these two units is strongly suspected due to lithologic similarity. Minor amounts of section between these two units may be missing or duplicated due to regional shortening.

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UNIT DESCRIPTIONS

Qu **Undifferentiated surficial deposits (Quaternary)**--Includes alluvial deposits, glacial deposits, lacustrine deposits, terrace deposits, eolian deposits

Qa **Alluvial deposits (Quaternary)**--Unconsolidated gravel, sand, silt, and clay, subject to reworking during high stream flow

Qg **Glacial deposits (Quaternary)**--Undifferentiated glacial deposits

Qs **Sand (Quaternary)**--Eolian sand deposits of the Kobuk Sand Dunes

Kc **Conglomerate (Cretaceous)**--Buff to gray, lenticularly bedded, poorly sorted, quartz- and carbonate-rich, pebble and cobble conglomerate; reddish gray, massive to thin bedded, fine- to coarse-grained quartz sandstone; subordinate olive-gray, fossiliferous, mica-rich siltstone, and rare coal lenses. The unit consists of approximately 70 percent conglomerate, 20 percent sandstone, 9 percent siltstone and 1 percent coal. Conglomerate clasts are well-rounded, moderately sorted, and consist of approximately 60 percent quartz, 30 percent limestone or dolostone, 6 percent mudstone, 3 percent mica schist, and 1 percent granitic rock, with sparse plant fragments in a sandy siliceous matrix. Plant fossils include *Pseudoprotophyllum* sp., and also *Castaliites* sp. and represent a late Cenomanian assemblage typical of rivers and marshes (Table 1, map locality 61). This unit is best exposed along the banks of the Kobuk River east of Trinity Creek

KJm **Melange (Cretaceous and(or) Jurassic)**--Tectonic melange consisting of blocks of various sizes, ages, and lithologies in a matrix of foliated and slightly recrystallized thin-bedded argillite and fine-grained quartz wacke. Block types include marble of probable Paleozoic age, Devonian carbonate rock, Mississippian carbonate rock, carbonate rock with 50 percent or more black chert beds, red radiolarian chert and siliceous argillite of Pennsylvanian or Permian age, gray to black argillaceous chert of Pennsylvanian or Permian age, gray and green bedded chert of Triassic and Jurassic age, pillow basalt, massive basalt and andesite, gabbro, green phyllite, quartz sandstone, calcareous sandstone, and volcaniclastic wacke and conglomerate. Block size ranges from meter to kilometer scale. Blocks are fault-bounded, sometimes with no matrix between them. Kilometer scale blocks are mapped independently where possible. Blocks and matrix are both intruded by ophitic clinopyroxene gabbro (Mzg); some gabbro has also been tectonically

incorporated into the melange, suggesting multiple episodes of faulting. Serpentine occurs in numerous locations along major fault zones in pods up to 10 m thick. At one locality the serpentine is adjacent to 50 m of foliated amphibolite. The melange matrix consists of argillite and fine-grained quartz wacke. The wacke is composed of 80 percent or more angular quartz grains with fresh, equant albite grains (unlike any of the elongate An60-80 plagioclase laths in the associated gabbro and basalt) and mica in a pseudo-matrix of clay minerals. The wacke occurs in cm-scale beds, sometimes showing turbidite features, intercalated with dominantly argillaceous rocks. Similar wacke 25-30 km to the north in a similar structural setting on strike with melange unit KJm yielded Late Jurassic *Buchia* (Jw of Curtis and others, 1984). The protolith age of the melange is considered to be the age of the wacke and argillite matrix and the same or younger than the youngest block (Table 1, map locality 11). The tectonic age of the melange is bracketed by the protolith age and the age of regional Brookian metamorphism, because the recrystallization and deformation of the argillite and quartz wacke matrix is attributed to that event, which is considered to extend from Late Jurassic to Late Cretaceous, bracketed by metamorphic mineral ages (Turner and others, 1979; Armstrong and others, 1986), and the occurrence of metamorphic clasts (quartz-mica schist) that were derived from the Brookian orogeny in Cretaceous rocks of the Nanushuk Group (Bartsch-Winkler, 1985; Till, 1988).

The thin bedding and fine grain size of the argillite and quartz-wacke turbidites suggest a deep-water depositional environment. The tectonic environment in which the melange formed is uncertain. Most of the blocks can be correlated with rock units involved in the Brookian fold and thrust belt. The melange could be debris from a thrust front that was overridden during continued thrusting of the Brookian orogeny. Major normal and strike-slip faults cutting the melange indicate that it was also affected by post-Brookian deformation.

This unit is best exposed in the Grand Canyon of the Noatak River. The melange unit KJm is mapped only in the Maiyumerak Mountains in the northwestern corner of the quadrangle. This unit may correlate with the lithologically similar but undated unit MzPzm, a melange unit coextensive with melange units mapped along the southern flank of the Brooks Range between the schist belt and the Anguyucham terrane (Pallister and Carlson, 1987; Dillon and others, 1987). Better age control and understanding of the composition of the matrix and the timing of deformation for both units will be required before correlation of these units can be confirmed

JPe **Etivluk Group, undivided (Jurassic to Pennsylvanian)**--Maroon, red, green, gray, black and variegated chert and siliceous argillite, with minor maroon calcareous siltstone and argillite, and rare maroon or gray limestone lenses. Chert is rhythmically bedded with 1-6 cm-thick beds with shaley to phyllitic partings. The proportion of chert in the unit varies from 30 to 100 percent. The chert contains sponge spicules and

radiolarians from Pennslyvanian to Jurassic in age (Table 1, map localities 3, 4, 6, 7, 8, and 11).

This unit is poorly exposed in the Baird Mountains quadrangle. Upper and lower contacts have not been observed. The thickest section most likely to be intact occurs on the west side of a tributary to the Eli River in the northwestern part of the quadrangle. No fossils were recovered from this locality. The section consists of 20 percent maroon, green, and black chert and 80 percent cherty to silty phyllite. The chert forms rhythmic cm-scale beds in lenses up to 4 m thick, alternating with siliceous phyllite in sections to 12 m thick. This section overlies black chert of probable Mississippian to Pennsylvanian age, and is overlain structurally by black phyllonite of the Mississippian Kayak Shale. The lower contact is not exposed, but appears to be conformable.

Etivluk Group cherts also make up some of the largest blocks in the melange (KJm). The common association of the chert-argillite rocks with the quartz wacke-argillite rocks suggests the possibility of a gradational depositional relationship. Although both lithologic associations represent deep-water deposition, a gradational stratigraphic relationship has not been confirmed anywhere in the Brooks Range. The upper contact of the Etivluk Group elsewhere in the Brooks Range is inferred to be a disconformity, and the lower contact is inferred to be a disconformity or gradational to the underlying Mississippian shales and cherts (Mull and others, 1982).

The Etivluk Group was named by Mull and others (1982) for exposures along the Etivluk River in the Howard Pass quadrangle to the northeast of the map area. There the Etivluk Group consists of the Pennsylvanian to Triassic Siksikpuk Formation and the Triassic to Jurassic Otuk Formation. Rocks in the Baird Mountains quadrangle are broadly similar in lithology to rocks of the same age at the type locality, but proportions of argillite, chert, and siltstone differ; specifically the rocks in the Baird Mountains map area are notably shalier in the Pennsylvanian to Triassic part of the section, and chertier in the Triassic to Jurassic part of the section. In the central Brooks Range the Otuk Formation includes calcareous rocks which are extremely rare in the Baird Mountains map area. In both parts of the Etivluk section, the rocks in the Baird Mountains quadrangle appear to represent a slightly deeper water depositional environment than do Etivluk Group rocks to the east.

Mzb **Basalt (Mesozoic)**--Dark dull green to bluish green, aphanitic to augite porphyritic basalt. Locally basalt is vesicular, amygdaloidal, massive layered, or pillowed. Minor amounts of andesite and volcaniclastic rocks are also included in the unit. Thickness of the unit is undetermined; the structural thickness is a maximum of 5 km. All observed contacts are faults; stratigraphic relations with other rock units in the map area are uncertain. Petrography and chemical analyses indicate there are two basalt subunits. These subunits can also be

differentiated by different reflectances in aerial photographs. Similar observations have been made for basalts in a continuation of this belt to the southwest in the Noatak quadrangle by Wirth and others (1987) and Harding and others (1987).

Basalt subunit I forms a belt as much as 5 km thick and trends northeasterly in the northwestern corner of the quadrangle. The belt extends to the southwestward into the adjacent Noatak quadrangle, and northeastward into the adjacent Misheguk Mountain quadrangle. The basalt is massive to pillowed, and the unit includes minor amounts of andesite.

The basalts in subunit I are fine-grained with unzoned, twinned plagioclase laths (An_{70-80}), rare interstitial augite grains, and magnetite in some places. Secondary chlorite, calcite, and quartz are also present. Chemical analyses indicate that these basalts are tholeiitic and slightly more alkalic than basalt subunit II and the gabbro of unit Mzg. Basalts of subunit I also have different minor and Rare Earth Element signatures from the basalts of subunit II and the gabbros. They have lower chromium and zirconium, and are significantly depleted in tantalum and enriched in thorium relative to subunit II and the gabbros. This is also in contrast to the chemistry of the Angayucham terrane basalts of Pallister and Budahn (1988) and Barker and others (1988), to which basalts of the Maiyumerak Mountains have been compared by other workers (Mayfield and others, 1983a). The chemistry of basalt subunit I, when plotted on various discriminant diagrams of Pearce (1982) and Woods (1980) suggests that these basalts represent a contaminated tholeitic oceanic arc (Karl and Dickey, 1989).

The age of the basalts of subunit I is uncertain. No intercalated sedimentary rocks were observed, and no fossils have been recovered from the map area. However, 55 km on strike to the northeast, interpillow cherts in this belt of basalt have yielded Triassic radiolarians (Ellersieck and others, 1984); 21 km to the north, in a fault repetition of this basalt subunit, Triassic radiolarians are also reported by Curtis and others (1984). Consequently the age of the basalts of subunit I may be Triassic, but may range slightly younger based on the possibility that basalt subunit I may be in part coeval with basalt subunit II.

Basalt of subunit II forms a discontinuous belt west of subunit I, and is massive to pillowed, dark dull green, more reflective in aerial photographs, and locally contains interpillow lenses of unfossiliferous carbonate and silicified carbonate. At one locality coarse, angular, poorly sorted volcaniclastic conglomerate is intercalated with vesicular basalt flows. The basalt is typically subophitic or diabasic in texture, containing augite and calcic plagioclase laths (An70-85). Some basalts contain accessory magnetite and secondary calcite, quartz, chlorite, serpentine(?), epidote, or stilpnomelane. Fibrous amphibole (actinolite?) was observed in one sample. Unfaulted upper and lower

contacts have not been observed and the age of the basalt is undetermined.

Chemical analyses of the basalt of subunit II indicate the basalts are tholeiitic. They have trace element signatures similar to slightly enriched MORB, and depleted to flat Rare Earth Element signatures at 10 to 20 times chondrite (Karl and Dickey, 1989). These basalts are chemically similar to the Triassic basalts of the Angayucham terrane which are interpreted to represent oceanic islands or plateaux (Pallister and Budahn, in press; Barker and others, 1988).

Because the basalts of subunit II are petrographically and chemically similar to the gabbro (Mzg) which intrudes Mesozoic Etivluk Group chert (Table 1, map locality 6), and because the basalts of subunit II are consistently associated with Triassic and Jurassic cherts of the Etivluk Group (although all observed contacts are faults), they are considered to be Mesozoic in age.

Mzg **Gabbro (Mesozoic)**--Massive, isotropic, medium-grained, light to medium green gabbro. Gabbro is ophitic to subophitic with augite and zoned calcic plagioclase (An70-85) and very similar petrographically and chemically to basalts of subunit II of unit Mzb. The plagioclase is typically altered to clay minerals, epidote/clinozoisite, and calcite. Some samples contain accessory olivine, sphene, magnetite or pyrite. Secondary minerals include chalcedony, calcite, chlorite, epidote, and prehnite. Actinolite was observed in one sample. Prehnite veins indicate these rocks have been slightly metamorphosed.

The chemistry of the gabbros is very similar to the basalts of Mzb subunit II. They are tholeiitic with slightly enriched MORB trace element signatures. They have flat Rare Earth Element signatures at about 10 to 20 times chondrite, with a negative europium anomaly (Karl, unpublished data). The gabbros intrude chert of the Etivluk Group, quartz wacke of unit KJm, and calcareous quartz sandstones of probable Paleozoic age. These are sedimentary rocks of the Brookian continental margin, and this setting is in conflict with the strongly oceanic chemical signatures of the gabbros. The chemical signatures suggest these sedimentary rocks did not have continental basement. It is possible that these gabbros intruded marginal basins floored by oceanic crust of Mesozoic or Paleozoic age.

MzPzi **Intrusive rocks of intermediate to mafic composition (Mesozoic or Paleozoic)**--Light- to medium-green massive semischistose metadiorite and metagabbro with relict igneous textures. These intrusive rocks are fine- to medium-grained, inequigranular, locally porphyroblastic. Mineral assemblages include chlorite-albite-epidote $\pm$ quartz; chlorite-clinozoisite-albite-quartz; actinolite-epidote-plagioclase-sphene-quartz $\pm$ biotite. Some samples contain relict amphibole or clinopyroxene; one sample from metagabbro intruding rocks of the Tukpahlearik Creek sequence contains cores of relict clinopyroxene in barroisitic amphibole. Iron oxides or pyrite are locally abundant. The unit

intrudes metasedimentary rocks and metabasite of the Tukpahlearik Creek sequence. This unit also includes a metadiorite fault block in MzPzm of unknown derivation, which is probably unrelated to igneous rocks intruding Tukpahlearik Creek sequence units.

No ages have been determined for this unit. Rocks in this unit differ in mineralogy, texture, and chemistry from gabbros of unit Mzg. The chemistry of MzPzi intrusive rocks is higher in silica, sodium, potassium, thorium and trace and Rare Earth Elements, and lower in iron and magnesium than the gabbros of unit Mzg. Unit MzPzi is best exposed at Deviation Peak in the Kiana Hills

MzPzm **Melange and phyllite (Mesozoic and Paleozoic)**--Dark gray to black siliceous phyllite with fault-bounded blocks of marble, ribbon chert, dolostone, metabasite, schist, and serpentinite. Phyllite locally contains intercalated fine- to medium-grained semischistose metagraywacke with relict turbidite structures, light green meta-volcaniclastic layers, and dikes and plugs of intermediate to mafic igneous rock. In some places phyllite contains discontinuous quartz segregation layers. Phyllite consists of quartz, albite, white mica, and chlorite. Metabasite blocks and plugs contain albite, actinolite, chlorite, epidote, $\pm$ stilpnomelane, $\pm$ glaucophane. Schist blocks contain quartz, albite, muscovite, chlorite, $\pm$ biotite, $\pm$ garnet. A marble block on the eastern boundary of the quadrangle contains Silurian conodonts (A.G. Harris, J.A. Dumoulin, and A.B. Till, unpublished data). Block lithologies are similar to structurally underlying units (Pzqms and PzPku, PzPks, PzPkc), and to structurally overlying units mapped in the Ambler River quadrangle (Pzb, Trb, and Jb of Pallister and Carlson, 1988).

The unit is tectonically thickened. The depositional thickness of the phyllite, and the tectonic thickness of the melange are unknown, but inferred to be variable. The protolith age of the phyllite is unknown. Protolith ages of blocks range from Paleozoic to Mesozoic, based on protolith ages of lithologically similar rocks in overlying and underlying units. Tectonic deformation of this unit is considered to be of Late Mesozoic Brookian age.

This melange unit overlies ductilely deformed quartz mica schist (Pzqms) and underlies brittlely deformed rocks of the Angayucham terrane in the Ambler River quadrangle (Pallister and Carlson, 1988). Phyllites of MzPzm contain ductile folds as well as cataclastic textures and are inferred to have formed under conditions transitional between ductile and brittle deformation.

This unit may correlate with the melange map unit KJm of Pallister and Carlson (1988), and with map unit MzPzs of Dillon and others (1986). The protolith age of the phyllite may be Jurassic and Cretaceous, similar to the matrix of melange unit KJm of this map in the Maiyumerak Mountains, or it may be Devonian as suggested by Murphy and Patton (1988) for other phyllite and metagraywacke units in the same structural

position in the southern Brooks Range. If thrusting during the Brookian orogeny was produced by southward-directed subduction of the Brooks Range continental margin deposits beneath an oceanic arc (Mayfield and others, 1983a), melange of units MzPzm of this map and KJm of Pallister and Carlson (1988) would form part of the subduction complex. Unit MzPzm is best exposed west of the Kaligurichеark River.

PMc **Carbonaceous chert and siliceous phyllite (Pennsylvanian to Mississippian)**--Black carbonaceous metachert, quartzite, and siliceous or calcareous phyllite, commonly with a distinctive silvery blue (phosphatic) bloom on weathered surfaces. This unit locally contains abundant iron sulfides that have high zinc and silver values (Zayatz and others, 1987). Alluvium in streams draining this unit commonly has intense red staining. Chert is more abundant in top of unit and occurs in beds 2 to 10 cm thick. The unit locally contains cm-scale lenses of black limestone or quartz wacke sandstone. Depositional environment was a restricted marine basin or a slope facies oxygen minimum zone.

Conodonts from a limestone lens provide age constraints for this unit in the map area; they are latest Devonian to Mississippian (Table 1, map locality 29). This unit gradationally overlies Kayak Shale of Mississippian age, and gradationally underlies Pennsylvanian to Triassic Etivluk Group cherts, and is consequently assigned a Mississippian to Pennsylvanian age. This unit is similar to, and correlative with, the Kuna Formation of Mull and others (1982). Unit PMc is estimated to be less than 50 m thick. It is best exposed in tributaries in the upper reaches of Kivivik Creek.

PDl **Limestone (Pennsylvanian, Mississippian, Devonian)**--Light gray limestone forms several small outcrops in the northwestern part of the map area (D-6 quadrangle). The youngest rocks are found in the northernmost outcrop. Here massive, light- to medium-gray-weathering, white to dark-gray, fine to coarse crystalline recrystallized limestone and cherty dolomitic limestone contain silicified coral and crinoid debris and conodonts of latest Chesterian (latest Mississippian) to early Morrowan (Early Pennsylvanian) age (Table 1, map locality 2, sample 85 ADn 86B). The conodont fauna indicates deposition in a shallow-water, possibly high-energy environment and is similar to that found in the Nuka Formation of Tailleur and Sable (1963).

Adjacent to these rocks at this locality are brownish-gray-weathering, dark-gray, very fine-grained dolomicrite and wackestone in 3-10-cm-thick even beds. These rocks contain silicified coral debris and conodonts of middle Givetian (Middle Devonian) age (Table 1, map locality 2, sample 85 ADn 86E). The contact between the two lithologies is not exposed.

Mko **Kogruk Formation (Mississippian)**--Light- to medium-gray-weathering, medium- to dark-gray, fine to coarse crystalline, recrystallized limestone and lesser dolostone. Chert, black or less commonly gray to white, occurs in layers and nodules that may constitute as much as 40 percent of the unit. This unit locally forms cliffs tens of meters

high; more typically exposed as terraced low outcrops with intervals of rubble crop. In general, better exposures consist of medium- tc thick-bedded bioclastic packstone; rubble crop is thin- to platy-bedded, locally reddish weathering wackestone, lime mudstone, or calcareous shale. Megafossils, commonly silicified, are abundant and include colonial and solitary corals, brachiopods, and crinoid debris; microfossils include endothyrid foraminifers, conodonts, and ichthyoliths.

The Kogruk Formation is exposed in a northeast-trending belt in the Maiyumerak Mountains (D-6 and C-6 quadrangles) and in several small outcrops northeast of Mount Angayukaqsraq (D-1 quadrangle). The top of the formation not exposed in the map area, but one km southwest of the map area in the Noatak quadrangle, the Etivluk Group conformably overlies the Kogruk Formation (I. Ellersieck, unpublished mapping). In the Maiyumarak Mountains, the Kogruk Formation conformably overlies unit MDue; in the D-5 quadrangle, it conformably overlies the Kayak Shale; in the Mount Angayukaqsraq area, it is in probable fault contact above unit Pzqs. In the southern Maiyumerak Mountains, this unit contains conodonts of probable early Meramecian age at the top and of late Osagian age at the base of a measured section 160 m thick (Table 1, map locality 17). Four miles to the north, more than 300 m of section are exposed; conodonts from near the top of this section are of late Meramecian to earliest Chesterian age (Table 1, map locality 13). Thirty meters of section crop out in the Mount Angayukaqsraq area and contain conodonts of latest Meramecian to early Chesterian age (Table 1, map locality 60). Conodont faunas indicate a shallow- to very shallow-water, locally high-energy, normal-marine depositional environment. Outcrop patterns and sedimentary structures suggest deposition as local bioherms or bioclastic buildups surrounded by sparsely bioclastic calcareous muds.

The Kogruk Formation was defined by Sable and Dutro (1961) in the DeLong Mountains quadrangle to the north. In the Baird Mountains quadrangle, the unit is distinguished by the combination of generally abundant chert, abundant and relatively well-preserved megafossils, and a lack of intercalated siliciclastics. This unit may include rocks coeval with the Tupik Formation of Sable and Dutro (1961).

Ml **Limestone (Mississippian)**--Medium-gray-weathering, medium- to dark-gray, fine crystalline recrystallized limestone and lesser light-brown weathering, medium-gray, fine crystalline dolostone. This unit is exposed as small outcrops and rubbly hilltops in the northwestern map area (D-6 quadrangle). Some outcrops contain 1 to 30 percent black nodular chert, and locally abundant megafossil (crinoid, bryozoan, and brachiopod) debris.

Most exposures are fault-bounded, but locally unit Ml appears to overlie Kayak Shale. This limestone contains Mississippian lithostrotionellid corals (A.K. Armstrong, written commun., 1966), Early Mississippian conodonts indicative of a shallow-water depositional environment, and

Late Mississippian (Visean) endothyrid foraminifers (B.L. Mamet, written commun., 1983). The unit broadly similar in lithology and age range to the Kogruk Formation but its stratigraphic context is uncertain.

MDue **Utukok Formation and Eli Limestone (Mississippian to Devonian)**--Gray to brown, fine- to coarse-grained, planar- to cross-bedded to bioturbated limestone, sandy limestone, and calcareous sandstone; subordinate quartz sandstone, locally calcareous siltstone and shale. This unit is exposed as resistant limestone and sandstone ridges separated by recessive intervals of siltstone and shale, in a northeast-trending belt in the Maiyumerak Mountains (D-6, C-6 quadrangles); it conformably underlies the Kogruk Formation (Mko), and conformably overlies the Baird Group (DOb). Unit MDue includes rocks previously assigned to the Utukok Formation (Mississippian) of Sable and Dutro (1961) and to the Eli Limestone (Devonian) of Tailleur and others (1967). Where detailed mapping and biostratigraphic studies have been carried out, rocks of these two sequences can generally be distinguished. However, in less studied areas, especially those characterized by tectonic complexity or poor exposure, separation is difficult.

More than 180 m of Utukok Formation are exposed in the southern Maiyumerak Mountains. About 10 meters of white-weathering quartz sandstone forms a prominent marker bed near the top of the sequence. Light-gray to brown-weathering, crinoidal bioclastic packstone and brownish weathering, laminated to cross-bedded calcarenite make up most of the section, with minor intercalations of tan-weathering, black calcareous shale and siltstone densely crossed by horizontal tracks and trails. The top of the section contains conodonts of middle Osagean (late Early Mississippian) age; the base yields probable Kinderhookian (early Early Mississippian) conodonts (Table 1, map locality 18).

The contact between the Utukok Formation and the Eli Limestone within the Baird Mountains quadrangle is typically represented by several hundred meters of massive light-gray, medium to coarse crystalline, strongly recrystallized limestone with local ferruginous partings. This lithology has yielded no fossils, and it is not clear that it occurs everywhere at the same stratigraphic horizon. Distinctive lithologies of the Eli Limestone, as exposed in its type section (Tailleur and others, 1967), are irregularly bedded, yellow-brown- to orange-weathering, medium- to dark-gray, fine-grained bioturbated limestone; orange-weathering, medium-dark-gray limestone in even planar beds; and gray to orange, locally mottled, medium- to coarse-grained bioclastic packstone with locally abundant corals and lenses of orange lime mudstone. At least 250 m of section are exposed in the type area. Conodonts indicate that the base of the section is of Middle Devonian (Givetian) age (Table 1, map locality 15), and the top of the section is at least as young as latest Devonian (Famennian) (Table 1, map locality 14).

The conodonts indicate a high energy, shallow-water shelf environment. In general, the Utukok Formation is sandier and less argillaceous than

the Eli Limestone, but both units contain intervals of mottled bioclastic packstone, orange-weathering shale, and light-gray, recrystallized limestone. The Utukok Formation is distinguished from the Kugururok Formation (Dk) by its lack of dolostone and lack of feldspar grains, and from the limestone of the Nakolik River (Dnl) by the fine scale at which the clastic material is intercalated within the sequence. The Eli Limestone is distinguished from somewhat similar orange- and gray-weathering impure Ordovician carbonates of the Baird Group (DOb) in the central map area by the presence of locally abundant megafossils and by the absence of associated dolostone.

Mlt **Limestone and tuff (Mississippian)**--Orange-, tan-, or light brown-weathering, thinly laminated limestone, tuff, and volcaniclastic rocks, with subordinate sills and plugs of intermediate to mafic composition. Limestone is chloritic and locally fossiliferous. Tuff contains relict volcanic fragments and flattened lapilli. Volcaniclastic rocks are massive to crudely layered, and contain volcanic rock fragments, quartz, calcite, white mica, chlorite, and devitrified glass shards. At one locality the contact of a pyroclastic tuff on limestone was observed in thin-section to have 3 mm of recrystallized calcite at the contact.

Unit Mlt is laterally discontinuous and occurs as lenticular bodies associated with the Kayak Shale (Mk). Individual bodies may be several tens of meters thick; some are lenses only a few m thick. Contacts are gradational in some places and conformable in other places. Conodonts from limestone in this unit are early Early Mississippian (Kinderhookian) in age (Table 1, map locality 19).

Unit Mlt is foliated and contains minerals consistent with low greenschist facies metamorphism. Locally this unit contains abundant disseminated iron sulfides. Unit Mlt is best exposed between the Eli River and Kivivik Creek.

Mk **Kayak Shale (Mississippian)**--Dark gray to black siliceous or calcareous slate and phyllite, with subordinate intercalated orange- to rusty-weathering gray recrystallized limestone, calcareous metasiltstone, and thin-bedded, locally calcareous quartz metasandstone. Locally contains ironstone concretions. The Kayak Shale is locally fossiliferous, containing crinoids, brachiopods, mollusks, horn corals, bryozoans, foraminifers, and conodonts. This unit is recrystallized but relict sedimentary textures are preserved in some places. Metasiltstone and metasandstone beds are 2 cm to 50 cm thick and fine-grained. Sandstone is composed dominantly of quartz with secondary calcite, white mica, and graphite. Its depositional environment is shallow marine.

Unit thickness exceeds 100 m. The Kayak Shale (Mk) gradationally overlies pebbly quartz sandstone of Kanayut Conglomerate (MDk). Unit Mk is laterally gradational to, and gradationally overlain by, calcareous tuff and volcaniclastic rocks of unit Mlt. Units Mk and Mlt are gradationally overlain by carbonaceous phyllite and chert of unit PMc.

unit is interpreted to represent pro-delta deposits (Moore and Nilsen, 1984).

Unit thickness is approximately 300 m along the Eli River where it gradationally overlies maroon and green phyllite, marble and metaconglomerate of the Nakolik River sequence, and where it is gradationally overlain by the Noatak Sandstone. Brachiopods and mollusks of late Frasnian or early Famennian age (Table 1, map locality 30) provide a Late Devonian age for this unit. The Hunt Fork Shale was defined by Chapman and others (1964) and outcrops extensively throughout the Brooks Range. In the Baird Mountains quadrangle, the most complete section is found along the Eli River. Along the Noatak River near the confluence of the Aklumayuak River sedimentary structures are better preserved due to lower metamorphic grade. In most of the map area, unit Dhf contains quartz, albite, white mica and chlorite mineral assemblages consistent with low greenschist facies metamorphism.

Dnu **Phyllite, carbonate and clastic rocks of the Nakolik River, undivided (Devonian)**--Light green, gray and maroon siliceous and calcareous phyllite, metalimestone, and quartzose metasandstone and metaconglomerate. Metalimestone occurs as thin maroon lenses in phyllite, and also as medium-bedded dark gray fossiliferous layers more than 10 m thick. Metasandstone and metaconglomerate are poorly to moderately sorted, and typically have a calcareous matrix. Metasandstone contains mostly quartz and calcite grains with secondary white mica and chlorite. Metaconglomerate has a matrix of quartz sand and subrounded pebbles and cobbles of quartzite, metalimestone, and maroon, green and gray metasiltstone and phyllite. Metaconglomerate beds are massive, clast supported, less than 2 m thick. Lithologies alternate on a meter scale and are interpreted to represent facies of a very shallow marine depositional environment.

The thickness of this unit is unknown but is estimated to exceed 300 m. Unit Dnu is laterally gradational to, and gradationally overlies metalimestone of unit Dnl. Unit Dnu is gradationally overlain by phyllite of the Hunt Fork Shale (Dhf). Conodonts from limestone lenses in maroon and green phyllite are Late Devonian (Table 1, map localities 27, 31). This unit is similar in part to unit Pzqs and parts of the Beaucoup Formation of Dutro and others (1978) and Dillon and others (1986), and may be partly correlative with those units.

Unit Dnu contains metamorphic minerals consistent with low greenschist facies metamorphic conditions. The unit is best exposed on the west side of the Nakolik River.

Dnl **Limestone of the Nakolik River (Devonian)**--Generally fossiliferous metalimestone and marble; subordinate quartz-carbonate metasandstone, metasiltstone and phyllite. Forms terraced hillsides capped by resistant cliffs of carbonate or metasandstone. Light- to dark-gray, fine to coarse crystalline metalimestone and marble consists primarily of bioclastic packstone and wackestone. Solitary and colonial corals,

Unit MDk gradationally overlies shallow marine Noatak Sandstone (Dn) and is gradationally overlain by shallow marine Kayak Shale (Mk). Unit MDk is as much as 300 m thick; best exposed section south of Eli River is approximately 200 m thick. No fossils have been recovered from unit in map area. The underlying Noatak Sandstone contains Late Devonian fossils, the overlying Kayak Shale contains Mississippian fossils. Ages of depositionally overlying and underlying units bracket the age of unit MDk. This unit was defined by Bowsher and Dutro (1957).

Chlorite and white mica on bed partings, pressure-solution textures in the siliceous matrix of the quartzite in thin-section, and the semischistose texture suggest low greenschist facies metamorphic conditions.

Dn **Noatak Sandstone (Devonian)**--Tan to brown-weathering, dull greenish gray, maroon, gray or white, thin- to medium-bedded, commonly cross-bedded, quartz metasandstone, metasiltstone and phyllite. Locally unit Dn contains up to 30 percent maroon and green phyllite. Meta-sandstone typically contains orange sideritic specks and has calcareous matrix. Ironstone concretions, brachiopods, and mollusks are present in some places. Metasandstone occurs in 2-10 cm beds, in alternating meter scale bundles of planar and trough cross-laminated beds, and near the top of the unit where it is transitional to the overlying conglomeratic unit (MDk), the metasandstone includes pebbly beds in meter thick coarsening-upward cycles. Pebbles are quartz or argillite up to 1 cm in diameter. The depositional environment was shallow marine.

Unit Dn may be as much as 200 m thick, and gradationally overlies phyllite of the Hunt Fork Shale (Dhf); it gradationally underlies quartzite and metaconglomerate of Kanayut Conglomerate (MDk). Unit Dn contains Late Devonian brachiopods (Table 1, map localities 24,26). It was named by Dutro (1952) for good exposures a few km north of the map area in the Misheguk Mountain quadrangle.

Unit Dn is phyllitic to semischistose and contains secondary minerals, including white mica, chlorite, quartz and calcite, attributed to low greenschist facies metamorphic conditions. This unit is best exposed on ridges along the south side of the Eli River.

Dhf **Hunt Fork Shale (Devonian)**--Light to dark, silvery gray to green or black phyllite with intercalated siliceous or calcareous metasiltstone, wacke, and metasandstone. In several places unit contains massive mafic sills and dikes more than ten meters thick, and in one place along the Agashashok River this unit contains a 30 m section of pillowed(?) mafic flows. Metasiltstone beds are mm to cm scale, metasandstone beds are rare, but may be up to one m thick and contain transported fossil debris. In northern map area along Noatak River sedimentary turbidite features are locally well-preserved. Metasandstone is moderately sorted and contains quartz, feldspar, calcite, white mica, chlorite. The depositional environment is marine, outer-shelf to slope facies. This

Unit Mk contains conodonts and foraminifers of Early Mississippian age (Table 1, map localities 12, 21). The Kayak Shale was defined by Bowsher and Dutro (1957) and is mapped extensively in the central and northern Brooks Range. In the Baird Mountains quadrangle, this unit is best exposed in the upper tributaries of Kivivik Creek.

MDl **Limestone (Mississippian and(or) Devonian)**--White- to gray-weathering, light- to dark-gray, fine to medium crystalline recrystallized limestone and lesser dolostone. Exposed as small, isolated outcrops and fault slices in the northwestern map area. Contains conodonts of Mississippian or Devonian age. Unit MDl includes rocks that may correlate with rocks of units Mko, Mk, MDue, and(or) DOb but that lack sedimentary features and fossils diagnostic of these units (Table 1, map locality 25).

MDe **Endicott Group, undivided (Mississippian and Devonian)**--As mapped, this unit includes two or more formations within the Endicott Group in an area too small to map them at 1:250,000 scale, and also areas where subunits could not be delineated adequately.

As defined by Tailleur and others (1967), this unit includes the Hunt Fork Shale, Noatak Sandstone, Kanayut Conglomerate, Kekiktuk Conglomerate, and Kayak Shale. the Hunt Fork Shale is Upper Devonian; the Noatak Sandstone is Devonian and Mississippian and gradationally overlies Hunt Fork Shale; the Kanayut Conglomerate gradationally overlies Noatak Sandstone and may be Devonian where the Noatak sandstone is Devonian, and must be Mississippian where the Noatak Sandstone is Mississippian. The Kanayut Conglomerate is conformably overlain by the Kayak Shale of Mississippian age. The Kekiktuk Conglomerate rests on an unconformity over Lower Paleozoic rocks, but where it crops out it is also overlain conformably by the Kayak Shale. None of the rocks mapped as Endicott Group in the Baird Mountains quadrangle include the Kekiktuk Conglomerate. The Kekiktuk and Kanayut Conglomerates represent a fluvial depositional environment; the Hunt Fork-Noatak-Kanayut sequence represents a progradational deltaic environment that is dominantly marine (Moore and Nilson, 1984).

MDk **Kanayut Conglomerate (Mississippian and Devonian)**--White-weathering, light gray, medium bedded and cross-bedded quartzite pebbly quartzite, and metaconglomerate. Metasandstone is locally semischistose but contains well-preserved sedimentary textures. Metasandstone and metaconglomerate are well-sorted with 90 percent well-rounded quartz and lesser chert clasts, and up to 10 percent argillite fragments. Minor amounts of dark gray argillite are intercalated with the quartzites. Maximum clast size observed in conglomerates is 3 cm for rounded quartz and chert pebbles, 6 cm for rounded ironstone concretions, and 25 cm x 5 cm for rip-ups of argillite and clay galls. Plant fragments are locally present. Quartzite forms beds 2-10 cm thick, typically trough cross-bedded and in fining upward cycles up to 2 m thick. Conglomerates occur in graded beds less than one m thick. The depositional environment is interpreted to be fluvial non-marine, to very shallow marine.

stromatoporoids, brachiopods, crinoids, and skeletal debris form buildups (some of which may be organic reefs) several tens of meters across separated by intervals of lime mudstone or clastic rocks. Yellow- to orange-weathering, fine- to medium-grained, planar to cross-laminated metasandstone typically contains 20 to 80 percent quartz, along with calcareous bioclasts and lithic grains and lesser white mica. Purple-weathering metasiltstone and phyllite form poorly exposed rubble-covered slopes and saddles. Metaclastic intervals are 0.5-40 m thick and comprise 20-40 percent of most sequences.

This limestone is exposed in the north-central map area. The limestone is gradationally overlain by the Hunt Fork Shale to the north; the base of the unit is not exposed in the map area. At least 120 m of section crop out east of the Nakolik River (section F, Dumoulin and Harris, 1987). Conodonts and megafossils indicate an age of late Middle through early Late Devonian (Table 1, map locality 28)--entirely younger than or just overlapping the age of the youngest Baird Group limestones (DOb), and correlative with the oldest Endicott Group rocks (MDe). The unit appears to represent a facies transitional in time and space between the Lower to Middle Devonian carbonate platform sequence of the upper Baird Group (DOb) to the south and the dominantly clastic, mostly Upper Devonian Endicott Group (MDe) to the north.

Ds **Shale (Devonian)**--Black sooty siliceous and calcareous shale containing lenses of chert and fossiliferous calcareous quartz sandstone. Sandstone is gray, weathers buff to slightly orange, and forms beds 1 to 2 cm thick in lenses up to 30 cm thick. Some beds have casts of brachiopods on bed surfaces. Sandstone is fine-grained, well-sorted, with approximately equal amounts of angular quartz and calcite grains in a carbonaceous and calcareous matrix. Chert occurs in lenses up to 10 cm thick, as cm scale beds with stylolitic partings. Chert is light gray, weathers slightly orange. Chert contains abundant calcite rhombs and calcite veinlets, and rare ghosts of radiolarians. Abundant disseminated calcite rhombs suggest chert is silicified limestone. The depositional environment is shallow marine with restricted circulation.

Brachipods from sandstone beds are Middle to early Late Devonian (Table 1, map locality 22). The shale is coeval with calcareous phyllites and sandstones of the Nakolik River sequence (Dnu).

In the limited exposures of unit Ds, shale composes 85 percent of the outcrop. All observed contacts are faults. The unit is exposed in the Maiyumerak Mountains south of the Eli River.

Dk **Kugururok Limestone (Devonian)**--Gray- to orange-weathering, medium- to dark-gray calcareous sandstone, dolostone and limestone. The carbonate rocks typically form subdued hilltop outcrops and rubble-covered slopes; rare cliff exposures. Calcareous sandstone is fine- to coarse-grained, locally cross-bedded. Composition is variable from bed to bed but generally includes abundant calcite, calcareous bioclasts and lithic fragments, and quartz; some samples contain abundant feldspar (including

potassium feldspar and microcline) and volcanic lithic grains. Sandy brachiopod coquina occurs in lens-shaped beds as much as 2 m thick. Subordinate lithologies include locally orange-weathering, green to gray, laminated calcareous siltstone and shale; creamy-textured, beige- to orange-weathering, gray to blue-gray, fine-grained dolostone; and bioturbated, gray and orange mottled, fine- to medium-grained limestone, locally rich in coral and crinoid skeletal debris. All lithologies are generally medium-bedded (4-20 cm); beds are even to wavy to nodular. Some shaley intervals are cut by sandstone dikes. Many of the coarser sandstone layers are lens-shaped, truncate underlying beds, and probably represent channel deposits.

Unit Dk forms a northeast-trending belt in the Maiyumerak Mountains; it constitutes the lower, east-facing slopes of a prominent ridge of basalt (Mzb) that bisects the D-6 quadrangle. Its contact with the basalt is nowhere well exposed in the map area, but is presumed to be a fault because evidence of a depositional contact, such as baked textures, have not been observed. Mafic dikes in the limestone cannot be traced into the overlying basalt. At least 60 m of section are exposed in a cliff in the northern end of the outcrop belt; several hundred meters of section may crop out to the south, but the rubbly nature of these outcrops precludes an accurate assessment of thickness. Age in Baird Mountains quadrangle is Middle (probably late Middle) to Late Devonian, based on brachiopods, foraminifers, and conodonts. Brachiopods include *Atrypa* sp., of probable Middle Devonian (Givetian) age (J.T. Dutro, Jr., written communication, 1984). Endothyrid foraminifers are of early Late Devonian (Frasnian) age and indicative of reef and lagoonal biofacies (B.L. Mamet, written communication, 1983). Diagnostic conodont faunas of late Middle to early Late Devonian (Givetian-Frasnian) and latest Devonian (late Famennian) age have been obtained from several localities (Table 1, map localities 1, 5, 10).

The Kugururok Limestone was defined by Sable and Dutro (1961) in the DeLong Mountains. The type section is more than 400 m thick and contains fossils of Frasnian age. In the Baird Mountains, unit is distinguished by the presence of dolostone that weathers to a distinctive "creamy"-textured pale beige or orange and by feldspar-bearing calcareous sandstones. Sequences of Middle to Late Devonian carbonate rocks here assigned to MDue may include calcareous sandstones and mottled, bioturbated limestones similar to those of Dk, but do not contain dolostone or feldspathic sandstones.

Dl **Limestone (Devonian)**--Whitish-gray-weathering, brownish-gray, very fine crystalline to micritic, locally recrystallized limestone forms isolated outcrops in northwestern map area (D-6 quadrangle). Some outcrops contain abundant silicified bioclastic debris, and corals of early Late Devonian age were recovered at one locality (Table 1, map locality 9). Other rocks in this unit are lithologicly similar to rocks included in unit PDl that contain Middle Devonian conodonts.

DOtu **Metasedimentary and metavolcanic rocks of Tukpahlearik Creek, undivided (Devonian to Ordovician)**--Black carbonaceous quartzite and siliceous argillite with lenses of dolostone and marble, silvery gray to silvery green pelitic schist, gray chert pebble metaconglomerate, green calc-schist, orange-weathering micaceous marble, dark green mafic metavolcanic rocks, gray or white metachert and gray- to white-weathering marble. Lithologies are intimately intermixed by both depositional and tectonic processes. Good exposures north and west of Tukpahlearik Creek allow differentiation of subunits, poor exposure south of Tukpahlearik Creek makes differentiation of subunits difficult.

The age of this unit is based on Ordovician conodonts from the black quartzite (Table 1, map locality 44) and Ordovician to Devonian conodonts from gray marble (Table 1, map locality 48). The lower contact of the unit is a fault; underlying rocks contain Mississippian conodonts. The upper contact is also a fault where observed, but appears to be lithologically gradational to the overlying phyllite of the Hunt Fork Shale unit (Dhf). The contact may represent telescoping of a conformable stratigraphic sequence.

The rocks have greenschist and blueschist facies metamorphic mineral assemblages. Pelitic schists are composed of quartz, albite, chlorite and biotite in the southern part of the unit; biotite is not present in pelitic schists in the northern part of the unit. The chert pebble metaconglomerate and graphitic quartzites commonly contain chloritoid and locally contain stilpnomelane throughout the unit. Metabasites contain blue amphibole in some places. Garnets have not been recognized in this unit. Faulted helicitic albites in this unit suggest brittle deformation post-dated ductile deformation during which the metamorphic minerals formed. East-vergent folds are also attributed to this late, brittle, late or post-Brookian phase of deformation. Structurally overlying rocks of the Hunt Fork Shale record only brittle deformation. The rocks of the Tukpahlearik Creek sequence may record uplift through the ductile-brittle transition during a late phase of the Brookian orogeny, or they may record a later, east-vergent compressional event (Grantz and others, 1975, 1981; Karl and Long, 1987).

These rocks are distinguished from other units of the same age in the quadrangle, the Baird Group (DOb) and equivalent unit (DOc), in having significantly less carbonate and a larger component of black, carbonaceous rocks. The fine-grained nature of the sedimentary rocks, and the normal-marine, cool-water conodonts (Table 1, map locality 44), suggest deposition occurred in a basinal environment, possibly an interplatform basin. These rocks occupy a structurally intermediate position between DOc and DOb, and may originally have been situated paleogeographically between those extensive carbonate bodies.

This unit may be coeval with Paleozoic black quartzite, black shale, and quartz conglomerate (Pzbq, Pzbs, and Pzqs) in the northeastern part of the quadrangle; with parts of PzPku, PzPks, and PzPkc in the southern and eastern part of the quadrangle, and with mixed carbonaceous,

pelitic, and calcareous rocks of Ordovician to Devonian age mapped by Dillon and others (1986) in the vicinity of Snowden Mountain in the Wiseman quadrangle. Unit DOtu is best exposed north and west of Tukpahlearik Creek.

DOtq **Carbonaceous quartzite and quartz conglomerate of Tukpahlearik Creek (?Devonian to Ordovician)**--Black carbonaceous quartzite, gray chert pebble metaconglomerate, and quartz schist with minor intercalated lenses of gray marble, micaceous marble, dolostone, and gray quartz mica schist; carbonaceous quartzite commonly has mm-scale white quartz segregation layers and weathers rusty due to ubiquitous mm grains of pyrite. Metaconglomerate is also carbonaceous and contains stretched ellipsoidal pebbles of black, white, and gray quartz and chert. Some metaconglomerate is matrix supported, and may represent debris flows, but most metaconglomerate is clast supported. Clasts are dominantly chert; detrital tourmaline is rare but present. Metamorphic minerals include white mica, stilpnomelane, chloritoid, and chlorite

The thickness of unit DOtq is unknown; its lower contact is faulted. Upper and lateral contacts are gradational to micaceous marble and calcareous mica schist of units DOtmq and DOtm. Meter scale lithologic alternations are probably both structurally and depositionally derived. Quartzite lenses are as thick as 50 m, metaconglomerate lenses range from 1 m to 100 m in thickness. The abundance of carbon and the presence of cool-water, normal marine conodonts (Table 1, map locality 44) suggest deposition of this unit in a restricted marine basin.

The age of this unit is uncertain. Ordovician conodonts (Table 1, map locality 44) are found near the structural base of the unit. Metaconglomerates and black quartzite higher in the section may be younger or may be structural repetitions. This unit may be correlative in part with unit Pzbq which yielded lower to middle Ordovician conodonts just 2 km east of the quadrangle boundary, in the Ambler River quadrangle (Mayfield and others, 1983b, fig. 5, locality 39). Metaconglomerates of similar composition are found in unit Pzqs although the associated maroon and green phyllites of unit Pzqs are not found in unit DOtq. Unit DOtq is best exposed along the west bank of Tukpahlearik Creek.

DOtm **Marble of Tukpahlearik Creek (Devonian to Ordovician)**--Orange-weathering gray micaceous marble. Marble is layered on a mm- to cm-scale, with chloritic partings, relict cross-lamination structures, and grain-size grading in some places. Marble unit contains meter-scale lenses of black carbonaceous calcareous or siliceous semischist and is locally chloritic. Metamorphic fabric is apparently lower grade than other rocks in the Tukpahlearik Creek sequence, but this difference is attributed to the composition of the protoliths and the difficulty of forming schistose surfaces in calcareous and carbonaceous rocks.

Marble forms sections up to 300 m thick, alternating with black quartzite or semischist that is typically a few m thick but may be as

much as 100 m thick. Unit DOtm is estimated to be 1500 m thick. Carbonaceous semischist composes approximately 5 percent of the unit. Unit DOtm gradationally overlies black quartzite of unit DOtq. The contact of the marble of unit DOtm over the schist of unit DOtp is a west-dipping fault in some places but may be stratigraphic in other places. The marble of DOtm is overlain by massive gray marble and black quartzite with marble lenses of unit DOtmq or by well-segregated quartz chlorite schist of unit DOtp. This contact is sharp and may be a fault in some places.

The age of this unit is unknown and no fossils have been recovered from it. An Ordovician to Devonian age is inferred from its stratigraphic association with unit DOtq and its inferred stratigraphic position beneath the Endicott Group. Unit DOtm is best exposed at the headwaters of Nakolikurok Creek.

The lack of fossils, the association with deeper water black quartzite and semischist, and relict sedimentary structures suggest that the protolith for this unit may have been calcareous turbidites derived from carbonate platforms adjacent to the depositional basin.

DOtmq **Marble and quartz schist of Tukpuhlearik Creek (Devonian to Ordovician)**--Gray, medium-grained, massive to thick-bedded marble in lenses tens of meters thick, intercalated with green chloritic quartz schist, gray calcareous quartz schist, and black carbonaceous quartz semischist. Siliceous schists and semischist have mm quartz segregation layers and are tightly crenulated. Marble forms prominent white-weathering tors in more recessive schists. Marbles compose approximately 30 percent of the unit, chlorite schists 40 percent, calcareous schists 10 percent, carbonaceous schists 20 percent. Metamorphic mineral assemblages include quartz, chlorite, albite, white mica, calcite, graphite, ± stilpnomelane, ± chloritoid, ± pyrite.

This unit and its components are lenticular and gradational to adjacent units of the Tukpalearik Creek sequence. In some places unit DOtmq overlies carbonaceous quartzite of unit DOtq conformably or disconformably and may represent a lateral facies of the marble of unit DOtm. No fossils have been recovered from this unit. The unit thickness unknown, and may be several hundred meters. Unit DOtmq is best exposed south of Kanaktok Mountain.

DOtp **Pelitic schists of Tukpahlearik Creek (Devonian to Ordovician)**--Greenish gray, gray, or green, fine- to medium-grained chloritic quartz schists and siliceous chlorite schists. Schists have mm quartz segregation layers when they contain sufficient quartz, and are tightly folded and crenulated, locally with a superimposed mm- to cm-spaced cleavage. Metamorphic mineral assemblage includes quartz, white mica, chlorite, ± albite, ± biotite, ± calcite.

Unit DOtp overlies black quartzite and marble (DOtmq) gradationally. Unit is gradational to, or in fault contact with marble unit (DOtm).

Unit DOtg is laterally gradational to the pelitic schist and greenstone unit (DOtpg). The schist of unit DOtp is overlain structurally and(or) stratigraphically by pelitic phyllite of the lower Endicott Group (Dhf). The thickness of unit DOtp is unknown but estimated at 200 m or less. No fossils have been found in this unit; its age is inferred from its association with other units in the Tukpahlearik Creek sequence. This unit is best exposed at the drainage divide near the headwaters of Sapun Creek.

DOtpg **Pelitic schist and greenstone of Tukpahlearik Creek (Devonian to Ordovician)**--Green and gray pelitic schists identical to the schist of unit DOtp with intercalated masses of dark green metabasite, mafic dikes, mafic extrusive rocks and white metachert. Mafic rocks form resistant outcrops up to 100 m in diameter and sometimes have associated lenses of white ribbon metachert as much as 30 m thick. Metachert occurs in cm thick beds with crenulated chloritic partings. Metachert lenses or blocks also occur in pelitic schist independent of metabasite. Pelitic schists contain quartz, white mica, chlorite, $\pm$ biotite, $\pm$ chloritoid. Metabasite contains plagioclase, chlorite, calcite, ilmenite and quartz, and locally contains glaucophane or crossite. Chloritic layers in pelitic schist are tightly crenulated and crenulations are offset by spaced microfaults on which chlorite has formed oriented at a high angle to the segregation foliation. These crosscutting surfaces correspond to the mesoscopic spaced cleavage and represent a brittle structural overprint on older ductile deformation structures. Unit DOtpg is gradational to pelitic schist of DOtp and overlies marble and quartzite of DOtm and DOtq. Unit DOtpg is structurally overlain by gray phyllite of the Hunt Fork Shale (Dhf). The thickness of unit DOtpg is undetermined but is estimated to exceed 300 m. The age of this unit is unknown. No radiolarians have been found in the metachert. An Ordovician to Devonion protolith age for this unit is inferred from its association with other subunits of the Tukpahlearik Creek sequence. Unit DOtpq is best exposed on the south side of Nakolikurok Creek near its headwaters.

DOb **Baird Group, undivided (Devonian to Ordovician)**--Beige- to orange-weathering, wavy, thinly laminated gray metalimestone and argillaceous to silty metalimestone; light- to dark-gray flaggy-bedded to massive metalimestone and marble; light- to dark-gray thin-bedded to massive dolostone. The metalimestone and dolostone form rubble-covered rounded hills; the metalimestone and marble tend to form better outcrops than dolostone. The Baird Group is exposed in the northwestern part of the map area in the Maiyumerak Mountains (D-6, C-6 quadrangles), and throughout most of the central part of the map area. Age control is provided by conodonts and megafossils (Dumoulin and Harris, 1987; Tailleur and others, 1967). The age of the Baird Group ranges from Silurian to Devonian in the Maiyumerak Mountains, and Ordovician to Devonian in the central part of the map area. Ordovician rocks are exposed mostly in the southern part of the central area; a broad belt in the northern B-4, B-5 and B-6, southern C-4 and C-5 quadrangles contains primarily Ordovician rocks. Definitely Silurian rocks have so far been

found only in a few localities in the C-5 and C-6 quadrangles. Devonian rocks occur mainly in the northern part of the central outcrop belt. Although the Baird Group (DOb) encompasses considerable lithologic variation, major lithologies may be grouped into several broad subunits on the basis of age and spatial relationships.

Two primary Ordovician lithofacies can be discerned (Dumoulin and Harris, 1987). Lithofacies I is dolostone with locally well-developed fenestral fabric, evaporite molds, and a conodont fauna of middle Early to earliest Middle Ordovician age (Faunas D through 2 of the North American Midcontinent Province conodont fauna succession) indicative of warm, locally restricted, shallow to very shallow water conditions (Table 1, map locality 38). At least 340 m of this lithofacies are exposed on the Middle Fork of the Squirrel River (Section C, Dumoulin and Harris, 1987). Dominant rock types are finely laminated mudstone and wackestone with subordinate intercalations of intraclast and pelletal packstone. Shallowing-upward cycles of fenestral texture occur locally: horizontal to laminar fenestrae indicative of lower intertidal environments are succeeded by irregular and vertical fenestrae more typical of upper tidal environments.

Ordovician Lithofacies II consists of bioturbated to laminated, characteristically ferruginous, orange- and gray-weathering, dolomitic to argillaceous metalimestone and marble with a normal marine, slightly cooler water conodont fauna of Early Ordovician through earliest Middle Ordovician age (Table 1, map locality 34). Local acrotretid brachiopods (J.T. Dutro, Jr., written communication, 1985). Some sequences contain 50 percent or more impurities, mostly white mica and quartz. Original sedimentary structures (including cross-bedding, ripple and flame structures, and a variety of tracks and trails) are best preserved in sequences that have been at least somewhat dolomitized and in which foliation parallels bedding. Locally, may show pronounced deformation fabrics, such as boudinage, isoclinal folds, and well-developed schistose texture.

Although Lithofacies I and II are broadly contemporaneous, Lithofacies II appears to be slightly older. Lithofacies II samples have yielded the oldest in situ conodonts yet obtained from the Baird Group (early Early Ordovician age: Fauna C) (Table 1, map locality 35), as well as redeposited conodonts of Late Cambrian age (in a sample which also contained Early Ordovician conodonts) (Table 1, map locality 34). More than 800 m of Lithofacies II are exposed north of the upper reaches of the Omar River (Section D, Dumoulin and Harris, 1987), but this section may have been tectonically thickened.

Several other Ordovician lithofacies appear to be more spatially restricted; the thicknesses of these sequences are unknown. Medium- to dark-gray, fine crystalline metalimestone contains conodonts of Early Ordovician age (early Arenigian); these conodonts indicate the coolest water or most basinal depositional environments for Ordovician rocks in the map area, and are older than the oldest graptolite-bearing beds in

unit O€c (Table 1, map locality 41). Middle Ordovician metalimestone and dolostone contains conodonts equivalent in age and biofacies to the youngest graptolite-bearing beds of unit O€c (Table 1, map locality 42). Middle to late Middle Ordovician (probably high Fauna 6) dolostone contains conodonts indicative of a very restricted, warm, shallow-water, innermost platform environment (Table 1, map locality 39). A single locality of definitively Upper Ordovician rocks--gray-brown, fine to medium crystalline marble--contains late Late Ordovician conodonts deposited in cooler, somewhat deeper water than coeval rocks of unit DOc (Table 1, map locality 40).

Silurian rocks in the central part of the map area consist of massive, typically orange-weathering dolostone. More than 300 m of section are exposed in the C-5 quadrangle, but this sequence may be tectonically thickened. Lithologies include finely laminated mudstone and lesser bioturbated, bioclastic to pelletal packstone. Halysitid corals and tubular and laminar stromatoporoids are locally abundant. Biostratigraphically diagnostic conodonts are of Late Silurian age; several of the assemblages indicate deposition in shallow, somewhat restricted platform conditions (Table 1, map locality 36). Fine-grained, thinly bedded light-gray metalimestone in the C-6 quadrangle contains Middle Silurian (late early Wenlockian) conodonts deposited in a normal marine, middle to outer platform environment (Table 1, map locality 23).

Devonian rocks consist of dolostone, lesser metalimestone and marble, and rare metasandstone (found only in the central part of the map area). Bioclastic grainstone to wackestone, locally cherty, contains a sparse to abundant megafauna of corals, stromatoporoids, gastropods, brachiopods, and bryozoans. Dendroid stromatoporoids form bafflestones several meters thick; coral-stromatoporoid bioherms and biostromes may be tens of meters thick. Rare calcareous metasandstone intervals contain notable amounts of chlorite and sphene (Dumoulin and Harris, 1987). Biostratigraphically diagnostic conodonts are of late Early and Middle Devonian age (Table 1, map localities 16, 20, 32, and 37); fossils and sedimentary structures indicate a range of normal marine shelfal depositional environments. Exposures in the central part of the map area are poor; 60 m of section were measured on the Middle Fork of the Squirrel River (Section E, Dumoulin and Harris, 1987), but this is certainly a minimum thickness for Devonian Baird Group rocks in this area. More than 200 m of late Emsian and Eifelian rocks crop out in the Maiyumerak Mountains.

The base of the Baird Group (DOb) is not exposed in the map area. In the Maiyumerak Mountains, it is thrust above the Endicott Group; in the central area, it is thrust above Middle and Late Devonian rocks of unit Dnu. The top of unit DOb is not exposed in central area, but in the Maiyumerak Mountains, it appears to be conformably overlain by unit MDue. The Baird Group was defined by Tailleur and others (1967). As used here, the Baird Group does not include upper Middle to Upper Devonian rocks of the Eli Formation (which are included in unit MDue),

or lower Paleozoic carbonate rocks of the Mount Angayukaqsraq area, which are assigned to units O€c and DOc. Although broadly contemporaneous and in part lithologically similar to unit DOb, the Mount Angayukaqsraq sequence is not contiguous with it and seems better treated separately until regional stratigraphic and structural relationships are more completely understood. Unit DOb shows many similarities in biofacies and lithofacies to the Ordovician and Silurian carbonate rocks of the York Mountains on the western Seward Peninsula, and to the Devonian rocks of the eastern Seward Peninsula (Dumoulin and Harris, 1987).

DOc **Carbonate rocks (Devonian?, Silurian, and Ordovician)**--Very light- to dark-gray (locally orange)-weathering, medium-gray to black, fine-grained dolostone and lesser metalimestone. The lower part of section forms excellent cliff exposures, distinctively color banded on a scale of one-half to several meters. The upper part of section is more poorly exposed; it typically forms rubble-covered rounded hills and rare low outcrops. The cliff-forming lower section is at least 80 m thick and contains conodonts of latest Ordovician (Richmondian) age throughout its extent; the conodonts indicate a warm, very shallow water depositional environment (Table 1, map locality 52). This sequence consists of fine-grained dolostone in even to slightly undulous beds 5-50 cm thick that constitute shallowing-upward peritidal cycles one to several meters thick. A typical cycle consists of dark- and light-gray, coarsely mottled, bioturbated pelletal mudstone that grades upward into lighter gray mudstone with local small-scale cross-bedding and sparsely distributed individual burrows; average burrow diameter decreases upwards from several cm to a few mm. The cycle is capped by whitish-gray-weathering, light-gray mudstone that contains crenulated stromatolitic laminations, fenestral fabric, and possible evaporite molds.

The rubble-forming upper sequence is at least 150 m thick and consists of dolostone grading upward into calcitic dolostone and metalimestone. Dominant lithologies are similar to those in the lower sequence and include laminated dolostones with local fenestral fabric, and cross-bedded to sparsely burrowed to thoroughly bioturbated pelletal dolostones. Coral- and stromatoporoid-rich bioclastic packstone and wackestone are also locally abundant. These lithologies may also form cyclic alternations, but their generally poor exposure makes it difficult to discern bed and cycle thickness. These rocks contain conodonts and megafossils of Silurian, and possibly Devonian age (Table 1, map localities 50, 51, 53, and 59).

This unit is exposed in a series of fault slices in the northeastern part of the map area, primarily north and west of Mount Angayukaqsraq (D-1, D-2, C-1 quadrangles), and also occures as fault-bounded sequences within unit O€c too small to show at the scale of this map. Upper and lower contacts are generally faults, and the relationship of this unit to older rocks in the area, such as the rocks of unit O€c, is unclear. Locally, the upper (Silurian-Devonian?) part of the unit directly

overlies unit O€c; the lower (Ordovician) sequence appears to have been cut out by a fault and(or) unconformity.

Rocks of this unit are similar lithologically and in part coeval with Baird Group (DOb) carbonate rocks in the central part of the map. However, Lower Ordovician and Devonian rocks appear to constitute the bulk of unit DOb, whereas Upper Ordovician and Silurian rocks make up most of unit DOc. Because the two map units are not contiguous and have different stratigraphic associations, they are here mapped separately until regional stratigraphic relations are better understood.

O€c **Carbonate rocks (Ordovician to Cambrian)**--Orange- and gray-weathering, variously impure metalimestone and marble, thin-bedded couplets of metalimestone and dolostone, graptolite-bearing phyllite, interbedded phyllite and dark-gray metalimestone, and massive white to gray marble. Exposed in several fault slices west and south of Mount Angayukaqsraq (D-1 and D-2 quadrangles); in general, rocks become younger to the south and to the west. This unit includes fault slices of units PzPcb and DOc too small to show at 1:250,000 scale.

Unit O€c consists of four subunits distinguished by lithology and paleontology but not mapped separately here. Subunit one contains pure to impure metalimestone, marble, and dolostone, and lesser calcareous schist and phyllite; it is exposed mainly in the more northeasterly fault slices and forms distinctively brown to orange terraced hillsides in fault contact beneath units Psv and Pm. Large-scale (tens of meters thick) lithologic cycles are characteristic of this subunit and typically consist of orange dolostone grading downward into dolomitic marble, quartzose and micaceous marble, and finally chloritic marble. It is unclear if these repetitions are of tectonic or depositional origin. Smaller scale cycles, on a scale of millimeters to centimeters, are probably of depositional origin; typically, these consist of thicker layers of flaggy, medium crystalline, gray-weathering, purer carbonate intercalated with thinner intervals of platy, orange-weathering, more impure (quartzose and(or) micaceous) carbonate. Locally preserved original sedimentary structures in these rocks include small-scale cross-beds and ripples, parallel laminations, and graded bedding. Some intervals contain abundant coated grains. Subordinate lithologies include calcareous and chloritic schists, gray to green, locally chloritic phyllite, and intervals of metaconglomerate as much as 2 m thick that consist of carbonate cobbles in a chloritic matrix. This sequence is isoclinally folded on a mesoscopic and megascopic scale, and cut by numerous small faults. It has probably been tectonically thickened; true depositional thickness cannot be determined, but is probably at least several hundred meters. No fossils have been recovered from this subunit; if these rocks are in depositional contact with adjacent rocks to the south and west, they are probably at least as old as Early to Middle Cambrian in age, and may be (at least in part) Precambrian.

Subunit two appears to gradationally overlie the rocks of subunit one, and is best exposed in a section more than 60 m thick south of Mount Angayukaqsraq (section A, Dumoulin and Harris, 1987). This section consists of massive, crudely bedded, medium to coarse crystalline marble that grades upward into thinner bedded, platy metalimestone, and then into thin couplets of laminated dolostone and bioturbated metalimestone. Acrotretid brachiopods of Middle Cambrian (probably late Middle Cambrian) age occur near the base of the section (Table 1, map locality 55, samples 83 ADn 101FF and 101GG), and Late Cambrian agnostid trilobites have been recovered from near the top of the section (Table 1, map locality 55, sample 8-12-83D). The dolostone/metalimestone couplets probably represent peritidal cycles deposited in the supratidal to shallow subtidal environment. Phosphatized steinkerns of monoplacophoran mollusks also indicate a shallow-water depositional environment (Dumoulin and Harris, 1987) (Table 1, map locality 55). Other fossils recovered from this sequence include chancelloriid sclerites, hyolithids, and protoconodonts (Table 1, map locality 54, locality 55). Fossils indicate a maximum age of Early (but not earliest) Cambrian for subunit two. At several localities, subunit one appears to conformably and gradationally underlie subunit two, but the contact could be faulted.

A third subunit consists of orange- to yellow-weathering, brown to black, locally calcareous metasiltstone, silty metalimestone, and phyllitie; gray to black phyllite; and gray to black metalimestone, locally intercalated with phyllite. This subunit has been tectonically dismembered, and the sequence described below has been pieced together from a number of separate fault slices. The lower part of subunit three is best exposed south of Mt. Angayukaqsraq (section A of Dumoulin and Harris 1987). Here, Upper Cambrian rocks of subunit two are overlain by 60 m of thinly bedded, dark-gray to black silty metalimestone of uncertain age, followed by about 10 m of black phyllite with subordinate limey interbeds. The contact between the silty metalimestone and the Cambrian section is not exposed; it may be a fault or an unconformity. The black phyllite forms a distinctive recessive-weathering marker bed which may be traced laterally for several miles; it contains graptolite assemblages that represent about 12 million years of late Early and earliest Middle Ordovician time (Carter and Tailleur, 1984). Conodonts from near the top of this sequence indicate deposition in a relatively cool-water, mid-shelf to basinal environment (Dumoulin and Harris, 1987) (Table 1, map localities 54 and 55).

At some localities, the phyllitic interval is overlain by as much as 40 m of thin-bedded, finely crystalline metalimestone and subordinate, intercalated phyllite. These rocks form thinning and fining upward sets and probably represent shelf edge turbidites (section B, Dumoulin and Harris, 1987); they have a clastic, locally graded texture and contain a Middle Ordovician fauna with a mixture of warm- and cool-water species (Table 1, map locality 53). An isolated fault sliver north of Mount Angayukaqsraq may represent the upper part of this sequence. At least 30 m of unevenly bedded, bioturbated, locally calcitic, black dolostone

overlies finely crystalline black limestone and calcareous phyllite; the dolostone contains cool-water, normal marine conodonts of middle Middle to early Late Ordovician age (Table 1, map locality 49).

The thin-bedded rocks of the third subunit are succeeded by at least 80 m of more thickly bedded, locally bioturbated metalimestone and marble of Middle to Late Ordovician age (Table 1, map locality 53) that constitute subunit four. A bioclastic packstone to grainstone texture is locally preserved, but these rocks are generally strongly recrystallized to light-gray, medium to coarse crystalline marble.

Where the top of unit O€c is exposed, it is overlain by unit DOc. At some localities, massive marble representing the top of unit O€c appears to be conformably overlain by color-banded dolostone representing the basal part of unit DOc. Elsewhere (notably section B of Dumoulin and Harris, 1987) uppermost rocks of unit O€c are overlain by Upper Silurian dolostone of unit DOc, and the Ordovician dolostone of unit DOc is missing. At section B this contact is marked by a 5-10 m thick horizon of solution cavities that are partly infilled by cross-bedded quartz-carbonate metasandstone. These cavities may represent a paleokarst terrain formed during a period of prolonged subaerial exposure. It is unclear whether the missing Ordovician section was removed by an unconformity or by a fault.

At least parts of unit O€c have been previously assigned to the Baird Group (Carter and Tailleur, 1984), but the two sequences are here mapped separately because they are not contiguous and are for the most part lithologically distinctive. Rocks that are lithologically similar to parts of unit O€c occur in the central Brooks Range in the Chandalar quadrangles; a black phyllite exposed near Snowden Mountain appears to be coeval with, or is just slightly younger than, the black phyllite interval of unit O€c (Dumoulin and Harris, 1987; Dillon and others, 1987).

Pzd **Dolostone (Paleozoic)**--Very pale orange to moderate reddish brown, creamy weathering, very fine-grained, slightly calcitic dolostone, locally laminated. This unit forms rubble-covered hills and low outcrops in the southwestern map area (A-6 quadrangle). No fossils have been recovered from this unit; a Paleozoic age is inferred because most carbonate units in the map area are Paleozoic

Pzm **Marble (Paleozoic)**--White to gray, fine to coarsely crystalline, massive to platy marble and subordinate light-gray, finely crystalline dolostone. The marble forms prominent tor and cliff outcrops in the northeastern and southwestern map areas. It locally contains appreciable quartz and(or) mica, but is generally pure. Relict sedimentary structures or textures are not preserved. No fossils have been recovered from this unit; a Paleozoic age is inferred from the age of adjacent units and because most carbonate units in the map area are Paleozoic. This unit may contain rocks of several different ages, and

may include unrecognized parts of other carbonate units such as DOb, Dnl, or DOc.

Pzkm **Marble of Klery Creek (Paleozoic)**--White-weathering medium- to light-gray marble with subordinate intercalated gray to green quartz chlorite schist, black carbonaceous quartzite and tan calcareous mica schist. Marble is thin-bedded, medium-bedded, thick-bedded or massive in layers tens of meters thick. Quartz chlorite schists are 1 to 20 m thick; calcareous mica schists are less than 20 m thick, black siliceous or calcareous carbonaceous rocks are less than 10 m thick.

Metamorphic mineral assemblages for siliceous schists include quartz, white mica, chlorite, albite, biotite, chloritoid, calcite, graphite and rare garnet. Tourmaline is present and may be a relict detrital mineral in siliceous metasedimentary rocks. Three phases of folding are recognized in microfabrics and attributed to Brookian deformation. A fourth phase of brittle deformation overprints the earlier ductile deformation (Zayatz, 1987).

The thickness of this unit is unknown. The unit structurally overlies quartz mica schists of unit Pzqms and structurally underlies quartzite of unit DOtq. Structural repetitions of east-vergent folds in marble layers indicate the unit has been tectonically thickened. These east-vergent folds may correspond to the brittle deformational overprint observed in thin-section. The east-vergent structures are interpreted to represent east-west compression that post-dated the north-vergent compression of the Brookian orogeny (Grantz and others, 1975, 1981; Patton and Tailleur, 1977; Karl and Long, 1987). The east-directed compression could result from the formation of a lateral ramp beneath this unit during a late phase of uplift in the Brookian orogeny, analogous to the late uplift described by Gottschalk (1987) for metamorphic rocks in the Wiseman quadrangle; alternatively, the east-west compression could result from a separate, independent tectonic event.

Two fossil localities provide some age control for this unit. Conodonts from the thick marble layers are Late Silurian to Early Devonian in age (Table 1, map locality 46). Conodonts from overlying black carbonaceous marble and quartzite are Earliest Mississippian (Table 1, map locality 45). Because the unit is only roughly mapped and poorly understood, a Paleozoic age is assigned. The marble unit is best exposed along the east side of Tukpahlearik Creek.

Pzqms **Quartz mica schists (Paleozoic)**--Grayish-green or greenish-gray fine-grained quartz-muscovite-chlorite schist and mica-quartz schists. Well developed mm quartz segregation layers are commonly cut by a younger mm- to cm-spaced cleavage. Unit is dominantly homogenous pelitic schist with local variations in quartz content, but in some places unit includes orange-weathering light green calcareous schist, black graphitic schist, and dark green meter-scale intercalations of glaucophane-bearing metabasite. Albite and chloritoid are common,

garnet is rare. Where present, garnets are inclusion-free, unzoned, and idioblastic to hypidioblastic.

Unit thickness is unknown. Upper and lower contacts are faults. Unit Pzqms is isoclinally folded and considerable structural thickening is inferred. This unit is lithologically correlated with quartz mica schists of the "schist belt" in adjacent quadrangles (Mayfield and Tailleur, 1978; Nelson and Grybeck, 1980, Dillon and others, 1986) which have yielded early to mid-Cretaceous K-Ar cooling ages of 130 to 100 Ma (Turner and others, 1979), providing a metamorphic age for the schists of Pzqms. Protolith age is unknown but inferred to be Paleozoic. Dillon and others (1986) suggest that the protolith may be the extensive pelitic rocks of the lower Endicott Group. Crosscutting spaced cleavage in schists of Pzqms may be due to a late phase of thrusting following the main phase of regional deformation and metamorphism as described by Gottschalk (1987), for similar rocks in the southern Wiseman quadrangle. This unit is best exposed in the Nikok drainage basin and the east central area of the quadrangle.

Pzqs **Quartz metaconglomerate, metasandstone, and siliceous phyllite (Paleozoic)**--Buff, white, or light green quartz pebble metaconglomerate, quartz metasandstone, calcareous quartz metasandstone, and green, maroon, and gray phyllite. Metaconglomerate contains 85 to 95 percent white, gray or black vein quartz and chert pebbles; either may be dominant. Many chert pebbles contain ghosts of radiolarians. Maximum pebble size (unstretched) is 8 cm; pebbles locally stretched to 15:1 length to width ratio; stretched pebbles trend in a northerly direction. Clast compositions include minor amounts of argillite, interlocking quartz-feldspar fragments, volcanic rock fragments, and tourmaline. Secondary minerals include white mica, chloritoid in grains and radial clusters, albite, euhedral garnet, stilpnomelane, and pumpellyite. Metaconglomerate occurs as meter-scale lenses in maroon and green phyllite; metaconglomerate and metasandstone are locally cross-bedded, with wedges up to 20 cm thick. Quartz metasandstone is foliated with maroon or green phyllitic partings, and fine- to medium-grained. Metaconglomerate and metasandstone are well-sorted with rounded clasts. Metaconglomerate matrix is siliceous with rare white mica or calcite. In some places cataclastic mortar textures, pressure-solution textures, or strain shadows accompany stretching of clasts. Maroon and green phyllite is mottled within foliation planes and coloration may be a product of depositional, diagenetic, and metamorphic processes. Locally metaconglomerate is associated with black carbonaceous phyllite in lenses up to several meters thick.

Unit thickness is undetermined. Most contacts are faults, although in one place near the Salmon River a depositional contact of metaconglomerate on carbonate of unit DOc was observed. The metaconglomerate is commonly associated with the carbonate of DOc and many of the contacts may be faulted unconformities. The unit is overlain by gray phyllite of the Endicott Group; this contact is covered, and may be either structural or stratigraphic, or both.

Metaconglomerate lenses in phyllite, crossbedding, and maroon, green and black colors suggest very shallow marine and locally fluvial depositional environments with fluctuating oxygen contents.

The age of this unit is unknown. No fossils or age-diagnostic plant debris have been recovered; chert pebbles have been processed unsuccessfully for radiolarians. Unit is lithologically similar to both the Mississippian Kekiktuk Conglomerate and to conglomerate of the Middle to Late Devonian Beaucoup Formation. Both conglomerates contain quartz and chert pebbles and are interbedded with maroon and green phyllites. Both conglomerate units rest unconformably on carbonate rocks coeval with unit DOc elsewhere in the Brooks Range (Nelson and Grybeck, 1980; Dillon and others, 1986). Because of the similarity of these units, some of the lithologically similar conglomerates elsewhere in the Brooks Range may be mapped in the wrong unit as suggested by Nelson and Grybeck (1980). The only other possible discriminating factor in the absence of fossils is stratigraphic context. The Kekiktuk conglomerate is typically overlain by the Kayak Shale, and this relationship is nowhere observed in the Baird Mountains quadrangle. The Beaucoup Formation conglomerates near the type area are associated with the siliceous and mafic Whiteface Mountain Volcanics and are overlain by the Hunt Fork Shale of the Endicott Group in the Wiseman quadrangle (Dillon and others, 1986). In the northeastern Baird Mountains quadrangle, metaconglomerate of unit Pzqs is intimately associated with siliceous volcanic rocks of unit Pzr and overlain by gray phyllites of the Endicott Group. Because of these lithologic associations, a Middle to early Late Devonian age is preferred for unit Pzqs.

Pzr **Rhyolite (Paleozoic)**--Light apple green, thinly laminated to massive, quartz porphyritic rhyolitic plugs, flows, and pyroclastic deposits. The rhyolite is locally silicified. Quartz phenocrysts are clear and euhedral to embayed. The rhyolite contains rare albite phenocrysts, secondary white mica, albite, and pyrite, and lacks mafic minerals. Rhyolite occurs in masses up to tens of meters thick. A rhyolitic dike cutting limestone of unit O€c was observed east of Mount Angayukaqsraq near a large rhyolite body. To the north, rhyolite has a consistent spatial association with conglomerate of unit Pzqs and in one place has a sharp, possibly intrusive contact with limestone of unit DOc. We were unsuccessful in obtaining any minerals suitable for isotopic dating, but a Paleozoic age is inferred by association of the rhyolite with other Paleozoic units. Unit Pzr may be correlative with Whiteface Mountain Volcanics mapped in the Wiseman quadrangle (Dillon and others, 1986). The Whiteface Mountain Volcanics are associated with conglomerate and carbonate units of Ordovician to Devonian age, and inferred to be Devonian by Dillon and others, (1986). Rhyolite unit Pzr is best exposed in the northeastern part of the quadrangle, 10 km south of Lake Kangilipak.

Pzbq **Black quartzite and siliceous semischist (Paleozoic)**--Sooty black quartzite and semischist which locally has quartz segregations, flattened quartz pebbles, and weathers rusty, yellowish, or bluish

The thickness of these rocks is unknown; they are found in cores of structural domes in the southern and eastern part of the quadrangle. Rolled garnets and isoclinal folds indicate these rocks were ductilely deformed during metamorphism, and they are considered to represent the deeper metamorphic conditions of the hinterland of the Brooks Range fold and thrust belt.

Glaucophane occurs only in certain metabasite or metapelite lithologies and is apparently compositionally controlled. Partial to nearly complete retrograde replacement of glaucophane by chlorite and albite, and replacement of garnet by chlorite along grain boundaries and fractures indicates high pressure bluechist facies metamorphism was followed by retrogressive greenschist facies metamorphism, represented by equillibrium assemblages of the chlorite zone (Zayatz, 1987). The presence of stilpnomelane suggests moderate pressures characterized this event (Miyashiro, 1973). Prograde development of biotite from chlorite in metapelitic schists indicates an increase in temperature to biotite zone during the late stages of greenschist facies metamorphism (Zayatz, 1987).

Microfabrics in various pelitic schists record three folding events. The earliest deformation (F1) is recorded by poorly preserved schistosity within large helicitic quartz and albite prophyroblasts. The dominant folding event (F2) is characterized by tight asymmetric crenulations and the dominant schistosity. F2 folds are re-folded by broader, gentler F3 folds that do not significantly alter F2 morphology (Zayatz, 1987). Because they are coaxial these three phases of folding are inferred to have developed during multiple phases of deformation and metamorphism of the same regional Brookian event.

Protolith ages for these mixed schists are not known, but are considered to be Paleozoic and(or) Proterozoic based on conodonts of Silurian to Mississippian age (Table 1, map locality 47) recovered from a marble lens in this unit at the north end of the Kallarichuk Hills, and a Proterozoic U-Pb age for zircons from a granodiorite intruding marble between Bear Creek and Central Creek. A K-Ar metamorphic age of 114 Ma for muscovite (Turner and others, 1979), and a K-Ar age of 91.6 $\pm$ 1.5 Ma for biotite (Nora Shew, written commun., 1988) for pelitic schists collected less than 2 km apart in the southern Kallarichuk Hills bracket the timing of greenschist facies metamorphism and cooling of these rocks. These schists are best exposed in the Kallarichuk Hills.

PzPks **Siliceous schist of the Kallarichuk Hills (Paleozoic and(or) Proterozoic)**--Light silvery gray to silvery grayish green to dark green garnet-mica-quartz schists. Well-developed mm quartz segregation layers are tightly folded. Some garnets are zoned, most garnets contain inclusions. Although proportion of quartz and mica varies, unit is mostly pelitic in composition. Metamorphic mineral assembages include quartz, muscovite, chlorite, albite, biotite, garnet. Subordinate lenses of metabasite contain glaucophane. Mineral textures and

white. The quartzite consists of quartz, graphite and chlorite, locally with calcite, stilpnomelane, or sulfides.

This black quartzite unit is a maximum of tens of meters thick, and is associated with unit Pzbs. Two km east of quadrangle boundary near Naneilik Creek, this unit contains Lower to Middle Ordovician conodonts with a color alteration index of six (Mayfield and others, 1983b, fig. 5, locality 39). Unit Pzbq may be Ordovician and younger, a Paleozoic age is tentatively assigned. Unit Pzbq may correlate with unit DOtq, of similar age and lithology, and with part of unit PzPku. Unit Pzbq is best exposed on a ridge north of Nanielik Creek near the eastern quadrangle boundary.

Pzbs **Black shale and carbonate rocks (Paleozoic)**--Dark gray to black siliceous and calcareous shale, with intercalated meter scale lenses of white- to tan-weathering gray limestone or dolostone, and lenses of light green volcaniclastic rock. Iron and sulfur staining are strong on some outcrops. These rocks contain calcite, quartz, graphite, chlorite, pyrite.

The thickness of this unit is estimated to be a maximum of several tens of meters. This unit is typically associated with unit Pzbq and may structurally underlie the rocks of unit Pzbq. The age of this unit is unknown, but a Paleozoic age is inferred from association with unit Pzbq, and its lithologic similarity to shale a few km to the east in the adjacent Ambler River quadrangle which yielded Silurian graptolites (Mayfield and others, 1983b, fig. 5, locality 38). Unit Pzbs is best exposed in prominant scarp on north side of Nanielik Creek near the eastern boundary of quadrangle.

PzPku **Mixed schists of the Kallarichuk Hills, undivided (Paleozoic and(or) Proterozoic)**--Silvery green and gray quartz-mica schists, brown calcareous schists, gray marble and black quartzite. Lithologies alternate on a meter to tens of meters scale. Unit is characterized by rapid alternation of lithologies and by the presence of carbonaceous rocks, which compose approximately 20 percent of the unit. Marble makes up less than 1 percent of the unit. Pelitic schists contain quartz, albite, muscovite, chlorite, $\pm$ biotite, $\pm$ stilpnomelane, $\pm$ calcite, $\pm$ actinolite, $\pm$ garnets with inclusions, $\pm$ glaucophane. Albites contain graphitic inclusions and commonly appear black in hand specimens. Mafic schists contain albite, chlorite, epidote, actinolite, garnet, $\pm$ glaucophane, $\pm$ stilpnomelane. The meter scale alternation of lithologies suggests rapid facies changes and shallow marine protoliths for metasedimentary rocks. Relict conglomeratic textures were recognized at one locality in the Kiana Hills and lithologically correlated with "knotty mica schist" of Dillon (1987) by J.T. Dillon (oral commun., 1985). Other rocks retain relict igneous textures and are interpreted to be mafic and felsic metavolcanic rocks. Blue quartz porphyroblasts were observed at one locality in felsic rocks east of the Kaligurichearк River.

microfabrics are similar to those described for the schists of unit PzPku and a similar metamorphic and deformational history is inferred.

Unit thickness is undetermined; protolith age is unknown. Muscovite from one schist sample yielded a K-Ar age of 116 ± 2.5 Ma (Nora Shew, written commun., 1988), which is inferred to represent Brookian Metamorphism. Also from this unit, a K-Ar age of 767 Ma for glaucophane, and K-Ar ages of 660 Ma and 632 Ma for two actinolite localities (Turner and others, 1979) suggest a possible Proterozoic metamorphic event. The relatively homogeneous pelitic protolith for unit PzPks is apparently similar to the protolith for unit Pzqms. The schists of unit PzPks differ from those of unit Pzqms only in metamorphic grade. If the Proterozoic K-Ar ages are questioned, it is possible that the schists of unit PzPks represent thrust sheets of unit Pzqms that were subjected to higher pressures and temperatures, but they may also be pelitic rocks of older Paleozoic or Proterozoic age. These rocks are best exposed near the headwaters of the Kallarichuk River.

PzPkc **Calcareous schist and marble of the Kallarichuk Hills (Paleozoic and(or) Proterozoic)**--Tan to brown calcareous quartz-mica schist, gray quartz-albite-mica schist, black carbonaceous schist, and lenses of massive gray marble tens of meters thick. Lithologies alternate on a meter to tens of meters scale. This unit is distinguished from other units in the Kallarichuk Hills by thick gray marble lenses.

Metamorphic mineral assemblages include quartz, calcite, albite, epidote, white mica, chlorite, stilpnomelane, biotite, and garnet. Protoliths are sedimentary. The thickness of this unit is unknown. The protolith age of this unit is unknown. South of Bear Creek, marble of this unit (PzPkc) is intruded by granodiorite containing zircons that yielded a U-Pb age of 705 ± 35 Ma (John Aleinkoff, written commun., Sept. 1989), so some of the marbles in this unit must be Proterozoic. The association of this unit with units PzPku and PzPks suggests a similar age and metamorphic and deformational history. The age of metamorphism is inferred to be Brookian (mid-Cretaceous). This unit is best exposed on the west side of the Kallarichuk Hills between Rocky Creek and the Kobuk River.

PzPcb **Carbonate rocks and metabasite (Paleozoic and(or) Proterozoic)**--Orange- to light-gray-weathering, dark- to light-gray, fine to medium-grained crystalline dolostone, metalimestone and marble, with subordinate intercalated calcareous quartzite, quartz-mica schist, green and silver phyllite, carbonate cobble metaconglomerate, and blue amphibole-bearing metabasite. Typically exposed as massive, cliff-forming outcrops. Carbonate rocks are generally massive to thick-bedded, with abundant quartz- or white mica-filled fractures. Well-preserved original sedimentary structures--notably stromatolites and coated grains--occur locally in fine-grained dolostones. Stromatolitic morphologies range from flat or slightly hummocky tabular sheets a few cm thick to discrete club-shaped mounds as much as 15 cm high. Grainstones composed of ooids, composite grains, and local pisoids are commonly intercalated

with stromatolitic layers. Other sedimentary structures observed include fenestral fabrics and oolitic intraclasts; the total association of structures suggests an intertidal to shallow subtidal depositional environment (Dumoulin, 1988).

Lithologies intercalated with the carbonate rocks include white- to tan-weathering locally calcareous quartzite, in beds as much as 30 cm thick, schists containing various proportions of quartz, white mica, chlorite, and calcite, and green, gray or silver phyllite. Matrix-supported carbonate metaconglomerate occurs as massive layers up to 20 m thick. Clasts are rounded to angular, as much as 1 m in diameter, dominantly pale-gray- to orange-weathering dolostone (some with stromatolitic textures); matrix is sandy, locally calcareous dolostone. The massive, clast-poor nature of these conglomerates suggests a debris-flow origin. Metabasite forms intercalated lenses and layers tens of meters thick that may be in depositional contact with the carbonate rocks.

Metabasite is bluish green to dull olive green, massive, pillowed, or layered, intercalated with gray marble, orange weathering calcareous mica schist, gray banded pelitic schist and semischist, siliceous mica schist, and banded quartzite (metachert). Greenstone may compose up to 90 percent of the unit in some places; proportions of lithologies vary. Metabasite includes metamorphosed pillow breccia, pillow lava, and mafic pyroclastic rocks. Mafic rocks are partially recrystallized to assemblages containing blue amphibole, actinolite, chlorite, epidote, and quartz. Amphiboles are common in veins and tension gashes.

Unit PzPcb is exposed as a northeast-trending belt of fault slices on the southeast side of Mount Angayukaqsraq (C-1 quadrangle) and as fault-bounded pieces too small to show within OЄc at 1:250,000 scale. Due to structural complexities, thickness is not known but may be several 100's of meters. No age-diagnostic fossils have been recovered from any of the associated lithologies. A Paleozoic or Precambrian age is assigned due to spatial association with both Paleozoic and Precambrian lithologies. Unit PzPcb is distinguished by locally abundant coated grains and stromatolites, massive aspect, and association with metabasite lenses and layers. Parts of this unit may correlate with subunit one of OЄc, which also contains locally abundant coated grains, and with parts of units PzPku and PzPkc.

Similar lithologic associations elsewhere in the Brooks Range that may be correlative with this unit include parts of the Kogoluktuk Schist of Hitzman and others (1982) in the Ambler River quadrangle (stromatolitic dolostones, dolomitic matrix-supported conglomerates, quartzites, metabasites) and perhaps the Proterozoic Katakturuk Dolomite in the northeastern Brooks Range, a thick carbonate sequence that contains abundant oolitic grainstones and stromatolitic morphologies (Blodgett and others, 1986).

PzPi **Meta-intrusive rocks of intermediate composition (Paleozoic and(or) Proterozoic)**--White, light gray, or green and white, massive to

gneissic, granitic to dioritic meta-intrusive rocks. Granitic rocks retain relict igneous textures such as hypidiomorphic quartz and feldspar with interstitial green hornblende. Granitic rocks contain quartz, plagioclase, microcline, k-feldspar, hornblende, muscovite, biotite, apatite, fluorite, zircon and sphene. Metamorphic minerals include muscovite, biotite, euhedral garnet, calcite, quartz, feldspar, and epidote. Dioritic rocks contain quartz, plagioclase, hornblende, opaques, sphene and metamorphic white mica, chlorite, calcite, and euhedral garnet. In some samples biotite is replacing muscovite and locally has cores of muscovite.

Rocks in this map unit occur as km-scale or smaller bodies that have crosscutting relationships with Paleozoic and(or) Proterozoic rocks of the Kallarichuk Hills. These intrusive bodies are metamorphosed to typical Brookian greenschist facies mineral assemblages. Unit PzPi is thus older than the regional mid-Cretaceous Brookian metamorphic event. One sample yielded a K-Ar age of 107 Ma for metamorphic muscovite and a biotite K-Ar age of 95.9 Ma (Turner and others, 1979). Another sample gave a biotite K-Ar age of 96 $\pm$ 1.2 Ma (Nora Shew, written commun., 1988). Because other similar granitic rocks intruding pelitic schists and mixed schists of the southern Brooks Range have yielded Devonian U-Pb ages (Dillon and others, 1980, 1987), and because zircons from one of the bodies in the Kallarichuk Hills yielded a Proterozoic U-Pb age of 705 $\pm$ 35 Ma (John Aleinikoff, written commun. Sept. 1989), which is comparable to the 750 Ma age for the granodiorite at Mount Angayukaqsraq (unit Pi), the meta-intrusive rocks of the Kallarichuk Hills sequence may have either Paleozoic or Proterozoic protoliths. The dated granodiorite body (south of Bear Creek) is assigned a Proterozoic age; the undated bodies are designated as Paleozoic and(or) Proterozoic. Some of these bodies are exposed in the upper reaches of Crooked Creek, Klery Creek, and the Killik River in the Kallarichuk Hills. There are also rocks with granitic protoliths within undifferentiated unit PzPku at the eastern margin of the quadrangle.

Pi **Intrusive rocks of Mount Angayukaqsraq (Proterozoic)**--Light to medium green gabbro and leucogabbro and buff to light gray granite and granodiorite. Gabbro and leucogabbro compose 70 percent of intrusive rocks, granite 20 percent and granodiorite 10 percent. Gabbroic rocks have color indices ranging from 28 to 60 and contain clinopyroxene and hornblende generally replaced by epidote, actinolite and an additional pale colored amphibole, and iron oxides or pyrite. Plagioclase is completely altered to mats of fine grained clinozoisite. Accessory minerals include rutile and apatite. Granite and granodiorite have a color index of approximately 10 and contain biotite and traces of iron oxides. They have abundant microcline and perthite and include accessory zircon, sphene, apatite, igneous(?) garnet, and metamorphic white mica and stilpnomelane.

The intrusive rocks are massive, inequigranular, and locally foliated. They lack a penetrative fabric but near some contacts and in shear zones they contain microscopic mortar textures consistent with fabric

development in high strain zones. This deformation and the metamorphic minerals are attributed to the Brookian orogeny.

Dikes of granite, aplite, granite pegmatite, hornblende-plagioclase pegmatite, and gabbro intrude metasedimentary and metavolcanic rocks of Psv. Dikes of granitic pegmatite intrude the gabbro, and consequently the granite is inferred to be younger than the gabbro. The trace element chemistry of the gabbros and granites is similar but does not conclusively show that they are related. The gabbroic rocks have high Al_2O_3 contents (up to 24 weight percent). The granites are mildly peraluminous with 75 weight percent silica, and high Rb/Sr ratios ranging from 6.1 to 22.0 (Karl and others, 1989). Gabbroic rocks have low Rare Earth Element (REE) abundances with low fractionation of light to heavy REE and a small positive europium anomaly; granitic rocks have moderate REE abundances with a moderate europium anomaly and low light/heavy fractionation (Karl and others, 1989). The REE data for the gabbros are consistent with a cumulate origin for the plagioclase. The similar slight fractionation of light and heavy REE suggests both gabbroic and granitic rocks were derived from a similar weakly fractionated source. This fractionation is less than that typical of granites derived from arc magmas; the granites plot in the field of within-plate granites on trace element diagrams (diagram of Pearce and others, 1984, in Karl and others, 1989).

Zircons in the granite and granodiorite yielded a U-Pb age of 750 $\pm$ 6 Ma (Karl and others, 1989). Because the granitic and gabbroic rocks were apparently affected only by regional greenschist-blueschist facies Brookian metamorphism, this intrusive age for the granitic rocks provides a minimum age for the gabbro and a minimum age for the amphibolite facies metamorphism affecting the rocks intruded by the granites. These intrusive rocks are best exposed on the ridge extending west from Mount Angayukaqsraq in the northeastern corner of the map area. Metagranodiorite from south of Bear Creek in the Kallarichuk Hills yielded a U-Pb age of 705 $\pm$ 35 Ma (John Aleinikoff, written commun., Sept. 1989) and may be coeval with the granitic rocks at Mount Angayukaqsraq.

Granitic rocks at Mount Angayukaqsraq have been correlated by Dillon and others (1980) with granitic gneisses at Ernie Lake and Sixtymile River of the Survey Pass and Wiseman quadrangles, which have yielded discordant Pb-Pb ages of 800 to 1000 Ma. This correlation is considered tenuous because of differences in the zircon populations and in the metamorphic histories of the granitic rocks (Karl and others, 1989).

Psv **Metasedimentary and metavolcanic rocks of Mount Angayukaqsraq (Proterozoic)**--Dark green to dark brownish-black garnet amphibolite; buff, tan, apple green, dark olive-brown and dark gray quartzite, micaceous quartzite, calc-silicates and calc-schist, and light greenish gray and gray pelitic schist. Unit includes fault slivers, dikes, and small stocks of metamorphosed mafic, intermediate and granitic rocks (Pi). Outcrops are massive; lithologies are layered on a cm- to m-

scale. Garnet amphibolite is fine- to medium-grained, locally foliated and lineated, and locally contains garnets up to 1.5 cm in diameter. Garnets recrystallized to chlorite and epidote in some places. Quartzite is massive, color-banded on a cm scale. Muscovite quartz schist locally contains small garnets, biotite, or pyrite. Calc-silicate rocks are massive and aphanitic to banded and fine grained and contain diopside, epidote and garnet. Calc-schist is also massive, locally color banded on a cm scale, and contains albite, epidote, quartz, hornblende, and garnet.

Pelitic schist is medium to coarse grained with abundant white mica, some biotite, and pink garnets up to 6 mm in diameter. Biotite and garnet are locally recrystallized to chlorite.

This unit has yielded K-Ar and Rb-Sr ages from muscovite and hornblende indicating amphibolite facies metamorphism occurred at approximately 595-655 Ma (Turner and others, 1979; Mayfield and others, 1982; Armstrong and others, 1986); isotopic age uncertainties are permissive of the 750 Ma minimum age for amphibolite facies metamorphism indicated by intrusive contacts of unit Pi (Karl and others, 1989). Unit Psv is best exposed in the creek bottom south of Mount Angayukaqsraq. Unit Psv may correlate with parts of units PzPku and PzPks.

Pm **Polymetamorphic mafic rocks (Proterozoic)**--Dark greenish-blue, strongly lineated mafic rocks with subordinate white-weathering marble or dolostone. Bluish color distinguishes mafic rocks of this unit. Mafic rocks may contain layers, lenses, or knots of epidote, blue amphibole, and calcite. In thin section, relict medium green hornblende is found in cores of blue amphibole; epidote and chlorite form pseudomorphs after garnet (A.B. Till, oral commun., 1988). Outcrops are massive to crudely layered or crudely lenticular. Carbonate occurs in lenses up to tens of meters thick; mafic rocks may be hundreds of meters thick.

There are no ages for this unit. Hornblende inferred to be a product of Proterozoic amphibolite facies metamorphism dated in unit Psv; blue amphibole inferred to be a product of Jura-Cretaceous Brookian metamorphism. This unit is best exposed on ridge west of Mount Angayukaqsraq.

b **Metabasalt**--Metabasaltic rock of unknown age, not a separate mappable unit, but of significant size within other units to warrant distinction on the map. Metabasaltic occurrences in the western map area of Baird Group (DOb) are noted because they are unusually abundant there, and because they contain glauophane, providing important evidence for the metamorphic history of the Baird Group carbonate rocks. Metabasalt blocks are also mapped in units KJm and MzPzm.

c **Metachert**--blocks of bedded metachert in melange of units KJm and MzPzm

cs **Chlorite schist**--Blocks of chlorite schist in melange of MzPzm

g **Gabbro**--Blocks of gabbro (Mzg) occurring in melange of unit KJm. Gabbro is identical to Mzg but lacks intrusive contacts.

m **Marble**--Blocks of bedded or massive marble of unknown age or affinity in melange of unit KJm or MzPzm.

s **Serpentinite**--Green and black serpentinite of unknown age or source. Occurs only along faults, as lenses up to 10 m thick, associated with melange units KJm and MzPzm. On Kivivik Ck, a 10 m zone of serpentinite lies adjacent to amphibolite 50 m thick.

 Bedding attitude

 Bedding attitute--tops indicated, right-side up

 Foliation

 Fold axis--antiformal or anticlinal fold

 Fold axis--overturned fold

 Contact, dashed where inferred

 Fault, dashed where inferred

 Thrust fault, sawteeth on upper plate, dashed where inferred

 Thrust fault, faulted unconformity, or out-of-sequence thrust, sawteeth on upper plate, dashed where inferred

 Normal fault, ball-and-stick on down-dropped block, dashed where inferred

 Normal fault and thrust fault coincide, sawteeth on upper plate of thrust fault, ball-and-stick on down-dropped block of normal fault

 Fossil locality, numbers refer to Table 1

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Table 1. Fossil data to accompany geologic map of the Baird Mountains and part of the Selawik quadrangles

MAP NUMBER: 1 FIELD NUMBER: 85 ADn 91E USGS COLLN. NO. 11373-SD
LOCATION: D-6, 67° 58.8', 161° 36.3' UNIT: Dk
FOSSILS: Conodonts: *Apatognathus varians, Mashkovia similis, Ozarkodina* sp. indet., *Polygnathus* sp. indet. of Devonian morphotype
AGE: latest Devonian (latest Famennian)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=3.5-4

MAP NUMBER: 2 FIELD NUMBER: 85 ADn 86B USGS COLLN. NO. 29865-PC
LOCATION: D-6, 67° 57.7', 161° 31.6' UNIT: PD1
FOSSILS: Conodonts: *Adetognathus* sp. indet., *Gnathodus girtyi, Rhachistognathus muricatus*
AGE: extremely narrow interval that straddles the Mississippian-Pennsylvanian boundary (*muricatus* to *noduliferus-primus* Zones)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=4; species association indicates deposition in shallow-water, normal marine, possibly high energy environment.

MAP NUMBER: 2 FIELD NUMBER: 85 ADn 86E USGS COLLN. NO. 11414-SD
LOCATION: D-6, 67° 57.5', 161° 31.5' UNIT: PD1
FOSSILS: Conodonts: *Polygnathus linguiformis linguiformis, Polygnathus parawebbi*
AGE: Middle Devonian (middle Givetian; middle *varcus* through *hermanni-cristatus* Zones)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=3.5-4. Sample 86B is from light gray, finely crystalline, slightly dolomitic limestone with 5 to 10% chert; sample 86E is from brownish gray, very fine grained, evenly bedded dolomicrite located about 1/5 mile south of 86B. The contact between the two rock types is not exposed; it may be a fault.

MAP NUMBER: 3 FIELD NUMBER: 85 SK 227B USGS COLLN. NO. MR 7451
LOCATION: D-6, 67° 58.0', 161° 36.6' UNIT: JPe
FOSSILS: Radiolarians: *Pseudoalbaillella simplex, Pseudoalbaillella* sp. aff. *P. elegans*, ? *Tormentum* sp., ringed form
AGE: Middle Pennsylvanian (Atokan?, Desmoinesian) to Early Permian
IDENTIFIED BY: B. Murchey
REMARKS: Sample is from a large fault block caught up in KJm.

MAP NUMBER: 4 FIELD NUMBER: 86 SK 044B USGS COLLN. NO. DR 447
LOCATION: D-6, 67° 57.0', 161° 39.8' UNIT: JPe
FOSSILS: Radiolarians: entactinids, ?Albaillellids
AGE: Pennsylvanian/Permian
IDENTIFIED BY: C.D. Blome
REMARKS: poorly preserved

MAP NUMBER: 5 FIELD NUMBER: 86 AD 21J USGS COLLN. NO. 11514-SD
LOCATION: D-6, 67° 55.8', 161° 40.8' UNIT: Dk

FOSSILS: Conodonts: *Polygnathus* spp. of Givetian-Frasnian morphotype
AGE: late Middle-early Late Devonian (Givetian-Frasnian)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=3.5-4; conodonts indicate platformal/shelfal environment.

MAP NUMBER: 6 FIELD NUMBER: 86 MZ 023C USGS COLLN. NO. DR 443
LOCATION: D-6, 67° 55.3', 161° 38.7' UNIT: JPe
FOSSILS: Radiolarians: ?*Pantanellium* sp., ?*Pseudoheliodiscus* sp.
AGE: Mesozoic (?Lower Jurassic)
IDENTIFIED BY: C.D. Blome
REMARKS: Individuals very fragmentary, very poorly preserved.

MAP NUMBER: 7 FIELD NUMBER: 84 SK 70A
LOCATION: D-6, 67° 54.1', 161° 51.2' UNIT: JPe
FOSSILS: Radiolarians: ? *Canoptum* sp., *Droltus* (?) *hecatensis, Livarella densiporata, Pseudoheliodiscus* sp., *Veghicyclia* sp.
AGE: Early Jurassic (Hettangian)
IDENTIFIED BY: C.D. Blome

MAP NUMBER: 8 FIELD NUMBER: 84 SK 68A
LOCATION: D-6, 67° 53.3, 161° 51.9' UNIT: JPe
FOSSILS: Radiolarians: *Eptingium* (?)*acythus, Pseudostylosphaera helicatum, Pseudostylosphaera japonica, Poulpus* sp., *Staurodoras*(?) *cochleata, Triassocampe* sp.
AGE: Late Triassic (early to middle Karnian)
IDENTIFIED BY: C.D. Blome
REMARKS: Sample is from a fault block caught up in KJm.

MAP NUMBER: 9 FIELD NUMBER: 66 Tr 103
LOCATION: D-6, 67° 43.5', 161° 57.4' UNIT: Dl
FOSSILS: *Cladopora* sp., *Macgeea* sp., Tabulophyllum sp, Brachiopods: *Atrypa* sp., *Eleutherekomma*? sp., *Spinatrypa* sp.
AGE: early Late Devonian (Frasnian)
IDENTIFIED BY: W.A. Oliver (corals); J.T. Dutro, Jr. (brachiopods)
REMARKS: Sample is from a fault block in KJm.

MAP NUMBER: 10 FIELD NUMBER: 85 ADn 79Z USGS COLLN. NO. 11371-SD
LOCATION: D-6, 67° 48.2', 161° 53.2' UNIT: Dk
FOSSILS: Conodonts: *Polygnathus* aff. P. *denisbricaeae, Polygnathus linguiformis linguiformis*
AGE: latest Middle-earliest Late Devonian (Givetian-Frasnian, Upper *dengleri* - Lower *asymmetricus* Zones)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=3.5

MAP NUMBER: 10 FIELD NUMBER: 81 EK 269 USGS COLLN. NO. 10511-SD
LOCATION: D-6, 67° 48.2', 161° 53.2' UNIT: Dk
FOSSILS: *Panderodus* sp., *Polygnathus* sp. inlet. of latest Early through Middle Devonian morphotype
AGE: latest Early through Middle Devonian (Emsian to Givetian)
IDENTIFIED BY: A.G. Harris and K. Denkler

REMARKS: CAI 2.5 to 3

MAP NUMBER: 10 FIELD NUMBER: 81 EK 269A
LOCATION: D-6, 67° 48.2', 161° 53.2' UNIT: Dk
FOSSILS: Endothyrid foraminifers: *Ortonella* sp., and *Parqthurammina* sp.
AGE: early Late Devonian (Frasnian)
IDENTIFIED BY: B. Mamet
REMARKS: reef and lagoon facies. There is an apparent disagreement between conodont and foraminifer ages at this locality. This may be due to reworking of the conodonts or to age uncertainties.

MAP NUMBER: 10 FIELD NUMBER: 81 Tr 118A
LOCATION: D-6, 67° 48.2', 161° 53.0' UNIT: Dk
FOSSILS: Endothyrid foraminifers: *Archaesphaera* sp., *Bisphaera* sp., *Parathurammina* sp., *Tharama*? sp.; algea: Renalcid?
AGE: early Late Devonian (Frasnian)
IDENTIFIED BY: B. Mamet
REMARKS: reef and lagoon facies. There is an apparent disagreement between conodont and foraminifer ages at this locality. This may be due to reworking of the conodonts or to age uncertainties.

MAP NUMBER: 11 FIELD NUMBER: 86 SK 8A USGS COLLN. NO. DR 438
LOCATION: C-6, 67° 43.7', 161° 59.5' UNIT: JPe
FOSSILS: Radiolarians: *Capnodoce* sp., *Capnuchosphaera deweveri, Capnuchosphaera puncta, Capnucosphaera smithorium, Latium paucum;* conodont fragment
AGE: Late Triassic (lower *betraccium* Zone, late middle Norian)
IDENTIFIED BY: C.D. Blome
REMARKS: Fauna is equivalent to fauna from the upper part of the chert member of the Otuk Formation of the Etivluk Group (JPe). Sample is from a fault block in KJm.

MAP NUMBER: 12 FIELD NUMBER: 84 EK 8 USGS COLLN. NO. 29635-PC
LOCATION: D-6, 67° 49.7, 161° 36.6' UNIT: Mk
FOSSILS: Conodonts: *Polygnathus* cf. P. *longiposticus, Polygnathus* sp. indet.
AGE: Early Mississippian, probably Kinderhookian
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5; conodonts are hydraulically broken.

MAP NUMBER: 13 FIELD NUMBER: 86 AD 14A USGS COLLN. NO. 29972-PC
LOCATION: D-6, 67° 49.3', 161° 47.6 UNIT: Mko
FOSSILS: Conodonts: *Cavusgnathus* sp., *Kladognathus* sp. indet.
AGE: Late Mississippian (late Meramecian-Chesterian)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5.5-6; all specimens have healed fractures. Species association indicates deposition in a shallow-water, normal marine environment.

MAP NUMBER: 13 FIELD NUMBER: 86 AD 14B USGS COLLN. NO. 29973-PC
LOCATION: D-6, 67° 49.4', 161° 48.0' UNIT: Mko
FOSSILS: Conodont: *Hindeodus scitulus*
AGE: late Early-Late Mississippian (late Osagean-earlist Chesterian)

IDENTIFIED BY: A.G. Harris and R.T. Lierman
REMARKS: CAI=4-4.5,; this is a very shallow-water species. Sample 14B was taken about 0.4 km NW of sample 14A and is probably stratigraphically higher.

MAP NUMBER: 14 FIELD NUMBER: 85 ADn 78B USGS COLLN. NO. 11302-SD
LOCATION: D-6, 67° 48.6, 161° 49.3' UNIT: MDue
FOSSILS: Conodonts: *Apatognathus varians, Icriodus* sp., *Polygnathus communis*
AGE: late Late Devonian (middle to late Famennian)
IDENTIFIED BY: A.G. Harris and K.S. Schindler
REMARKS: CAI=4; species association indicates a shallow-water depositional environment.

MAP NUMBER: 15 FIELD NUMBER: 85 ADn 71L USGS COLLN. NO. 11370-SD
LOCATION: D-6, 67° 47.3', 161° 51.0' UNIT: MDue
FOSSILS: Conodonts: *Icriodus* sp. of Middle-Late Devonian morphotype, *Polygnathus* cf. P. *pacificus*
AGE: Late Devonian (probably Frasnian)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5; species association indicates deposition in a shelfal, high-energy, probably shallow- (not shallowest) water environment.

MAP NUMBER: 15 FIELD NUMBER: 84 ADn 69A USGS COLLN. NO. 11137-SD
LOCATION: D-6, 67° 47.3', 161° 51.0' UNIT: MDue
FOSSILS: Conodonts: *Icriodus* sp. indet. of Middle-Late Devonian morphotype, *Polygnathus* cf. *P. pseudofoliatus, Polygnathus xylus xylus, Polygnathus* spp. indet.
AGE: late Middle Devonian (Givetian, probably lower-middle *varcus* subzones)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=4.5-5; conodonts appear to be broken due to hydraulic activity. Sample taken from fine-grained, red-weathering shaley limestone that stratigraphically underlies sample 85 ADn 71L.

MAP NUMBER: 16 FIELD NUMBER: 85 ADn 71G USGS COLLN. NO. 11369-SD
LOCATION: D-6, 67° 47.3', 161° 50.7' UNIT: DOb
FOSSILS: Conodonts: *Neopanderodus* sp., *Polygnathus linguiformis linguiformis*
AGE: Middle Devonian
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5.5

MAP NUMBER: 17 FIELD NUMBER: 84 ADn 65A USGS COLLN. NO. 29381-PC
LOCATION: D-6, 67° 46.8', 161 53.0' UNIT: Mko
FOSSILS: Conodonts: *Mestognathus beckmanni, Ozarkodina* sp. indet.
AGE: late Early-earliest Late Mississippian (late Osagean-early Meramecian)
IDENTIFIED BY: A.G. Harris and W. Thompson
REMARKS: CAI=4.5; species association indicates a shallow-water depositional environment.

MAP NUMBER: 17 FIELD NUMBER: 84 ADn 65D USGS COLLN. NO. 29411-PC
LOCATION: D-6, 67° 46.8', 161° 53.0' UNIT: Mko
FOSSILS: Conodonts: *Eotaphrus burlingtonensis, Ozarkodina* sp. indet.

AGE: latest Early Mississippian (late Osagean; *anchoralis-latus* to lower *texanus* Zone)
IDENTIFIED BY: A.G. Harris, and J.A. Dumoulin
REMARKS:CAI=4.5; species association indicates a relatively shallow-water depositional environment. Sample 65D is about 160 m stratigraphically below sample 65A and represents basal Mko at this locality.

MAP NUMBER: 18 FIELD NUMBER: 84 ADn 66A USGS COLLN. NO. 29383-PC
LOCATION: D-6, 67° 46.7', 161° 52.5' UNIT: MDue
FOSSILS: Conodonts: *Gnathodus typicus, Ozarkodina* sp., *Polygnathus communis communis, Pseudopolygnathus multistriatus, Pseudopolygnathus nudus, Pseudopolygnathus* sp. indet.
AGE: middle late Early Mississippian (middle Osagean)
IDENTIFIED BY: A.G. Harris and W. Thompson
REMARKS: CAI=4.5; sample taken from top of MDue at this locality.

MAP NUMBER: 18 FIELD NUMBER: 84 ADn 66H USGS COLLN. NO. 29382-PC
LOCATION: D-6, 67° 46.7', 161° 52.5' UNIT: MDue
FOSSILS: Conodonts: *Bispathodus* sp. indet., *Polygnathus communis communis, Polygnathus* cf. *P. longiposticus, Polygnathus* cf. *P. symmetricus, Ozarkodina* sp. indet.
AGE: Early Mississippian (probably Kinderhookian)
IDENTIFIED BY: A.G. Harris and W. Thompson
REMARKS: CAI=4.5; sample taken about 100 m stratigraphically below 66A.

MAP NUMBER: 19 FIELD NUMBER: 85 SK 192B USGS COLLN. NO. 29777-PC
LOCATION: D6, 67° 45.5', 161° 44.1' UNIT: Mlt
FOSSILS: Conodonts: *Polygnathus* spp. indet., *Polygnathus* cf. *P. bischoffi, Siphonodella* sp. indet.
AGE: early Early Mississippian (Kinderhookian, probably early to middle Kinderhookian)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5; species association indicates a probable shallow-water depositional environment.

MAP NUMBER: 20 FIELD NUMBER: 86 AD 38A USGS COLLN. NO. 11502-SD
LOCATION: C-6, 67° 44.5', 161° 54.3' UNIT: DOb
FOSSILS: Conodont: *Polygnathus* sp. indet. of Givetian-Frasnian morphotype
AGE: late Middle-early Late Devonian (Givetian-Frasnian)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=4; conodont indicates a shelf or platformal, high-energy or partly turbid-water environment.

MAP NUMBER: 21 FIELD NUMBER: 81 EK 259
LOCATION: C-6, 67° 41.8', 161° 38.7' UNIT: Mk
FOSSILS: Conodont: "*Spathognathodus*" *crassidentatus*; foraminifers: *Mametella skimoensis, Balandia* sp.
AGE: Mississippian - at least Osagean or younger
IDENTIFIED BY: A.G. Harris and K.E. Denkler (conodont); B.L. Mamet (foraminifers)
REMARKS: CAI=5

MAP NUMBER: 22 FIELD NUMBER: 85 SK 247C
LOCATION: C-6, 67° 41.5', 161° 56.5' UNIT: Ds
FOSSILS: Brachiopod: probably atrypid
AGE: probably Middle-early Late Devonian
IDENTIFIED BY: J.T. Dutro, Jr.

MAP NUMBER: 23 FIELD NUMBER: 86 MZ 53A USGS COLLN. NO. 11518-SD
LOCATION: C-6, 67° 34.3', 161° 58.5' UNIT: DOb
FOSSILS: Conodonts: *Kockelella amsdeni, Kockelella* cf. *K. walliseri*, N. gen., n. sp.
AGE: Middle Silurian (late early Wenlockian; lower *amsdeni* Zone)
IDENTIFIED BY: A.G. Harris and K.E. Denkler
REMARKS: CAI=5.5; species association indicates a normal marine, mid- to outer platform depositional environment.

MAP NUMBER: 24 FIELD NUMBER: 66 ABe 242 USGS COLLN. NO. 8169-SD
LOCATION: D-5, 67° 52', 161° 10' UNIT: Dn
FOSSILS: Brachiopod: *Cyrtospirifer* sp.
AGE: Late Devonian (late Frasnian or early Famennian)
IDENTIFIED BY: J.T. Dutro, Jr.

MAP NUMBER: 25 FIELD NUMBER: 84 JS 22 USGS COLLN. NO. 11132-SD
LOCATION: D-5, 67° 51.6', 161° 15.0' UNIT: MDl
FOSSILS: Conodonts: *Apatognathus* sp., "*Ozarkodina*" sp. (long-bladed morphotype), *Polygnathus communis*
AGE: late Late Devonian (late Famennian)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI-5; conformably overlies Noatak Sandstone (Dn).

MAP NUMBER: 26 FIELD NUMBER: 84 EK 177 USGS COLLN. NO. 10998-SD
LOCATION: D-4, 67° 49.3', 160° 56.0' UNIT: Dn
FOSSILS: Brachiopod: *Cyrtospirifer* sp.
AGE: Late Devonian (late Frasnian or early Famennian)
IDENTIFIED BY: J.T. Dutro, Jr.

MAP NUMBER: 27 FIELD NUMBER: 83 SK 148A USGS COLLN. NO. 10882-SD
LOCATION: D-4, 67° 46.6', 160° 49.3' UNIT: Dnu
FOSSILS: Conodonts: *Ancyrodella* sp., *Belodella devonica, Icriodus symmetricus, Palmatolepis* sp., *Polygnathus* spp.
AGE: early Late Devonian (Frasnian)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5

MAP NUMBER: 28 FIELD NUMBER: 8-4-83D1 USGS COLLN. NO. 10846-SD
LOCATION: D-4, 67° 46', 160° 41' UNIT: Dnl
FOSSILS: Conodonts: *Icriodus symmetricus, Polygnathus* cf. *P. dubius, Polygnathus* cf. *P. latifossatus, Polygnathus varcus*
AGE: latest Middle Devonian (late Givetian; upper *varcus* through upper *hermanni-cristatus* subzones)
IDENTIFIED BY: A.G. Harris

REMARKS: CAI=5

MAP NUMBER: 29 FIELD NUMBER: 81 EK 220E
LOCATION: D-5, 67° 52.1', 161° 36.0' UNIT: PMc
FOSSILS: Conodont: "*Spathognathodus*" cf. "*S.*" *macer* s.f.
AGE: late Famennian through Mississippian
IDENTIFIED BY: A.G. Harris and Kirk Denkler
REMARKS: CAI=5

MAP NUMBER: 30 FIELD NUMBER: 66 ATr 99.2 USGS COLLN. NO. 8172-SD
LOCATION: C-5, 67° 44.5', 161° 22.3' UNIT: Dhf
FOSSILS: Brachiopods: *Cyrtospirifer* sp., rhynchonelloid, indet.; mollusk: bellerophontacean?, indet.
AGE: Late Devonian (late Frasnian or early Famennian)
IDENTIFIED BY: J.T. Dutro, Jr.

MAP NUMBER: 31 FIELD NUMBER: 84 EK 183A USGS COLLN. NO. 11146-SD
LOCATION: C-5, 67° 39.3', 161° 18.2' UNIT: Dnu
FOSSILS: Conodont: *Pandorinellina* cf. *P. insita*
AGE: Late Devonian
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=6-7; sample taken from a 2-cm-thick layer of flaser-bedded, shaley, encrinitic limestone intercalated in a section of maroon sandstone and light-green phyllite.

MAP NUMBER: 31 FIELD NUMBER: 84 EK 183B USGS COLLN. NO. 11141-SD
LOCATION: C-5, 67° 39.2', 161° 18.3' UNIT:Dnu
FOSSILS: Conodonts: *Icriodus* sp. indet., *Polygnathus* cf. *P. xylus xylus*, robust coarsely noded Devonian *Polygnathus* sp.
AGE: late Middle to earliest late Devonian
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5-5.5; sample taken from a 7-cm-thick bed of sparry limestone intercalated in a section of maroon sandstone and light-green phyllite; 183B taken about 50 m structurally below 183A.

MAP NUMBER: 32 FIELD NUMBER: 84 EK 182 USGS COLLN. NO. 11140-SD
LOCATION: C-5, 67° 39.4', 161° 17.9' UNIT: DOb
FOSSILS: Conodonts: *Polygnathus costatus costatus, Polygnathus linguiformis linguiformis*
AGE: early early Middle Devonian (early Eifelian; *P. costatus costatus* Zone through *Tortodus australis* Zone)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5

MAP NUMBER: 33 FIELD NUMBER: 84 EK 132A USGS COLLN. NO. 11144-SD
LOCATION: C-5, 67° 38.1', 161° 5.5' UNIT: Dnl
FOSSILS: Conodonts: *Neopanderodus* sp., *Polygnathus parawebbi*
AGE: middle Middle Devonian (middle Eifelian-early Givetian; australis Zone through lower *varcus* subzone)
IDENTIFIED BY: A.G. Harris

REMARKS: CAI=5-5.5; sample consists of very dark gray, coarse-grained recrystallized bioclastic limestone.

MAP NUMBER: 33 FIELD NUMBER: 84 EK 132B USGS COLLN. NO. 11145-SD
LOCATION: C-5, 67° 38.1, 161° 5.5' UNIT: Dnl
FOSSILS: Conodonts: *Polygnathus linguiformis linguiformis, Polygnathus pseudofoliatus;* mollusks: phosphatized steinkerns of indet. tentaculitids and gastropods
AGE: Middle Devonian (early-middle Givetian; *varcus* Zone--possibly middle *varcus* subzone)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5-5.5; sample 132B consists of dark-gray, brown-weathering, coarse-grained, recrystallized limestone and was taken 15-20 m stratigraphically above sample 132A.

MAP NUMBER: 34 FIELD NUMBER: 8-11-84A USGS COLLN. NO. 10506-CO
LOCATION: C-4, 67° 37.7', 160° 52.2' UNIT: DOb
FOSSILS: Conodonts: *Drepanodus arcuatus, Drepanoistodus sp., Oistodus lecheguillensis;* indet. phosphatic brachiopod
AGE: Early Ordovician (Fauna D)
IDENTIFIED BY: A.G. Harris and J.E. Repetski
REMARKS: CAI=5-5.5; species association indicates a normal marine, platformal depositional environment. All samples prefixed 8-10-84 or 8-11-84 and listed here as map number 34 are from measured section D of Dumoulin and Harris (1987); 8-11-84A was taken at the base of the section.

MAP NUMBER: 34 FIELD NUMBER: 8-10-84I USGS COLLN. NO. 10296-CO
LOCATION: C-4, 67° 37.7', 160° 52.2' UNIT: DOb
FOSSILS: Conodonts: *Paroistodus parallelus, Proconodontus* cf. *P. muelleri* (redeposited Late Cambrian conodont), *Protopanderodus*? sp., *Scolopodus* cf. *S. cornuformis, Scolopodus* sp.
AGE: Early Ordovician; middle Arenigian (low Fauna D if sample is in stratigraphic continuity with overlying samples) with redeposited Late Cambrian conodonts
IDENTIFIED BY: A.G. Harris and J.E. Repetski
REMARKS: CAI=5-5.5; species association indicates a normal marine, relatively cool water depositional environment. Sample taken 213 m above base of measured section D of Dumoulin and Harris (1987).

MAP NUMBER: 34 FIELD NUMBER: 8-11-84C USGS COLLN. NO. 10512-CO
LOCATION: C-4, 67° 37.7'. 160° 52.2' UNIT: DOb
FOSSILS: Conodonts: *Drepanodus arcuatus, Fryxellodontus*? n. sp., *Paroistodus* cf. *P. proteus, Protopanderodus*? n. sp. 2, *Scolopodus gracilis, Scolopodus rex,* N. gen. n. sp.
AGE: Early Ordovician (low Fauna D; near the Tremadocian/Arenigian boundary)
IDENTIFIED BY: A.G. Harris and J.E. Repetski
REMARKS: CAI=5-5.5; species association indicates a normal marine, slightly cool water depositional environment. Sample taken 596 m above base of measured section D of Dumoulin and Harris (1987).

MAP NUMBER: 34 FIELD NUMBER: 8-11-84E USGS COLLN. NO. 10297-CO

LOCATION: C-4, 67° 37.7', 160° 52.2' UNIT: DOb
FOSSILS: Conodonts: *Drepanodus arcuatus, Drepanoistodus* sp., *Paroistodus* cf. *P. proteus, Rossodus*? n. sp. 1, *Scolopodus gracilis*
AGE: Early Ordovician (low Fauna D)
IDENTIFIED BY: A.G. Harris and J.E. Repetski
REMARKS: CAI=5-5.5; species association indicates a normal marine, platformal depositional environment. Sample taken 806 m above base of measured section D of Dumoulin and Harris (1987).

MAP NUMBER: 35 FIELD NUMBER: 84 SK 210 USGS COLLN. NO. 9935-CO
LOCATION: C-5, 67° 32.1', 161° 23.25' UNIT: DOb
FOSSILS: Conodonts: *Acanthodus lineatus, Cordylodus angulatus, Paltodus spurius, Rossodus manitouensis*
AGE: early Early Ordovician (Fauna C)
IDENTIFIED BY: A.G. Harris and J.E. Repetski
REMARKS: CAI=5.5-6

MAP NUMBER: 36 FIELD NUMBER: 8-8-84A USGS COLLN. NO. 11539-SD
LOCATION: C-5, 67° 30.6', 161° 20.8' UNIT: DOb
FOSSILS: Conodonts: *Distomodus*? sp. indet., *Pelekysgnathus*? sp. indet.
AGE: probably Silurian; possibly Middle-Late Silurian (Wenlockian-Ludlovian)
IDENTIFIED BY: A.G. Harris and K.E. Denkler
REMARKS: CAI=5.5-6; species association indicates a warm, shallow-water depositional environment. All samples prefixed 8-8-84 and listed here as map number 36 are from a section measured by J.A. Dumoulin and A.G. Harris; 8-8-84A was taken 95 m above the base of the section.

MAP NUMBER: 36 FIELD NUMBER: 8-8-84B USGS COLLN. NO. 11289-SD
LOCATION: C-5, 67° 30.6', 161° 20.8' UNIT: DOb
FOSSILS: Conodonts: *Ozarkodina* n. sp. aff. *C. confluens, Panderodus* sp.
AGE: Middle-early Late Silurian (Wenlockian-Ludlovian; possibly Ludlovian)
IDENTIFIED BY: A.G. Harris and K.E. Denkler
REMARKS: CAI=5.5; species association indicates a warm, relatively shallow-water depositional environment. Sample from float probably derived 333-340 m above base of a section measured by J.A. Dumoulin and A.G. Harris.

MAP NUMBER: 37 FIELD NUMBER: 8-5-84C USGS COLLN. NO. 11094-SD
LOCATION: C-5, 67° 30.2', 161° 21.5' UNIT: DOb
FOSSILS: Conodonts: *Icriodus taimyricus, Pandorinellina exigua philipi, Pandorinellina*? sp., *Panderodus* sp., *Neopanderodus* sp.
AGE: earliest late Early Devonian (earliest Emsian; *dehiscens* Zone)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5; species association indicates a high-energy, shallow, warm-water depositional environment. Sample taken 9 m above base of measured section E of Dumoulin and Harris (1987).

MAP NUMBER: 38 FIELD NUMBER: 8-4-84B USGS COLLN. NO. 10299-CO
LOCATION: B-5, 67° 28.1', 161° 21.8' UNIT: DOb
FOSSILS: Conodonts: *Clavohamulus* n. sp., *Drepanodus arcuatus, Drepanoistodus* sp., *Eucharodus* sp., *Fryxellodontus* n. sp., *Macerodus* n. sp., *Paroistodus proteus, "Scolopodus" bolites, Scolopodus* aff. *S. floweri, Scolopodus*

gracilis, Scolopodus rex, Scolopodus? n. sp. A, *Scolopodus* n. sp. B, *Ulrichodina* sp.
AGE: Early Ordovician (low Fauna D)
IDENTIFIED BY: A.G. Harris and J.E. Repetski
REMARKS: CAI=5-5.5; species association indicates a warm, shallow- (but not shallowest) water, normal marine depositional environment. All samples prefixed 8-4-84 and listed here as map number 38 are from measured section C of Dumoulin and Harris (1987); 8-4-84B was taken 42 m above the base of the section.

MAP NUMBER: 38 FIELD NUMBER: 8-4-84F2 USGS COLLN. NO. 10301-CO
LOCATION: B-5, 67° 28.1', 161° 21.8' UNIT: DOb
FOSSILS: Conodonts: *Drepanodus* cf. *D. concavus, Eucharodus parallelus, Glyptoconus quadraplicatus, Oneotodus* aff. *O. costatus, Oneotodus simplex*
AGE: Early Ordovician (high Fauna D-Fauna E)
IDENTIFIED BY: A.G. Harris and J.E. Repetski
REMARKS: CAI=5-5.5; species association indicates a warm, shallow-water depositional environment. Sample taken 191 m above base of measured section C of Dumoulin and Harris (1987).

MAP NUMBER: 38 FIELD NUMBER: 8-4-84J USGS COLLN. NO. 10302-CO
LOCATION: B-5, 67° 28.1', 161° 21.8' UNIT: DOb
FOSSILS: Conodonts: *Chosonodina* sp., *Drepanodus* cf. *D. arcuatus, Drepanoistodus* cf. *D. basiovalis, Eucharodus parallelus, Eucharodus* cf. *E. toomeyi, Glyptoconus quadraplicatus, Scandodus* sp., ?*Tropodus comptus*
AGE: Early Ordovician (high Fauna D-Fauna E)
IDENTIFIED BY: A.G. Harris and J.E. Repetski
REMARKS: CAI=5-5.5; species association indicates a warm, shallow-water depositional environment. Sample taken 279 m above base of measured section C of Dumoulin and Harris (1987).

MAP NUMBER: 38 FIELD NUMBER: 8-4-84L USGS COLLN. NO. 10304-CO
LOCATION: B-5, 67° 28.1', 161° 21.8' UNIT: DOb
FOSSILS: Conodonts: *Chosonodina* sp., *Diaphorodus delicatus, Drepanoistodus* sp., *Eucharodus* sp., *Glyptoconus quadraplicatus, Scandodus gracilis*
AGE: Early Ordovician (highest Fauna D-Fauna E)
IDENTIFIED BY: A.G. Harris and J.E. Repetski
REMARKS: CAI=5-5.5; species association indicates a warm, shallow-water depositional environment. Sample taken 310 m above base of measured section C of Dumoulin and Harris (1987).

MAP NUMBER: 38 FIELD NUMBER: 8-4-84N USGS COLLN. NO. 10305-CO
LOCATION: B-5, 67° 28.1', 161° 21.8' UNIT: DOb
FOSSILS: Conodonts: *Jumudontus gananda, Oistodus multicorrugatus, Oistodus* sp. indet.
AGE: very earliest Middle Ordovician (Fauna 1.5-lower Fauna 2)
IDENTIFIED BY: A.G. Harris and J.E. Repetski
REMARKS: CAI=5-5.5; species association indicates a normal marine, platformal depositional environment. Sample taken 381 m above base of measured section C of Dumoulin and Harris (1987).

MAP NUMBER: 39 FIELD NUMBER: OM 146 USGS COLLN. NO. 10260-CO
LOCATION: C-4, 67° 30.8', 160° 53.8 UNIT: DOb
FOSSILS: Conodonts: *Acanthocordylodus*? sp. indet., *Phragmodus*? aff. *P. flexuosus, Stereoconus corrugatus*
AGE: Middle Ordovician (post-Whiterockian; possibly high Fauna 6)
IDENTIFIED BY: A.G. Harris and J.E. Repetski
REMARKS: CAI=5.5 and 7-8; species association indicates a restricted, warm, shallow-water, innermost platform depositional environment.

MAP NUMBER: 40 FIELD NUMBER: 84 ADn 132C USGS COLLN. NO. 9914-CO
LOCATION: B-4, 67° 27.5', 160° 50.5' UNIT: DOb
FOSSILS: Conodonts: *Amorphognathus* sp. indet., *Belodina* sp., *Dapsilodus similaris, Drepanoistodus suberectus, "Oistodus" venustus, Panderodus* sp., *Protopanderodus insculptus*
AGE: late Late Ordovician (middle Maysvillian-Gamachian)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5.5; species association indicates deposition in water of moderate temperature and depth.

MAP NUMBER: 41 FIELD NUMBER: 86 AD 71E USGS COLLN. NO. 10479-CO
LOCATION: B-4, 67° 27.3', 160° 45.0' UNIT: DOb
FOSSILS: Conodonts: *Acodus* sp., *Drepanodus arcuatus, Drepanoistodus forceps, Paracordylodus gracilis, Paroistodus proteus, Prioniodus elegans, Walliserodus* sp.
AGE: Early Ordovician (early Arenigian; *Prioniodus elegans* Zone)
IDENTIFIED BY: A.G. Harris and J.E. Repetski
REMARKS: CAI=5-5.5; species association indicates a very cool-water and (or) basinal depositional environment.

MAP NUMBER: 42 FIELD NUMBER: 85 SK 39A USGS COLLN. NO. 10384-CO
LOCATION: B-4, 67° 24.2', 160° 56.4' UNIT: DOb
FOSSILS: Conodonts: *Belodina* sp. indet., *Panderodus* sp., *Periodon aculeatus, Protopanderodus varicostatus, Scandodus brevibasis*
AGE: early-middle Middle Ordovician (late Arenigian-Llandeilian)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5-5.5; species association consists predominantly of cool-water forms with a few warm-water elements.

MAP NUMBER: 43 FIELD NUMBER: 83 Ek 102A USGS COLLN. NO. 10880-SD
LOCATION: A-4, 67° 2.5', 160° 56.7' UNIT: Pzkm
FOSSILS: Echinoderm: silicified crinoid ossicle with two axial canals
AGE: latest Early-early Middle Devonian (late Emsian-Eifelian)
IDENTIFIED BY: A.G. Harris and W. Thompson

MAP NUMBER: 44 FIELD NUMBER: 84 EK 101 USGS COLLN. NO. 9971-CO
LOCATION: C-3, 67° 33.0, 160° 16.8' UNIT: DOtq
FOSSILS: Conodonts: *Periodon aculeatus, Protopanderodus* sp., *Pygodus serra*
AGE: early Middle Ordovician (late Llanvirnian-early Llandeilan; *Pygodus serra* Zone)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5; species association indicates a normal marine, cool-water

depositional environment.

MAP NUMBER: 45 FIELD NUMBER: 83 SK 281A USGS COLLN. NO. 29223-PC
LOCATION: C-3, 67° 30.25', 160° 17.7' UNIT: Pzkm
FOSSILS: Conodonts: *Siphonodella* sp. indet., *Protognathodus* cf. *P. meischneri, Protognathodus* n. sp.
AGE: Earliest Mississippian (very early Kinderhookian; probably *Siphonodella sulcata* Zone)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5

MAP NUMBER: 46 FIELD NUMBER: 85 ADn 151B USGS COLLN. NO. 11398-SD
LOCATION: B-3, 67° 27.8', 161° 19.2' UNIT: Pzkm
FOSSILS: Conodonts: *Ozarkodina* sp. indet. of Late Silurian-Early Devonian morphotype, *Pelekysgnathus* sp.; indet. brachiopod and trilobite fragments
AGE: Late Silurian-Early Devonian
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5.5-6

MAP NUMBER: 47 FIELD NUMBER: 83 EK 26G
LOCATION: B-3, 67° 26.25', 160° 10.5' UNIT: PzEku
FOSSILS: Conodont: Pa element fragment of Silurian-Mississippian morphotype
AGE: Silurian-Mississippian
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5.5

MAP NUMBER: 48 FIELD NUMBER: 83 EK 29i
LOCATION: B-3, 67° 16.1', 160° 29.8' UNIT: DOtu
FOSSILS: Conodont: *Panderodus* sp.
AGE: Middle Ordovician-Middle Devonian
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5-5.5

MAP NUMBER: 49 FIELD NUMBER: 84 ADn 143X USGS COLLN. NO. 10516-CO
LOCATION: D-1, 67° 53.5', 159° 6.3' UNIT:O€c
FOSSILS: Conodonts: *Belodina* sp., *Panderodus* sp., *Periodon* n. sp. aff. *P. aculeatus, Plectodina*(?) n. sp., *Pseudobelodina* sp. indet.
AGE: middle Middle-early Late Ordovician; possibly late Middle Ordovician (late Blackriveran-Shermanian)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5.5; species association indicates a normal marine depositional environment. All samples prefixed 85 ADn 143 and listed here as map number 49 are from a section measured by J.A. Dumoulin; 85 ADn 143X was taken at the base of the section.

MAP NUMBER: 49 FIELD NUMBER: 85 ADn 143Y USGS COLLN. NO. 10517-CO
LOCATION: D-1, 67° 53.5', 159° 6.3' UNIT: O€c
FOSSILS: Conodonts: *Belodina* sp., *Panderodus* sp., *Periodon* n. sp. aff. *P. aculeatus, Plectodina* n. sp., *Protopanderodus* sp. indet.
AGE: middle Middle-early Late Ordovician (possibly late Middle Ordovician)
IDENTIFIED BY: A.G. Harris

REMARKS: CAI=5.5; species association indicates a normal marine depositional environment. Sample taken 15 m above base of section measured by J.A. Dumoulin.

MAP NUMBER: 49 FIELD NUMBER: 85 ADn 143Z USGS COLLN. NO. 10518-CO
LOCATION: D-1, 67° 53.5', 159° 6.3' UNIT: O€c
FOSSILS: Conodonts: *Belodina compressa, Dapsilodus similaris, Periodon* n. sp. aff. *P. aculeatus, Protopanderodus* sp., *Pseudobelodina dispansa*
AGE: middle Middle-early Late Ordovician (possibly late Middle Ordovician)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5.5; species association indicates a normal marine, cool-water depositional environment. Sample taken 25 m above base of section measured by J.A. Dumoulin.

MAP NUMBER: 50 FIELD NUMBER: 8-6-83A USGS COLLN. NO. 10835-SD
LOCATION: D-1, 67° 47.1', 159°, 21.8' UNIT: DOc
FOSSILS: Conodonts: *Ozarkodina confluens, Panderodus unicostatus*
AGE: Middle-Late Silurian (Wenlockian-middle Pridolian)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5; species association indicates a shallow water depositional environment.

MAP NUMBER: 51 FIELD NUMBER: 85 ADn 141A USGS COLLN. NO. 11379-SD
LOCATION: D-1, 67° 47.3', 159 28.1' UNIT: DOc
FOSSILS: Conodonts: *Ozarkodina confluens, Ozarkodina remscheidensis, Ozarkodina* sp. indet., *Panderodus* sp.
AGE: middle Late Silurian (late Ludlovian-middle Pridolian)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI-5; species association indicates a warm, shallow-water depositional environment.

MAP NUMBER: 52 FIELD NUMBER: 85 ADn 138O USGS COLLN. NO. 10362-CO
LOCATION: C-2, 67° 44.5', 159° 33.0' UNIT: DOc
FOSSILS: Conodonts: *Aphelognathus divergens, Oulodus* sp. indet., *Panderodus* sp.
AGE: late Late Ordovician (Richmondian)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5; species association indicates a warm, very shallow water depositional environment. Sample 138O was taken at the top of an 81 m section measured by J.A. Dumoulin; the section contains an identical conodont fauna throughout its extent.

MAP NUMBER: 53 FIELD NUMBER: 8-6-84A USGS COLLN. NO. 10351-CO
LOCATION: C-2, 67° 41.4', 159° 38.1' UNIT: O€c
FOSSILS: Conodonts: *Belodina* sp., *Periodon aculeatus, Plectodina*? n. sp. aff. "*Spathognathodus*?" *dolboricus, Protopanderodus* cf. *P. varicostatus*
AGE: Middle Ordovician (middle Llandeilan through early Caradocian)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5-5.5; all specimens are broken and deformed. Species association consists chiefly of cool-water forms, with a few representatives of warm-water species that were probably transported basinward hydraulically.

All samples prefixed 8-6-84 or 85 ADn 60 and listed here as map number 53 are from measured section B of Dumoulin and Harris (1987); 8-6-84A was taken 0.7 m above the base of the section.

MAP NUMBER: 53 FIELD NUMBER: 8-6-84D USGS COLLN. NO. 10354-CO
LOCATION: C-2, 67° 41.1', 159° 38.2' UNIT: Oec
FOSSILS: Conodonts: *Belodina* sp., *Dapsilodus*? *similaris, Panderodus* sp., *Protopanderodus* cf. *P. liripipus;* indet. trilobite fragments and phosphatized gastropod steinkerns
AGE: middle Middle-Late Ordovician
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5-5.5; sample taken 40 m above base of section B of Dumoulin and Harris (1987).

MAP NUMBER: 53 FIELD NUMBER: 8-6-84H USGS COLLN. NO. 11355-SD
LOCATION: C-2, 67° 41.4', 159° 38.3' UNIT: DOc
FOSSILS: Conodonts: *Dapsilodus*? sp. indet., *Panderodus* sp., *Ozarkodina confluens*
AGE: Middle-Late Silurian
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=6.5-7; sample taken 180 m above base of section B of Dumoulin and Harris (1987).

MAP NUMBER: 53 FIELD NUMBER: 85 ADn 60F USGS COLLN. NO. 11363-SD
LOCATION: C-2, 67° 41.0', 159° 39.0' UNIT: DOc
FOSSILS: Conodonts: *Ozarkodina remscheidensis remscheidensis, Panderodus* sp. indet.
AGE: late Late Silurian-earliest Devonian (latest Ludlovian-early Lochkovian)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5-5.5; species association indicates a warm, shallow-water depositional environment. Sample taken 50 m below the top of a 95-m-thick, stratigraphically continuous interval that structurally overlies Section B of Dumoulin and Harris (1987). This interval is separated from Section B by a structurally complex zone several 100 m thick; the stratigraphic thickness represented by this zone is uncertain.

MAP NUMBER: 54 FIELD NUMBER: 86 AD 50A USGS COLLN. NO. 10487-CO
LOCATION: C-2, 67° 36.5', 159° 31.5' UNIT: Oec
FOSSILS: Protoconodonts: *Hertzina bisulcata, Phakelodus tenuis;* indet. phosphatic brachiopods; indet. phosphatized hyolithids.
AGE: late Early-early Late (middle Dresbachian) Cambrian
IDENTIFIED BY: A.G. Harris and J.E. Repetski
REMARKS: Thermal maturation is equivalent to at least a CAI of 5. All samples prefixed 86 AD 50 and listed here as map number 54 are from a traverse through the second, third, and fourth subunits of unit Oec. Sample 50A taken from the second subunit of Oec (massive marble to thin-bedded metalimestone and dolostone), about 0.5 m below its contact with the third subunit of Oec.

MAP NUMBER: 54 FIELD NUMBER: 86 AD 50B USGS COLLN. NO. 10488-CO
LOCATION: C-2, 67° 36.45', 159° 31.5' UNIT: Oec

FOSSILS: Conodonts: *Protopanderodus* sp. of Early to early Middle Ordovician morphotype
AGE: Early to early Middle Ordovician
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5; sample taken from the third submit of Oec (calcareous metasiltstone, metalimestone, and phyllitic shale) about 10 m below its contact with the fourth subunit of Oec.

MAP NUMBER: 54 FIELD NUMBER: 86 AD 50E USGS COLLN. NO. 10489-CO
LOCATION: C-2, 67° 36.4', 159° 31.5' UNIT: Oec
FOSSILS: Conodonts: *Belodina* sp., *Panderodus* sp. indet.
AGE: Middle-Late Ordovician
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=6.5-7; sample taken from fourth subunit of Oec (marble with relict bioturbated and bioclastic textures) about 2 m above its contact with the underlying third subunit of Oec.

MAP NUMBER: 55 FIELD NUMBER: 83 ADn 101ZZ USGS COLLN. NO. 10490-CO
LOCATION: C-1, 67° 35.5', 159° 22.2' UNIT: Oec
FOSSILS: Monoplacophoran mollusk: phosophatized steinkerns of *Pelagiella* sp.; Coeloschleritophora: phosphatized *Chancelloria* sp. sclerites
AGE: Early (but not earliest) to Late (but not latest) Cambrian
IDENTIFIED BY: A.G. Harris and J.E. Repetski
REMARKS: All samples prefixed 83 ADn 101, 8-12-83, or 8-3-83 and listed here as map number 55 are from measured section A of Dumoulin and Harris (1987); 83 ADn 101ZZ taken about 7 m above the base of the section, from subunit 2 of Oec.

MAP NUMBER: 55 FIELD NUMBER: 83 ADn 101GG USGS COLLN. NO. 10294-CO
LOCATION: C-1, 67° 35.5', 159° 22.2' UNIT: Oec
FOSSILS: Inarticulate brachiopods: *Linnarssonia* sp.
AGE: Middle Cambrian (probably late Middle Cambrian)
IDENTIFIED BY: A.R. Palmer
REMARKS: Sample taken 24.5 m above the base of section A of Dumoulin and Harris (1987), from subunit 2 of Oec.

MAP NUMBER: 55 FIELD NUMBER: 83 ADn 101FF USGS COLLN. NO. 10295-CO
LOCATION: C-1, 67° 35.4', 159° 22.2' UNIT: Oec
FOSSILS: Inarticulate brachiopods: *Acrothele* sp., *Prototreta* sp., ?paterinid
AGE: Middle Cambrian (probably late Middle Cambrian)
IDENTIFIED BY: A.R. Palmer
REMARKS: Sample taken 30 m above the base of section A of Dumoulin and Harris (1987), from subunit 2 of Oec.

MAP NUMBER: 55 FIELD NUMBER: 8-12-83D USGS COLLN. NO. 9776-CO
LOCATION: C-1, 67° 35.4', 159° 22.2' UNIT: Oec
FOSSILS: Monoplacophoran mollusk: phosphatized steinkerns of *Pelagiella* sp.; Agnostid: *Homagnostus* sp.
AGE: middle Late Cambrian (late Dresbachian-early Franconian)
IDENTIFIED BY: J. Pojeta, Jr. (mollusk); A.R. Palmer (agnostid)

REMARKS: *Pelagiella* sp. indicates a shallow-water depositional environment. Sample taken 59 m above the base of section A of Dumoulin and Harris (1987), from subunit 2 of O€c.

MAP NUMBER: 55 FIELD NUMBER: 8-3-83X USGS COLLN. NO. 9777-CO
LOCATION: C-1, 67° 35.3', 159° 22.2' UNIT: O€c
FOSSILS: Conodonts: *Periodon aculeatus, Protopanderodus* cf. *P. rectus*
AGE: very earliest Middle Ordovician (earliest Llanvirnian)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5; species association indicates a mid-shelf to basinal depositional environment. Sample taken 146 m above the base of section A of Dumoulin and Harris (1987) and 3.5 m below the top of a 10-m-thick graptolite-bearing black phyllite interval; from subunit 3 of O€c. Graptolites in this interval represent about 12 million years of late Early and earliest Middle Ordovician time and have Australasian affinities (Carter and Tailleur, 1984).

MAP NUMBER: 55 FIELD NUMBER: 8-3-83Y USGS COLLN. NO. 9778-CO
LOCATION: C-1, 67° 35.3', 159° 22.2' UNIT: O€c
FOSSILS: Conodonts: *Belodella* sp. indet., *"Cordylodus" horridus, "Oistodus" venustus, Periodon aculeatus, Polonodus* sp. indet., *Protopanderodus giganteus, Protopanderodus rectus, Spinodus spinatus*
AGE: early Middle Ordovician (early Llanvirnian: upper half of *Eoplacognathus? variabilis* Zone)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5; species association indicates a mid-shelf to upper slope depositional environment. Sample taken 149.5 m above the base of section A of Dumoulin and Harris (1987) and at the top of a 10-m-thick graptolite-bearing black phyllite interval; from subunit 3 of O€c.

MAP NUMBER: 56 FIELD NUMBER: 86 AD 75B USGS COLLN. NO. 10485-CO
LOCATION: C-1, 67° 36.1', 159° 11.2' UNIT: O€c
FOSSILS: Conodonts: *Dapsilodus*? sp., *Protopanderodus* sp.
AGE: Middle-Late Ordovician
IDENTIFIED BY: A.G. Harris
REMARKS: CAI= 5-5.5; sample taken 2 m above base of 10-m-thick interval of thin-bedded recrystallized limestone with lesser intercalated phyllite.

MAP NUMBER: 56 FIELD NUMBER: 86 AD 75A USGS COLLN. NO. 10486-CO
LOCATION: C-1, 67° 36.1', 159° 11.2' UNIT: O€c
FOSSILS: Conodonts: *Panderodus* sp., Sb element of Middle-Late Ordovician morphotype
AGE: Middle-Late Ordovician
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5-5.5; sample taken 6 m above 86 AD 75B.

MAP NUMBER: 57 FIELD NUMBER: 87 AD 8C USGS COLLN. NO. 10647-CO
LOCATION: C-1, 67° 37.5', 159° 10.5' UNIT: O€c
FOSSILS: Protoconodont: ?*Gapparodus* cf. G. *bisulcatus*, ?Coeloschleritophora: ?*Chancelloria* sp. scientes
AGE: Cambrian (most likely Middle to early Late Cambrian)
IDENTIFIED BY: A.G. Harris

MAP NUMBER: 57 FIELD NUMBER: 87 AD 8C USGS COLLN. NO. 10647-CO
LOCATION: C-1, 67° 37.5', 159° 10.5' UNIT: Oec
FOSSILS: Inarticulate brachiopods: *Acrothele*? sp.
AGE: Cambrian (probably Middle Cambrian)
IDENTIFIED BY: J.T. Dutro, Jr.
REMARKS: Poorly preserved fragments; thermal maturation probably equivalent to a CAI of at least 5.

MAP NUMBER: 58 FIELD NUMBER: 87 AD 33B USGS COLLN. NO. 10594-CO
LOCATION: C-1, 67° 40.8', 159° 18.0' UNIT: Oec
FOSSILS: Conodonts: *Amorphognathus*? sp. indet., *Dapsilodus*? *similaris, Drepanoistodus* sp., *Periodon aculeatus, Panderodus* sp., *Protopanderodus varicostatus, Spinodus ramosus;* acrotretid brachiopods
AGE: Middle Ordovician (late Llanvirnian - early Caradocian; *Pygodus serra* zone to within *Baltoniodus gerdae* subzone)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5; conodont fauna dominantly cosmopolitan and indicates a normal marine, cool-water depositional environment.

MAP NUMBER: 58 FIELD NUMBER: 87 AD 33C USGS COLLN. NO. 10595-CO
LOCATION: C-1, 67° 40.8', 159° 18.0' UNIT: Oec
FOSSILS: Conodonts: *Amorphognathus* sp. indet., *Ansella* sp., *Belodina sp. Dapsilodus*? *similaris, Drepanoistodus* sp., "*Oistodus*" *venustus, Dapsilodus*? *Panderodus,* sp., *Periodon aculeatus, Protopanderodus varicostatus, Spinodus ramosus;* acrotretid brachiopods
AGE: Middle Ordovician (late Llanvirnian - early Caradocian; Pygodus *serra* zone to within the *Baltoniodus gerdae* subzone)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5; conodont fauna dominantly cosmopolitan and indicates a normal marine, cool-water depositional environment.

MAP NUMBER: 59 FIELD NUMBER: 85 SK 326A USGS COLLN. NO. 11426-SD
LOCATION: C-1, 67° 45.0', 159° 00.0' UNIT: DOc
FOSSILS: Conodonts: *Ozarkodina excavata, Panderodus* sp.
AGE: Middle Silurian through most of Early Devonian (Wenlockian - early Emsian)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5, normal marine biofacies.

MAP NUMBER: 60 FIELD NUMBER: 83 ADn 102E USGS COLLN. NO. 28976-PC
LOCATION: D-1, 67° 47.7' 159° 14.0' UNIT: Mko
FOSSILS: Conodont: *Hindeodus* cf. *H. scitulus*
AGE: middle Late Mississippian (latest Meramec to early Chester)
IDENTIFIED BY: A.G. Harris
REMARKS: CAI=5

MAP NUMBER: 61 FIELD NUMBER: 85 AKn 35
LOCATION: A-2, 67° 5.9', 159° 46.4' UNIT: Kc
FOSSILS: Plants: *Pseudoprotophyllum* sp., *Castaliites* sp.
AGE: early Late Cretaceous (late Cenomanian)

IDENTIFIED BY: R.A. Spicer
REMARKS: Genera are typical of river margin derived assemblages.