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Geologic and Fossil Locality Maps of the West-Central Part of the Howard Pass Quadrangle and Part of the Adjacent Misheguk Mountain Quadrangle, Western Brooks Range, Alaska

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INTRODUCTION

This geologic map covers an area of about 2,100 sq mi (5,500 sq km), encompassing eight 15-minute quadrangles (scale 1:63,360, or 1 in./mi) along the north flank of the west-central Brooks Range, in northern Alaska (fig. 1). These eight quadrangles correspond to the west-central part of the Howard Pass quadrangle and the eastern part of the adjacent Misheguk Mountain quadrangle (scale 1:250,000). The part of the map that corresponds to the six easternmost 15-minute quadrangles (Howard Pass quadrangle) incorporates all available field observations and data of numerous geologists over the past 50 years (fig. 2); the part of the map that corresponds to the two westernmost quadrangles (Misheguk Mountain quadrangle) utilizes the data and mapping of Mayfield and others (1984). This map attempts to integrate previous stratigraphic and structural ideas, as represented by the existing mapping of Mayfield and others, into current geologic models and the geologic perspective developed during new geologic mapping within the Howard Pass quadrangle, mainly in the 1990's.

REGIONAL GEOLOGIC SETTING

The map area is mainly within the Arctic Mountains physiographic province of Wahrhaftig (1994), where altitudes reach 1,000–1,500 m, but the area includes the southernmost edge of the Arctic Foothills province to the north, where altitudes are generally 300–500 m or less. These provinces are the physiographic expression of the Brooks Range orogen. The map area is within a belt of complex folding and thrusting in the northern part of the Brooks Range orogen, which extends across arctic Alaska from the Bering sea on the west to the Canadian border on the east (fig. 1), where it appears to connect southeastward with the northern Cordilleran fold and thrust belt (Plafker and Berg, 1994; Dover, 1994). The belt of folding and thrusting in the Brooks Range includes the "disturbed belt" and "crestal belt" geologic provinces of Moore and others (1994), and the DeLong Mountains, Endicott Mountains, and Angayucham subterranes of their Arctic Alaska terrane.

The rocks of the Brooks Range orogen formed in carbonate platform and continental margin settings from Late Proterozoic through pre-Late Devonian time, and in a variety of continental margin settings from Late Devonian through Mesozoic and younger time (Plafker and Berg, 1994). Extensional basins associated with intermittent mafic or bimodal igneous activity formed repeatedly from Proterozoic through Mesozoic time (Plafker and Berg, 1994). Two major periods of tectonism are widely recognized in the Brooks Range fold and thrust belt—the pre-Early Mississippian Ellesmerian orogeny and the late Mesozoic to early Tertiary contractional Brookian orogeny. At least two distinct pulses of Brookian thrusting separated by Albian clastic deposition can be distinguished in the west-central part of the Brooks Range (Moore and others, 1994), and some of the key evidence for separating these pulses comes from this map area. Generally north-directed vergence is clearly indicated in the Howard Pass quadrangle for the younger of these pulses, and a similar direction of thrusting, but with vastly greater distances of tectonic transport from depositional sites far south of the present Brooks Range, has generally been interpreted for the earlier pulse as well. However, the magnitude and direction of emplacement, and original depositional sites of the early Brookian allochthonous sequences in the Howard Pass quadrangle, are poorly constrained by local evidence and regarded by two of the authors of this report (Dover and Dumoulin) as open to question.

STRATIGRAPHIC FRAMEWORK

Seven generally time-equivalent, allochthonous stratigraphic sequences have been recognized by previous workers in the Howard Pass and adjacent Misheguk Mountain quadrangles. These sequences have been confirmed, and their map distributions

refined by the mapping in the west-central Howard Pass area presented here. Major thrust faults separate these sequences from one another. The sequences are shown diagrammatically in the “Correlation of Map Units” (see sheet 1) to have a uniform direction of structural overriding relative to one another, but a consistent direction of emplacement has not been definitively demonstrated in the field, so the process of structural stacking and the actual directions of overriding may have been much more complex than the “Correlation of Map Units” implies.

In the west-central Howard Pass quadrangle, as elsewhere in the region, the map distribution of stratigraphic sequences is complicated by complex interaction of the two pulses of Brookian thrusting recognized here. The number of stratigraphic sequences that can be distinguished, and the complexity with which they are structurally juxtaposed, has complicated stratigraphic terminology in the western Brooks Range. Several different systems of terminology have been used by various workers in the region, usually with the object of clarifying or improving on the complications of prior descriptive frameworks. However, each new attempt has necessarily added its own layer of complexity by introducing new terms or new usages of old terms. The result has been a confusing mix of stratigraphic and structural terms with similar names, and the use of different terms for essentially the same rock packages (for example, see Mayfield and others, 1988, table 7.1, p. 148).

The descriptive system used on this map is no exception; it is a slightly modified version of an earlier one by Ellersieck and others (1979), judged to be the simplest and most logical of the descriptive frameworks previously used, to which some newer terminology of Mull and Werdon (1994) is added. This system recognizes seven distinct thrust-bounded stratigraphic sequences, or thrust sequences, named for the major thrust complexes they characterize. The term "sequence" is used here in the generic sense common to past usage in the western Brooks Range (see Mayfield and others, 1988), rather than in the specific sense of seismic stratigraphy. Five sequences correspond to those named by Ellersieck and others (1979), and to the equivalent allochthons designated by Mayfield and others (1988) and numerous other authors. These are, from structurally low to high, the Picnic Creek, Kelly River, Ipnavik River, Nuka Ridge, and Copter Peak sequences. A sixth, and the structurally lowest sequence, here called the Endicott sequence, corresponds to the Endicott Mountains allochthon of Mull and Werdon (1994). The Endicott sequence contains two distinct facies of Upper Devonian to Lower Mississippian rocks in the southeastern part of the map area. These are referred to herein as the Key Creek and Aniuk River facies of the Endicott sequence, and were included in the Key Creek and Aniuk River sequences, respectively, of Mull and Werdon (1994). The Key Creek and Aniuk River facies appear to be restricted to two distinctly different imbricated thurst panels representing at least moderate thrust telescoping within the Endicott sequence, but not as much telescoping as that inferred for emplacement of the overlying sequences. The seventh, and structurally highest, sequence is the Misheguk sequence, restricted to exposures at Siniktanneyak Mountain (Nelson and Nelson,1982; Bickerstaff, 1994). The term "allochthon" is not used on this map or in the stratigraphic nomenclature because of controversial structural implications that have come to be associated with it through common usage in the western Brooks Range regarding the areal extent and continuity of the allochthons, where they originated, their distance and direction of tectonic transport, and their mechanism of emplacement.

The seven stratigraphic sequences represent all or part of the age range from Devonian to Early Cretaceous (Neocomian), and most are unconformably overlain by upper Lower Cretaceous (Albian-Aptian) clastic rocks and Pleistocene surficial deposits. The two structurally highest sequences, the Copter Peak and Misheguk sequences, are predominantly igneous or igneous-derived. These two sequences are relatively poorly dated, and although previously regarded as genetically related components of an ophiolite, have uncertain plate tectonic settings and origins that are currently undergoing reassessment in areas southwest of the Howard Pass quadrangle (R.W. Saltus, T.L. Hudson, and S.M. Karl, written commun., 1999). The other five sequences, the Endicott , Picnic Creek, Kelly River, Ipnavik River, and Nuka Ridge sequences, consist predominantly of sedimentary rocks and differ most strikingly in their Devonian and Mississippian strata. However, some also have important differences in their Pennsylvanian to Jurassic sections, as, for example, the abundance of chert (Imnaitchiak Chert) in the Picnic Creek and Ipnavik sequences compared with that in the Endicott sequence. Distinctive Cretaceous lithologic components such as coquina and cannon-ball concretions, and faunal distinctions, may also characterize one sequence or another, but the data are sparse, and systematic Cretaceous variations between sequences are poorly documented; those differences

known to the authors are specified in the “Description of Map Units.”

Any thrust-based stratigraphic scheme is necessarily complicated where thrust sheets die out along strike and lose their structural identity, or where units pinch out or undergo lateral facies changes within a single thrust sheet. These problems are compounded on a regional scale because (1) the wider the region, the more likely individual stratigraphic sequences are to undergo lithologic changes, and (2) individual structures, including "allochthons," cannot be extended indefinitely. A local example is the decision to treat the Key Creek and Aniuk River facies on this map as lateral variations within the Endicott sequence, rather than split the Endicott into two different sequences. A regional example is that Pennsylvanian and Permian rocks in what is mapped as the Endicott sequence (or allochthon) in the De Long Mountains quadrangle, 100 mi west of the Howard Pass quadrangle, more closely resemble correlative rocks of the Picnic Creek sequence in their chert content than they do equivalent rocks in the Endicott sequence in this map area. Other examples of how the lithology of some map units within a single "allochthon" (“sequence” in our terminology) vary regionally are mentioned in the stratigraphic descriptions of Mull and Werdon (1994) and Mayfield and others (1984).

Despite the distinctive lithologic components or intervals by which they are characterized, all of the sequences mapped here, except for the Misheguk sequence, also have enough stratigraphic similarities and lithologies in common to make mapping distinctions difficult in places. These similarities suggest structural telescoping of originally connected Devonian through Early Cretaceous depositional settings for these sequences, rather than structural amalgamation of isolated and disparate depositional sites. Deposition along a rifted continent-ocean margin characterized in different places by a carbonate platform and (or) clastic wedge could produce all of the various sedimentary rock types and the mafic to bimodal igneous rocks juxtaposed in the sequences of the Howard Pass and Misheguk Mountain quadrangles, but the configuration and location of the hypothetical rift margin is uncertain. The location and precise plate tectonic setting in which the arkosic rocks of the Nuka Ridge sedimentary sequence formed is enigmatic, but they also could be derived locally from erosionally denuded crystalline basement rocks in uplifts along such a rift margin.

STRUCTURAL DISCUSSION

This geologic map depicts the complex interaction of two fundamentally different suites and ages of contractional structures, represented on the geologic map by several types of thrust fault and fold symbols, that deform the major sequences mentioned above. Figure 3 is a simplified tectonic map showing the distribution of these thrusted sequences and the pattern of structural interaction between the two main deformational phases.

The oldest and largest of the thrust faults form the structural soles of the thrust sequences, which are shattered by a complex array of smaller, imbricate thrust faults that typically splay from the sole thrusts. The structural distribution of these sequences and their sole thrusts, but not the subsidiary faults that imbricate the sequences, is shown in figure 3. The amount of displacement represented by these sequence emplacement structures has been estimated by Mayfield and others (1988) to be 700–800 km, assuming origination of all of the sequences from south of the present Brooks Range. We (Dover and Dumoulin) believe other tectonic models that would require less cumulative shortening may be possible.

The structural sequences typically have a broad, open, upright to overturned folded form produced by the younger episode of contractional folding and thrusting that occurred after their emplacement. Only the largest of these later structures are shown in figure 3. The most prominent of the fault zones (the Makpik-Bupto zone) is interpreted to have major right-lateral displacement where it trends northeast across structural grain along Makpik Creek, and to splay eastward into several prominent east-west-trending thrusts having major north-directed movement. This zone cuts all of the structural sequences in the map area except the Kelly River and Nuka Ridge sequences, which are not exposed along the zone. The Makpik Creek part of this zone may be controlled at depth by a major basement-controlled lateral ramp. Additionally, high-angle faults of several types are also represented on the map, but these are generally much subordinate to, and far less structurally significant than, the thrusts.

Sequence Emplacement Structures of Aptian or Older Age.

Most of the individual thrust-bounded sequences are structural duplexes. Duplexing is interpreted from the pattern by which the internal thrust faults that imbricate the stratigraphic sequences commonly curve into and merge with the major sole thrusts. The best examples in the map area are in the Endicott,

Picnic Creek, Ipnavik River, and Nuka Ridge sequences. These internal, imbricating thrusts are inferred to be essentially the same age as the sole thrust(s) they merge with, and the stacked structural panels they bound represent enormous internal thickening and shortening during emplacement of each complex. Imbrication and tectonic emplacement of the thrust complexes involved the Neocomian (lower Lower Cretaceous) and locally Upper Jurassic Okpikruak Formation, which is present at the top of several of the sequences; clasts in conglomerates of the Albian-Aptian (upper Lower Cretaceous) Fortress Mountain Formation foredeep deposits of the Colville Basin were derived from the thrust complexes during and after their emplacement and uplift. These relationships indicate a mid-Early Cretaceous age of emplacement for the structural sequences.

Amount and direction of tectonic transport is difficult to document for most individual thrust imbrications. Some are clearly related to overturned folds and have relatively small displacements of a few kilometers or less; others, including some related to large, commonly detached recumbent folds, require larger displacements based on the extent of overriding of underlying thrust imbricates or panels. Internal tectonic shortening of 200–300 percent or more seems likely from the number of imbricate splays, the degree of truncation and overriding apparent for at least some of them, and the amount of structural thickening indicated by the map pattern of imbricate stacking. Though the actual amounts of structural shortening and thickening are undocumented, and there is insufficient subsurface control for accurately constructing balanced retrodeformed structure sections for this map area, it seems clear that the component of total displacement respresented by **internal shortening** has been greatly underestimated in previous analyses of thrusting in the western Brooks Range.

The intensity of internal deformation and the degree of internal shortening mentioned above is a consideration separate from the question of the direction and extraordinary amount of transport previously inferred by Mayfield and others (1988) for emplacement of the major thrust sequences from their original depositional sites. On the basis of their work, emplacement of the structural sequences has generally been interpreted to have been toward the north and to have produced a structural stacking that places sequences formed successively farther south into progressively higher structural positions. However, independent evidence for the direction of imbricate thrusting during emplacement is not generally available from the internal fabric of the thrust sequences in this map area or in the "allochthons" elsewhere in the western Brooks Range. In the absence of such evidence, prevailing models of far-traveled allochthon emplacement may be open to question because of the possible masking effect of a later, second phase of superimposed deformation that dominates structural grain in the west-central Brooks Range. The asymmetry and north-vergence of overturned folds, and the geometry of thrust cutoffs, indicate consistently north-directed thrusting of this later, post-sequence-emplacement deformation, which produced reversals of dip and overturning of pre-existing structures. The extent to which the effects of this phase of deformation may have been mistakenly attributed to sequence emplacement is unclear, but this does appear to have happened in places, as indicated below. Therefore, in the absence of definitive evidence based on internal fabric, previously inferred models of far-traveled emplacement of sequences from the south are unconfirmed in our map area, and two of us (Dover and Dumoulin) believe that conceptional cross-sections like those of Mayfield and others (1988) and Mull and others (1987) are open to question.

A case in point is the prominent klippe of the Nuka Ridge sequence on Nuka Ridge, in the northwest corner of the map area, along the east edge of the Misheguk Mountain quadrangle (fig. 4). Here, as shown by the original mapping of Mayfield and others (1984), an imbricate stack of the Nuka sequence is folded into a large, broad, northwest-trending and northward-overturned syncline characteristic of post-emplacement, late phase structures throughout the map area. The north-south cross-section through this klippe drawn by Mayfield and others (1984) clearly shows the overturned geometry of the fold, but this is a post-emplacement structure and does not constrain the direction of original emplacement and imbrication of the Nuka sequence. Instead, the direction of emplacement thrusting should be viewed in a line of section normal to the cutoffs the imbricate thrust panels make with one another, and with the sole thrust of the klippe. As mapped by Mayfield and others (1984) at Nuka Ridge, this would require an approximately west-northwest structure section along the crest of the ridge (fig. 4). According to standard duplex geometry (Boyer and Elliott, 1982; Mitra, 1986), the pattern of flats with ramps cutting up-section seen in figure 4 suggests emplacement from the **west**, rather than the south. Whether the original mapping at Nuka Ridge is correctly portrayed by Mayfield and others (1984) or not, this geometric pattern does not support the emplacement direction they interpreted from their

mapping. Similar geometric reasoning, but based on somewhat less compelling geologic patterns, raises similar questions for emplacement of the main Ipnavik River thrust sequence of the De Long Mountains in the west-central part of the map area and for other major thrust sequences in the map area. The significance of this is that critical re-examination of evidence bearing on the direction of emplacement of each of the major structural sequences in the western Brooks Range is needed before the prevailing interpretation of palinspastic restoration from the south can be evaluated. A more complex model of development of the structural sequences involving original emplacement from other directions, followed by segmentation and structural overprinting of the sequences by **later** north-directed thrusting, may be required.

Post-Albian Deformation.

The predominantly east-west to northwest-southeast structural grain of the Howard Pass-Misheguk Mountain area is a product of the second generation of major thrusting and associated folding mentioned above (fig. 3). Second-phase structures cut and deform all of the major thrust complexes, postdate their emplacement, and involve their Aptian-Albian depositional products. The trends of many of these relatively younger faults have prominent linear or curvilinear topographic expression. This period of deformation broadly folded the Fortress Mountain Formation and Torok Shale, and the thrust sequences themselves, but tighter folding with associated small thrusts and reverse faults affected incompetent rocks, and earlier structures were probably reactivated and tightened up in many places. Map evidence for younger faults merging with the sole thrusts of older thrust complexes suggests that at least some of the younger generation of thrusts root in, were propagated from, or utilized weak zones of, reactivated older structures. Distances of transport of the largest of the younger thrusts were far less than for the emplacement of the earlier thrust complexes but may have been several kilometers or more in places and were sufficient to severely disrupt the earlier structural patterns. Some of the best examples are within the Drenchwater Creek and Cutaway Basin structural windows, the Makpik-Bupto structural zone, and the Memorial Creek fault zone (fig. 3). A key consequence of the recognition of two distinct ages of thrusting is that because the younger "out-of-sequence" thrusts cut and juxtapose different structural sequences, younger-on-older thrust relations are common in the map area where relatively younger rocks from one structural sequence are emplaced on older rocks of the same sequence, or where younger rocks of one structural sequence are thrust onto older rocks of another. Examples of this relationship involving the Endicott and Picnic Creek sequences are common in the Drenchwater and Cutaway Basin windows, and where Cretaceous rocks of the Picnic Creek sequence override older rocks of the Ipnavik River sequence on major thrusts crossing Story and Safari Creeks and the west fork of Swayback Creek. The possibility of younger-on-older displacements caused by extensional low-angle normal faulting cannot be eliminated in some places but is less consistent with the predominantly contractional relationships and patterns that can be documented throughout the map area. Second-generation thrusts consistently dip south, and related folds verge northward, indicating that the younger phase of folding and thrusting was consistently north- to north-northeast-directed. This phase of deformation, which dominates structural trends in the west-central Brooks Range, affects rocks as young as Albian (latest Early Cretaceous) and is therefore interpreted to be Late Cretaceous and (or) younger in age.

Structural Symbols

Some thousands of bedding attitudes and other structural data and controls were used in this map compilation. However, because of the complexity and tightness of the map, and questions about how representative much of the data are for numerous areas of complex small-scale folding, only a few bedding attitudes in structurally simple areas are included on this map. Instead, bedding traces and small fold axes are included. These were mapped in the field and from high-quality aerial photographs and judged to be more representative of the deformation style, less likely to add clutter or be obscured by mapping detail, and a visually much more graphic indication of the controls on the placement of the many small faults required by structural cut-offs and truncations than would otherwise be apparent. Outcrop-scale and larger fold axes are added where they do not obscure contact relations.

MAPPING CREDITS

Much of the current knowledge of the west-central Brooks Range stems from geologic mapping by the U.S. Geological Survey, starting mainly in the early 1950s. Instrumental in that mapping effort were the field activities of I.L. Tailleur over the course of

more than four decades. His work, supported by the mapping of numerous colleagues, led to a model of western Brooks Range geologic development still widely held today. This generation of mappers included I.L. Tailleur (1950–53, 1965–66, 1968, 1975–77, 1979, 1986, 1992); R.L. Detterman, A.H. Lachenbruch, M.C. Lachenbruch, and M.D. Mangus (1949); B.H. Kent (1950–51); H.N. Reiser (1951); and Ed Sable (1953). The contributions of these early workers—I.L. Tailleur and his associates—are therefore the foundation of this map, and our compilation depends heavily on the data and ideas they generated.

The next generation of geologic mapping utilized in this compilation resulted from various Federal and State Survey activities of the 1970s. Contributers to this phase of geologic exploration within the Howard Pass quadrangle include I. Ellersieck (1976–77, 1979); C.F. Mayfield (1975–77, 1979); M. Churkin (1977–78); G.R. Winkler (1977), W.J. Nokleberg (1977–78); M.L. Miller and M. Mullen (1978); W.P. Brosge (1979); S.W. Nelson (1978–79, 1991); and W.H. Nelson and S.M. Curtis (1979). Geologic contacts and the distribution of map units within the Misheguk Mountain part of this compilation are generally shown here as mapped in 1978 and published by Mayfield and others (1984), although stratigraphic units were combined in a few places, and characterization of fault type is modified locally in accord with interpretations based on later mapping in the adjacent Howard Pass quadrangle.

The main impetus for this compilation was geologic mapping done in 1992 by the U.S. Geological Survey, in cooperation with the Alaska Division of Geological and Geophysical Surveys. Participants in the 1992 map project and contributors of mapping and (or) data to the part of this compilation within the Howard Pass quadrangle were J.H. Dover, J.A. Dumoulin, R.T. Miyaoka, J.S. Kelley, J.M. Schmidt, and S. Bie (general area); D.P. Bickerstaff and M. Miller (Siniktanneyak Mountain mafic-ultramafic complex); M.B. Werdon (Story Creek area); and C.G. Mull, T.E. Moore, and Ellie Harris (southeastern part of the map area). Gravity data collected by R.L. Morin in 1992 helped in constraining the limits and tectonic configuration of the Siniktanneyak Mountain mafic-ultramafic complex. Other recent geologic mapping utilized in the compilation is from the following sources: D.C. Bradley and D. Bohn (1990), J.A. Dumoulin and J.M. Schmidt (1990–91), C.G. Mull (1990–93), R. Harris (1991), R.R. Reifenstuhl and T.E. Moore (1992–93), K. Adams and E.E. Harris (1993), and S.M. Karl (1994).

Identifications of geologic units in numerous small, isolated exposures, and bedding traces throughout the Howard Pass part of this map compilation, rely heavily on the field observations and aerial photograph interpretations of Tailleur and others (1966), and detailed interpretation of color-infrared imagery by J.H. Dover (1992–94).

DESCRIPTION OF MAP UNITS

SURFICIAL MATERIALS (QUATERNARY)

Qa **Main stream alluvium—**Unconsolidated silt, sand, and gravel in active main stream channels

Qs **Surficial deposits, undivided—**Unconsolidated stratified and unstratified surficial deposits, including side-stream alluvium; colluvium; terrace gravels; landslide deposits; delta, fan, and talus deposits; and glacial deposits

Qg **Glacial deposits, undivided—**Mainly unstratified glacial drift in moraines along west side of Makpik Creek

FOREDEEP DEPOSITS OF THE COLVILLE BASIN (LOWER CRETACEOUS)

Ktfm **Torok Shale and Fortress Mountain Formation, undivided (Albian and Aptian)—** Undifferentiated and regionally interfingering units of the Torok Shale, characterized by folded, thinly interbedded black clay shale and silty shale; and the Fortress Mountain Formation, consisting predominantly of greenish-gray graywacke, interbedded with dark-gray mudstone and shale, and massive beds of

pebble- to cobble-conglomerate containing clasts of variegated chert and altered mafic igneous rocks. Fortress Mountain Formation contains early (and rare middle) Albian megafossils in northern and eastern parts of Howard Pass quadrangle and in the De Long Mountains quadrangle (Elder and others, 1989), and Aptian-Albian microfossils in the De Long Mountains and Chandler Lake quadrangles (C.G. Mull, written commun., 2000)

ENDICOTT SEQUENCE
(LOWER CRETACEOUS TO DEVONIAN)

KDe **Rocks of the Endicott sequence, undivided (Lower Cretaceous (Neocomian) to Devonian)—**Mapped tentatively in a few areas of limited or isolated exposure in the north-central part of the map area. Not examined in the field or identifiable by photo interpretation; assignment based on inferred but unconfirmed continuity with stratigraphic assignments by other geologists within what appears to be the same structural plate or sequence. Assignment to other sequences is possible but would require additional structural complexity for which there is presently no independent evidence

KJo **Okpikruak Formation (Valanginian, Berriasian to Kimmeridgian)—**Dark-gray to grayish-tan mudstone, siltstone, graywacke sandstone, and minor conglomerate; locally contains interbeds of distinctive reddish-gray coquinoid limestone (c) composed of the pelecypod *Buchia sublaevis* of early Valanginian age (table 5, locs. 167, 168, 185); also contains *Buchia* species of middle to late Valanginian and possible Kimmeridgian ages in, and just west of, the map area (table 5, locs. 182, 188; Mayfield and others, 1984, table 2, loc. 53). *Buchia* species of Berriasian and early Valanginian age are found farther west (western Misheguk Mountain and De Long Mountains quadrangles); species of early Valanginian and possible Late Jurassic age occur to the east (eastern Howard Pass and Killik River quadrangles) (Elder and others, 1989, table 1, loc. 105, USGS colln. 22509; C.G. Mull, written commun., 1990). Includes rock types assigned to the Ipewik unit to the west and considered to be of Jurassic and Early Cretaceous age (for example, Mayfield and others, 1990). Intensely deformed and base structurally detached in places. Thickness unknown

JPe **Etivluk Group (Middle Jurassic to Pennsylvanian)—**Assemblage of variegated but mostly black, gray, or greenish-gray bedded chert containing partings and subordinate interbeds of shale and siliceous shale. Typically is intensely tectonically disrupted. Locally contains abundant radiolarians (table 2, locs. 15, 16, 31, 43, 58, 62, 107, 151, 152; and Mayfield and others, 1984, table 2, loc. 14A); ages include middle Permian, Middle Triassic (Ladinian), and Late Triassic (early to middle Norian). Late Triassic (Norian) bivalves (*Monotis* sp.) also occur in this unit (table 5, loc. 164)

JTo **Otuk Formation (Middle Jurassic to Triassic)—**Interbedded fossiliferous black chert and shale, and thin-bedded, black and banded limestone characterized by abundant *Monotis* sp. or *Halobia* sp. pelecypods of Late Triassic age (table 5, locs. 165, 166, 173, 176, 178, 187). Mapped separately where white-weathering limestone bands and layers are exposed and are easily identified on aerial photographs and color infrared imagery. Radiolarian collections from this unit (table 2, locs. 5, 13, 18, 19, 38, 42, 117, 127, 130; table 4, loc. 117; Mayfield and others, 1984, table 2, loc. 13) are of Middle Triassic (Ladinian) and Late Triassic (Carnian? and Norian) ages; a single conodont collection (table 4, loc. 117) is Middle Triassic. The Jurassic Blankenship Member at the top is locally exposed (but not mapped separately) and consists of organic-rich black shale and thin-bedded chert; east of the map area (eastern part of the Howard Pass quadrangle) it contains pelecypods (*Otapiria tailleuri*) of Early Jurassic

(Sinemurian) age (Elder and others, 1989, table 2, locs. 488–489). Formation is commonly exposed only as rubble or in structurally complicated partial sections in stream cuts. Thickness less than 100 m

PIPs **Siksikpuk Formation (Permian to Pennsylvanian)—**Predominantly nonresistant thin-bedded siltstone, shale, siliceous mudstone, and thin-bedded chert. Distinctive thin basal yellowish-orange-weathering, greenish-gray siltstone; grades upward into maroon to green mottled siltstone containing barite seams and crystals, and resistant green and greenish-gray siliceous mudstone and chert in beds 10 cm or less thick, and poorly exposed gray clay shale. Formation is commonly structurally complicated and exposed only as rubble on hillsides or recognized in streamcuts as the yellowish orange-weathering beds overlying the Lisburne Group. Mull and others (1987, p. 659) restricted the geographic extent of the Siksikpuk to "some areas of the western . . . and north-central Brooks Range" where it "consists dominantly of shale and siltstone and only minor chert." These authors noted that in the Killik River quadrangle the Siksikpuk Formation [restricted] is present only in the Endicott allochthon (our sequence), whereas other allochthons (our Picnic Creek and Ipnavik sequences) contain Imnaitchiak Chert; to the west, in the De Long Mountains, Imnaitchiak Chert occurs in all sequences, including the Endicott. The Siksikpuk as restricted by Mull and others (1987) has yielded only Permian fossils, but the basal age of the unit is poorly constrained (Murchey and others, 1988) and may gradually increase to the west, where gray chert overlying the Kuna Formation in the De Long Mountains quadrangle (probable "Imnaitchiak Chert" in the usage of Mull and others, 1987) contains Pennsylvanian radiolarians (K.M. Reed, written commun., 1998). In the Endicott sequence in the map area, most strata that lie between the Lisburne Group and the Otuk Formation are lithologically like the Siksikpuk Formation [restricted], but chert increases (gradationally?) to the west. Rocks here mapped as Siksikpuk in the eastern Misheguk Mountain quadrangle are lithologically intermediate between the Siksikpuk [restricted] and the Imnaitchiak Chert of Mull and others (1987) and have yielded radiolarians of Pennsylvanian to Early Permian (Atokan? to Leonardian) age (Mayfield and others, 1984, table 2, locs. 8A, 17, 20, and 29; Murchey and others, 1988)

Lisburne Group (Pennsylvanian and Mississippian)

IPMkv **Volcaniclastic rocks (Pennsylvanian? and Mississippian?)—**Predominantly light-gray to green-gray, light-brown- to rusty-weathering felsic tuff containing abundant feldspar and sparse biotite phenocrysts; typically has calcareous cement and disseminated sulfide minerals. Commonly associated with tuffaceous sandstone, coarse-grained limestone containing disseminated light-green chloritic minerals, and thick-bedded to massive calcareous rocks containing volcanic fragments. The felsic rocks are equivalent to units Mft, Mmt, Mct, and Mke of Nokleberg and Winkler (1982) in the Drenchwater Creek area, where their thickness ranges from 80 to 250 m. Also included in this unit are sparsely distributed and strongly altered mafic andesite, and keratophyre. The mafic rocks are equivalent to the Mma and Mke units of Nokleberg and Winkler (1982) in the Drenchwater Creek area, where their thickness is as much as 80 m, and a K-Ar age on biotite of 325.6 Ma (recalculated using decay constants of Steiger and Jager, 1977) was reported by Tailleur and others (1966). This unit is equivalent to unit IPMvc of Mayfield and others (1984), who recognized it only east of upper Picnic Creek in the Misheguk Mountain quadrangle. Biotite from similar alkaline intrusive rocks associated with Sedex and vein-breccia mineralization in this unit in the Drenchwater Creek area yielded $^{40}Ar/^{39}Ar$ plateau ages of 335–337 Ma (Werdon, 1999), indicating a Carboniferous age of mineralization

IPMk **Kuna Formation (Lower Pennsylvanian and Mississippian)—**Predominantly black siliceous mudstone and sooty, carbonaceous shale, including minor gray carbonate interbeds and concretions. Includes Mc (bedded chert) unit and various limestone units (Mls, Mko, and Mu) of Nokleberg and Winkler (1982) in Drenchwater Creek area. Siliceous beds are rich in sponge spicules and radiolarians. Thin carbonate layers are chiefly dolomitic mudstone and calcitized radiolarite. Some intervals of carbonate in Drenchwater Creek area are at least 20 m thick and may be (at least in part) carbonate turbidites derived from a shallow-water Lisburne Group source (Werdon, 1999). Sedimentologic and faunal evidence suggest that the Kuna was deposited in a deep-water setting in which anoxic or dysaerobic bottom-water conditions generally prevailed. Conodonts from carbonate layers near base of type section in Howard Pass B–3 quadrangle are early middle Osagean (lower part *S. anchoralis-D. latus* Zone); uppermost carbonate beds could be as young as Meramecian (Dumoulin and others, 1993, 1994) (table 1, locs. 21, 61, 146, 147; table 4, loc. 125). Carbonate layers also contain rare cephalopods of Osagean and Meramecian ages (table 5, locs. 174–175). Siliceous beds in the uppermost Kuna yield radiolarians of Late Mississippian–Early Pennsylvanian age (table 2, loc. 115; less diagnostic ages were obtained from locs. 17 and 21); similar ages are reported from this stratigraphic interval west of the map area in the De Long Mountains quadrangle (C.D. Blome, written commun., 2000). The lithology and fauna of these highest siliceous beds are locally gradational into those of the lower Etivluk Group. Depositional contact on underlying Kayak Shale and beneath overlying Siksikpuk Formation exposed in places, but top is generally faulted. Maximum thickness about 70 m

Mlb **Bupto facies (Upper and Lower Mississippian)—**Thin-bedded to massive dolostone, chert, and subordinate limestone; locally parallel- and cross-laminated. Mapped only at Mt. Bupto and two small areas about 10 km to the north. Well-exposed upper part of the section at Mt. Bupto is 195 m thick; entire succession may be as much as 360 m thick (Armstrong, 1970). Upper section has three subunits. Upper and lower subunits are chiefly chert; middle subunit mostly dolostone (this dolostone-rich middle unit was not recognized by early workers; see for comparison Dumoulin and Harris, 1993, p. 46). Relict textures indicate that most chert was limy bioclastic wackestone, packstone, and grainstone prior to silicification; bioclasts include sponge spicules, crinoid ossicles, bryozoans, and brachiopods. Dolostone was mainly crinoidal packstone and (or) grainstone; some intervals contain 1–15 percent moldic and intercrystalline pores, locally lined with solid hydrocarbons. Lowest beds are limestone (skeletal grainstone and packstone) with partings of noncalcareous black shale; lithofacies and biofacies of these rocks resemble those of the Rough Mountain Creek unit (table 1, locs. 67, 68). Uppermost beds are organic-rich, locally phosphatic and (or) petroliferous black shale, chert, and dolostone. Sedimentary structures and faunal evidence suggest most of section formed in an open-marine, outer shelf or platform setting. Dolostone subunit accumulated in shallower water (middle shelf?) shoals; some northern strata (table 1, locs. 37, 41) were deposited in very shallow-water environments. Conodonts indicate that uppermost 60 m of unit is late Meramecian, middle part of section is middle-late Osagean, and lowest beds may be as old as late Kinderhookian (table 1, locs. 33, 37, 41, 58, 66–72). Also contains Osagean-Meramecian megafossils and possibly Meramecian endothyrid foraminifers (Armstrong, 1970). Similar in lithology, age, and depositional environment to correlative sections to the northeast at Lisburne Ridge and in the Ivotuk Hills (Dumoulin and Harris, 1993).

Mlr **Rough Mountain Creek unit of Dumoulin and Harris, 1997 (Lower Mississippian)—**Predominantly light- to dark-gray limestone interbedded with subordinate black fissile shale and blocky mudstone. Limestone mainly poorly sorted to well-sorted, medium-grained to very coarse grained skeletal grainstone and packstone; cherty and spiculitic in part. Some beds are graded; others parallel-laminated or bioturbated. Late Kinderhookian age indicated by conodonts in the eastern Howard Pass quadrangle and by brachiopods in underlying Kayak Shale (Dumoulin and Harris, 1997; Mull, Harris, and Carter, 1997); contains Kinderhookian conodonts in central and eastern parts of map area (table 4, locs. 131, 144, 148–50, 155). In eastern Misheguk Mountain quadrangle, rocks provisionally included in this unit contain foraminifers of late Osagean (late Early Mississippian) age (Mayfield and others, 1984; table 2, locs. 8B, 14B). Lithologic and faunal data indicate deposition mainly in shallow-water, inner- to middle-shelf settings. Thickness generally 8–17 m

Endicott Group (Lower Mississippian and Upper Devonian)

Key Creek facies

Mk **Kayak Shale (Lower Mississippian)—**Dark-gray to black, fissile clay shale containing conspicuous yellowish-brown-weathering, thin, fossiliferous limestone interbeds near the top and greenish-gray siltstone and sandy siltstone in the lower part. Sideritic concretions are characteristic in places. Locally contains felsic to intermediate intrusive, extrusive, and volcaniclastic rocks. Contains Kinderhookian (locally late Kinderhookian; early Early Mississippian) conodonts and brachiopods within the map area (Dumoulin and Harris, 1997; Mull, Harris, and Carter, 1997) (table 4, locs. 116, 118, 119, 142, 143, 148, 153, 154). Mayfield and others (1984) reported brachiopods and corals of Early Mississippian age (table 2, locs. 38, 40, 42, and 44) from this unit in the eastern Misheguk Mountain quadrangle. Minimum thickness 45 m; typically complexly folded and pervasively sheared, especially near the structural base, where phyllitic textures and detachment from underlying rocks are common

Mkl **Limestone unit of Kayak Shale (lower Lower Mississippian)—**Orange-weathering, gray fossiliferous limestone in beds 0.1–5 m thick, interbedded with dark gray to black shale. Crinoid ossicles, corals, and other bioclasts locally abundant. Mapped separately only north of Safari Creek window. Lithologically similar beds commonly occur in the upper part of the Kayak Shale elsewhere in the map area but are too thin and (or) discontinuous to map separately; these beds contain Kinderhookian (early Early Mississippian) conodonts and brachiopods (Dumoulin and Harris, 1997; Mull, Harris, and Carter 1997).

Mik **Isikut unit of Mull and Werden (1994) and Kayak Shale, undivided (lower Lower Mississippian)—**Conodonts of early Early Mississippian age (table 4, locs. 123–126, 132, 133, 145) were reported by Dumoulin and others (1997) and Mull, Harris, and Carter (1997). See table 3 (loc. 125) for additional megafossil data

Mikv **Volcanic-rich part of Isikut unit of Mull and Werden (1994) and Kayak(?) Shale, undivided (lower Lower Mississippian)—**Isikut unit as described below, but representing a part of the Isikut containing more abundant volcanic components than is typical. Conodonts of early Early Mississippian (Kinderhookian; locally, middle to late Kinderhookian) age are reported by Dumoulin and others (1997) and Mull, Harris, and Carter (1997) (table 4, locs. 120, 122)

MDkn **Kanayut Conglomerate and Noatak Sandstone, undivided (Lower Mississippian? and Upper Devonian)**

MDk **Kanayut Conglomerate (Lower Mississippian? and Upper Devonian)—**Gray to brown, tannish-brown-weathering, quartzitic sandstone and subordinate

quartz- and chert-pebble conglomerate. Lower part contains gray to black shale, siltstone, sandstone, and conglomerate. Weathered surfaces characterized by black lichen growth. Forms resistant ledges and steep slopes of coarse, blocky talus. Thickness may vary across map area, but about 800 m was reported east of Etivluk River by Mull and Werdon (1994); distinctly thicker than equivalent rocks in the Aniuk River facies south and west of the Howard Hills thrust (Mull and Werdon, 1994)

Dn **Noatak Sandstone (Upper Devonian)—**Light-gray to tan, fine- to medium-grained, thick-bedded sandstone containing abundant siltstone and shale interbeds; sandstone is typically cross-bedded. Contains abundant limonitic spots and scattered to abundant detrital muscovite. Contains Late Devonian–Early Mississippian brachiopods in the Misheguk Mountain part of the map area (Mayfield and others, 1984, table 2, loc. 48) and Late Devonian brachiopods to the southwest in the Baird Mountains quadrangle (Karl and others, 1989). Thickness of 500 m or more reported east of Nigu River by Mull and Werdon (l994); distinctly thicker than equivalent rocks in the Aniuk River facies south and west of the Howard Hills thrust (Mull and Werdon, 1994)

Aniuk River facies

Mi **Isikut unit of Mull and Werdon (1994) (Lower Mississippian)**—Reddish-tan to grayish-green, tan- to reddish-brown-weathering, thin- bedded to platy siltstone and phyllitic shale; bioturbation and flaser structure common. Locally contains quartzitic sandstone interbeds at the base and thin, sandy limestone interbeds higher in the section. Includes interbeds typical of the Kayak Shale in places. Contains Kinderhookian (locally late Kinderhookian; early Early Mississippian) conodonts and brachiopods (Mull, Harris, and Carter, 1997) (table 4, locs. 101, 106, 155, 156). Minimum thickness about 200 m. Pervasively folded and typically displays prominent axial-plane cleavage

MDka **Kanayut Conglomerate (Lower Mississippian? and Upper Devonian)—**Gray to brown, gray-weathering, fine- to coarse-grained, quartzitic sandstone, and minor quartz- and chert-pebble conglomerate; commonly has gray to black mudstone, shale, and phyllitic shale partings and interbeds as much as a few meters thick. Forms coarse, blocky talus having weathered surfaces characterized by black lichen growth. Interfingers downward with Noatak Sandstone. Southeast of the map area (Howard Pass A–2 quadrangle), contains plant axes (lycopod trunks) of probable Mississippian age (S.H. Mamay, unpub. USGS fossil data, 1976). Thicknesses of about 183 m and 112 m measured at Isikut Mountain and along Aniuk River, respectively (T.E. Moore, written commun., 1994); distinctly thinner than equivalent rocks in the Key Creek facies north and east of the Howard Hills thrust (C.G. Mull, written commun., 1995)

Dna **Noatak Sandstone (Upper Devonian)—**Light-gray to tan, fine- to medium-grained, thick-bedded sandstone with abundant siltstone and shale interbeds; sandstone typically cross-bedded and ripple marked. Contains abundant limonitic spots; commonly has scattered to abundant detrital muscovite. In the Key Creek facies this unit contains Late Devonian–Early Mississippian brachiopods. Thicknesses of 138 and 215 m measured at Isikut Mountain and along Aniuk River, respectively (T.E. Moore, written commun., 1994); distinctly thinner than equivalent rocks in the Key Creek facies north and east of the Howard Hills thrust (Mull and Werdon, 1994)

PICNIC CREEK SEQUENCE
(LOWER CRETACEOUS TO MISSISSIPPIAN)

KMp **Rocks of the Picnic Creek sequence, undivided (Lower Cretaceous (Neocomian) to Mississippian)—**Mapped tentatively in areas of limited or isolated exposure not

examined in the field or identifiable by photo interpretation; unit assignment based on structural position of general sequence inferred from geologic relations mapped in surrounding areas

Kop **Okpikruak Formation (Lower Cretaceous (Valanginian))—**Dark-gray to grayish-tan mudstone, siltstone, and graywacke sandstone. Contains isolated pelecypods (*Buchia* spp.) of early and middle to late Valanginian ages in the map area (table 5, locs. 162 and 184) and in the De Long Mountains quadrangle to the west (Elder and others, 1989). Intensely deformed and base structurally detached in many places. Thickness unknown

JPip **Imnaitchiak Chert of Etivluk Group (Jurassic to Pennsylvanian)—**Gray to greenish-gray bedded chert or siliceous mudstone in beds 2–15 cm thick, intercalated with greenish-gray to distinctive maroon, siliceous, silty mudstone partings and interbeds. In Picnic Creek sequence, distinguish-able from Imnaitchiak Chert of Ipnavik River sequence only by stratigraphic association with underlying Akmalik Chert. Contains mainly Pennsylvanian to Late Triassic radiolarians (Mull and others, 1987); but a few samples yielded Early Jurassic radiolarians in the map area (table 2, loc. 80) and to the east (Mull, Glenn, and Adams, 1997). Unit typically structurally contorted; thickness probably 75 m or less. Radiolarian collections from this unit (table 2, locs. 6, 10, 11, 25, 26, 34, 36, 39, 45, 53, 78–80, 85, 94, 95, 102, 135, 136, 159; table 4, loc. 100; and Mayfield and others, 1984, table 2, locs. 9, 10, 15) include ages of Permian (possibly middle and Late Permian), Middle and Late Triassic (probably Ladinian, Carnian, and early to middle and middle to late Norian), and Early Jurassic (Hettangian or Sinemurian)

PMap **Akmalik Chert of Lisburne Group (Penn-sylvanian and Mississippian)—**Black bedded chert in beds as much as 10 cm thick, with thin, black siliceous shale partings; locally contains barite deposits (b) in Cutaway Basin window (Kelley and others, 1993) and rare interbeds of calcareous radiolarite. Chert contains abundant radiolarians and lesser sponge spicules. In the Howard Pass C–5 quadrangle (table 1, locs. 7, 10), unit includes abundant interbeds 2–7 cm thick of brownish-black dolostone; these beds are probable turbidites made up of graded skeletal packstone rich in echinoderm debris. Locally includes subordinate red and green chert (table 2, loc. 84). Radiolarians are chiefly Late Mississippian but locally may be as old as late Early Mississippian (Osagean) and are as young as Early or Middle Pennsylvanian (Morrowan or Atokan) (table 2, locs. 4, 8, 9, 12, 20, 25, 28, 57, 76, 77, 84, 102, 128, 129; table 4, locs. 48 and 160; Mayfield and others, 1984, locs. 11, 12, and 16); the youngest ages come from beds lithologically gradational into the overlying Imnaitchiak Chert. Within the map area conodonts are Osagean (late Early Mississippian) and Meramecian (probably middle Meramecian; early Late Mississippian) (Dumoulin and others, 1993) (table 1, locs. 7, 10; table 4, locs. 30, 32, 40, 48). Osagean conodonts and radiolarians of middle Osagean to probably late Meramecian age are reported from the type section of the Akmalik to the east (Blome and others, 1998). These rocks formed in a deep-water, basinal setting. Type section 70 m thick, but in the map area unit generally is a few tens of meters thick at most. Dolostone-rich sections are as much as 100 m thick.

KELLY RIVER SEQUENCE
(CRETACEOUS TO DEVONIAN)

Kok **Okpikruak Formation (Lower Cretaceous (Valanginian and Berriasian))—**Dark-gray to grayish-tan mudstone, siltstone, graywacke sandstone, and local conglomerate; contains rare pelecypods (various species of *Buchia*) of Berriasian and early and late Valanginian age in the western Misheguk Mountain

quadrangle (Elder and others, 1989; Curtis and others, 1984). Intensely deformed and base structurally detached in places. Thickness unknown. Mapped only in one locality within a small structural window in the south-central part of the Misheguk Mountain C–1 quadrangle

Lisburne Group (Mississippian)

Mko **Kogruk Formation—**Light-gray-weathering limestone containing black chert nodules and lenses. Common fossils are Late Mississippian corals, crinoids, brachiopods, and foraminifers. To the west in the Misheguk Mountain and De Long Mountains quadrangles, unit contains conodonts and foraminifers of chiefly Meramecian (early Late Mississippian) age; in the Baird Mountains and Noatak quadrangles, the base of the unit may be as old as late Osagean (late Early Mississip-pian) (Dumoulin and Harris, 1992). Thickness variable and base gradational with underlying Utukok Formation in Misheguk Mountain quadrangle (Mayfield and others, 1984)

Mu **Utukok Formation—**Buff-weathering limestone and locally calcareous, fine-grained sandstone. Contains brachiopods, crinoids, and corals. In the map area the unit has produced conodonts of early Early Mississippian (middle to early late Kinderhookian) age (table 4, loc. 14; Dumoulin and Harris, 1997; see also table 1, loc. 35) as well as Early Mississippian brachiopods (Mayfield and others, 1984; table 2, loc. 39). Conodonts of Kinderhookian and Osagean age occur to the west and southwest; top of unit probably middle Osagean in the Baird Mountains quadrangle but late Osagean in the De Long Mountains quadrangle (Dumoulin and Harris, 1992; A.G. Harris, written commun., 1999). May represent a thin, discontinuous tongue below the Kogruk Formation, and may not have been deposited in some places within this sequence. Depositional thickness probably ranges from 0 to 80 m (Mayfield and others, 1984; Dumoulin and Harris, 1997). Base is probably gradational into Devonian limestone

Dlk **Limestone (Devonian)—**Light-gray limestone and dark-gray dolostone. Common fossils in and just west of the map area are Middle and Late Devonian brachiopods, stromatoporoids, and corals (Mayfield and others, 1984; table 2, locs. 37, 43, 45, 52). Thickness is less than 700 m in outcrops to the west. Occurs depositionally beneath the Utukok Formation in the Misheguk Mountain quadrangle (Mayfield and others, 1984). Called Baird Group by previous workers (for example, Mayfield and others, 1984, 1988) but differs from Baird Group in its type area in the Baird Mountains quadrangle in age, metamorphic grade, and stratigraphic and structural position. Type Baird Group is chiefly or entirely older (Ordovician to early Middle Devonian; mostly Early Devonian and older), metamorphosed (conodont CAI values greater than or equal to 5), grades upward into Devonian and Mississippian siliciclastic rocks (Endicott Group), and is nowhere contiguous with unit Dlk. Because depositional continuity of these rocks with type Baird Group has not been established, we here exclude them from that unit

IPNAVIK RIVER SEQUENCE (CRETACEOUS TO MISSISSIPPIAN)

KMi **Rocks of the Ipnavik River sequence, undivided (Cretaceous to Mississippian)—** Mapped tentatively in areas of limited or isolated exposure not examined in the field or identifiable by photo interpretation; unit assignment based on structural position of general sequence inferred from geologic relations mapped in surrounding areas

Koi **Okpikruak Formation (Lower Cretaceous (Valanginian and Berriasian))—**Dark-gray to grayish-tan mudstone, siltstone, graywacke sandstone, and local conglomerate containing cobbles and boulders of gabbro, fine-grained mafic

igneous rocks, light-gray diorite or granodiorite, light-gray micritic limestone, and gray to black chert. Contains various species of the pelecypod *Buchia* of Berriasian and middle and late Valanginian age in and just west of the map area (table 5, locs. 170–172, 178, 179, 181; Mayfield and others, 1984, table 2, loc. 54), in the eastern Howard Pass quadrangle, and in the central and western Misheguk Mountain quadrangle. Intensely deformed and base structurally detached in places. Thickness unknown

Kot **Tuff (Cretaceous)—**Light-gray-weathering tuffaceous beds of clay, plagioclase and quartz; occurs as thin, discontinuous beds 4 m or less thick within the Okpikruak Formation. Mapped by Mayfield and others (1984) only in several small layers in the southwest corner of the map area; thickness exaggerated on map

JMmi **Mafic sills and dikes (Jurassic? to Mississippian?)—**Typically dark- greenish-gray, mostly diabasic to gabbroic sills and dikes; composed mainly of plagioclase and augite. Abundant and locally voluminous within the Lower Mississippian Rim Butte unit of the Lisburne Group of Dumoulin and others (1993), and locally intrude rocks of the Etivluk Group. Comprises a characteristic component of the Ipnavik thrust sequence, but similar mafic rocks locally intrude rocks of the Etivluk Group in the Picnic Creek and Endicott thrust sequences. Generally altered; age uncertain, but permissible age range based on intrusive relations with rocks of the Lisburne and Etivluk Groups

JPii **Imnaitchiak Chert of Etivluk Group (Jurassic to Pennsylvanian)—**Gray to greenish-gray bedded chert or siliceous mudstone in beds 2–15 cm thick, with greenish-gray to distinctive maroon, siliceous, silty mudstone partings and interbeds. Distinguishable from Imnaitchiak Chert of Picnic Creek sequence only by stratigraphic association here in the Ipnavik sequence with underlying Rim Butte unit of the Lisburne Group of Dumoulin and others (1993). Contains mainly Pennsylvanian to Late Triassic radiolarians (Mull and others, 1987), but a few samples contain Jurassic radiolarians (C.D. Blome, written commun., 1994); ages obtained in the map area include middle Permian (probably Guadalupian), Late Triassic (Norian), and Early Jurassic (probably Pliensbachian or Toarcian) (table 2, locs. 46, 63, 81–83, 90, 93, 189; table 4, loc. 158; and Mayfield and others, 1984, table 2 locs. 7, 18, 19, 27, 30). The unit has also produced Early Triassic conodonts (Mayfield and others, 1984, table 2, loc. 30) and a Late Triassic (Norian) monotid bivalve (table 5, loc. 180). Typically is intensely deformed; commonly occurs as rubble. Thickness probably 75 m or less

Mlri **Rim Butte unit of Lisburne Group of Dumoulin and others (1993) (Mississippian)—**Generally thin-bedded and distinctively color-banded succession composed of lighter layers of limestone turbidite, interbedded with darker layers of siliceous, spiculitic mudstone like that in the Kuna Formation and lesser chert. Limestone, in beds 3–80 cm thick, makes up 15–70 percent of sections studied. Chert interbedded with limestone is mostly gray but locally red or green. Turbidites are mostly complete or incomplete Bouma sequences with the base missing, composed of abundant reworked and redeposited bioclasts (derived from shallow- and deep-water settings), sedimentary lithic clasts, and as much as 15 percent detrital quartz. Redeposited conodonts are mainly of late Kinderhookian age but include forms as old as Famennian (Late Devonian) and as young as Osagean. Much of unit appears to have a depositional age of early middle Osagean (lower part of *S. anchoralis–D. latus* Zone) but at least one section is no older than late Meramecian (Dumoulin and others, 1993), and the base of another section may be as old as early Early Mississippian (Kinderhookian) (table 1, locs. 2, 3, 24, 27, 29, 44, 52, 56, 59, 60, 64, 75, 89, 91, 92; table 4, locs. 29, 47, 49–51, 54, 55, 105). Early Mississippian ammonoid cephalopods from one locality were reported (table 5, loc. 163). Radiolarians from bedded

chert in the uppermost part of the unit are Mississippian (Osagean to Meramecian and Meramecian to Chesterian; table 2, loc. 1), and locally as young as late Meramecian(?)–Morrowan (Mayfield and others, 1984, table 2, loc. 28; Murchey and others, 1988, p. 705). At least 70–85 m thick in the map area. Base of unit generally faulted or not exposed; at two localities (in the Howard Pass C–5 and C–2 quadrangles), appears to overlie shale, siltstone, and quartz pebble conglomerate that contains late Late Devonian (upper Famennian) spores (table 5, loc. 161). Gradational upper contact with gray chert of the Etivluk Group observed locally

Mki **Kayak Shale of Endicott Group (Lower Mississippian)—**Dark-gray to black fissile clay shale containing subordinate but conspicuous yellowish-brown-weathering, thin, fossiliferous limestone interbeds near the top, and greenish-gray siltstone and sandy siltstone in the lower part. Mayfield and others (1984; table 2, loc. 31) reported a single conodont collection of latest Devonian–Early Mississippian (late Famennian–middle Osagean) age from this unit. Minimum thickness 45 m; typically complexly folded and pervasively sheared, especially near the structural base, where phyllitic textures and detachment from underlying rocks are common

SEQUENCE AFFINITY UNCERTAIN

Dl **Limestone (Devonian)—**Limestone and dolostone structurally detached from surrounding rocks; occurs most commonly at the base of the Ipnavik thrust sequence. Uncertain stratigraphic affinity. Most likely limestone detached from the Kelly River sequence and dragged along the base of the overriding Ipnavik River sequence during its tectonic emplacement, but could represent correlative rocks originally deposited under the Rim Butte unit of the Lisburne Group of Dumoulin and others (1993) within the Ipnavik River sequence. Chief rock types are peloidal supportstone, lime mudstone with locally well-developed fenestral fabric, and skeletal grainstone and packstone; megafossils are locally abundant and include brachiopods, corals, pelmatozoans, and stromatoporoids. Megafossils (table 3, locs. 23, 73, 74, 86, 87) and conodonts (table 1, locs. 23, 73, 74, 87, 88), where most tightly dated, are of Middle and early Late Devonian age. Sections are generally fault-bounded and less than 130 m thick

NUKA RIDGE SEQUENCE
(CRETACEOUS TO MISSISSIPPIAN)

KMn **Rocks of the Nuka Ridge sequence, undivided (Cretaceous to Mississippian)—**Mapped tentatively in areas of limited or isolated exposure not examined in the field or identifiable by photo interpretation; unit assignment based on structural position of general sequence inferred from geologic relations mapped in surrounding areas

Kon **Okpikruak Formation (Lower Cretaceous (Valanginian))—**Gray mudstone and minor greenish-gray, medium- to fine-grained lithic wacke, containing distinctive cannon-ball concretions in the Nuka Ridge area (Mayfield and others, 1984); intensely deformed and base structurally detached in places. Contains isolated specimens of the pelecypod *Buchia crassicollis solida* (middle to late Valanginian) in the map area (table 5, loc. 169). Thickness unknown

JPen **Etivluk Group (Middle Jurassic to Pennsylvanian)—**Assemblage of variegated but mostly black, gray, or greenish-gray bedded chert containing partings and subordinate interbeds of shale and siliceous shale. Typically is nintensely tectonically disrupted. Radiolarians, foraminifers, and conodonts of

Carboniferous-Permian age from this unit were reported (Mayfield and others, 1984; table 2, locs. 56–58)

IPMn **Nuka Formation (Pennsylvanian and Mississippian)—**Light-gray- to buff-weathering, coarse- to medium-grained arkose, arkosic limestone, and limestone. Contains locally abundant glauconite and rare hematite-cemented beds. Arkose consists of quartz with potassium and plagioclase feldspars apparently derived from a southern source. The upper part of the Nuka was previously dated by brachiopods identified as Permian (Tailleur and others, 1973), but more recent collections of conodonts from the top of the structurally highest beds at Nuka Ridge are no younger than Early Pennsylvanian (A.G. Harris, written communication, 1982, cited in Mayfield and others, 1984). Late Mississippian–Early Pennsylvanian conodonts and foraminifers occur in the map area (Mayfield and others, 1984; table 2, locs. 55–58) and throughout the western Brooks Range. Depositional thickness is estimated to range from a few meters to 300 m. Base is gradational into Kayak Shale

Mkn **Kayak Shale of Endicott Group (Lower Mississippian)—**Dark-gray shale, interbedded with orange-weathering limestone, siltstone, and minor fine-grained sandstone. Contains Mississippian foraminifers and brachiopods. Maximum stratigraphic thickness estimated by Mayfield and others (1984) to be 350 m. Basal contact is a thrust fault, along which the unit is cut out completely in many places

COPTER PEAK SEQUENCE
(CRETACEOUS? TO DEVONIAN)

KJmv **Volcaniclastic rocks of Memorial Creek (Cretaceous? and Jurassic?)—** Predominantly volcaniclastic rocks and subordinate associated mafic to intermediate volcanic rocks, mapped only in the Memorial Creek area along the east-central edge of the map area. Unit has some lithologic similarities to the Okpikruak Formation in other thrust sequences and a similar degree of induration. Contains Early(?) Jurassic (Sinemurian? or Pliensbachian?) radiolarians at one locality (table 2, loc. 134)

JDbc **Basalt (Jurassic? to Devonian?)—**Greenish-gray, vesicular, and amygdaloidal, locally pillowed basalt; also contains minor volcanic breccia, tuff, and volcaniclastic rocks, as well as lenses or interpillow intercalations of radiolarian chert and fossiliferous limestone. In Memorial Creek area, chert contains Middle and Late Triassic, Permian(?), and pre-Permian (Mississippian?) radiolarians (table 2, locs. 137–139, 141), and limestone contains early Early Mississippian (Kinderhookian) conodonts (table 4, loc. 140). At Siniktanneyak Mountain, limestone and volcaniclastic rocks contain Permian brachiopods (table 3, loc. 103; table 4, loc. 97); other limestone pods yielded megafossils and conodonts of chiefly early Late Devonian (Frasnian, locally middle Frasnian) age (table 1, locs. 111,112; table 4, locs. 111–114; table 5, loc 186; Nelson and Nelson, 1982). Chert (locally interpillow?) on the east and west sides of Siniktanneyak contains Triassic and Early(?) Jurassic radiolarians (table 2, locs. 96, 104, 108–110). Assignment of the Siniktanneyak and Memorial Creek basalt exposures to one long-lived unit is tentative and based on similarities in petrologic character and structural occurrence, and because the age distribution of the unit is poorly known in both areas

PDlc **Limestone (Permian and Devonian)—**Mapped mainly west and northwest of Siniktanneyak Mountain. Brownish- to light-gray, fine-grained limestone, correlative with small limestone lenses included in unit JDbc. One occurrence contains numerous prisms apparently derived from shells of the Permian bivalve *Atomodesma* sp. (table 3, loc. 98); the other yields early Late Devonian (Frasnian) conodonts (table 4, loc. 99)

MISHEGUK SEQUENCE
(MIDDLE? JURASSIC)

Jsu **Igneous complex of Siniktanneyak Mountain, undivided (Middle? Jurassic)—** Predominantly mafic and ultramafic rocks considered by most workers to represent an essentially complete ophiolite sequence; grades upward from tectonized and serpentinized mantle peridotite, dunite, harzburgite, and lherzolite at the base, through a crustal sequence of cumulate ultramafic rocks and layered gabbro, massive gabbro, high-level felsic igneous differentiates, and sheeted diabase dikes, and capped by basalt and minor silicic tuffs (Nelson and Nelson, 1982; Bickerstaff, 1994). The mantle sequence has petrologic, geochemical, and geophysical characteristics of the upper part of oceanic mantle; a Middle Jurassic U-Pb age of 170±3 Ma was reported by Moore and others (1993). Crustal rocks have petrochemical signature transitional between MORB and an island-arc setting. Bickerstaff (1994) suggested a cogenetic tholeiitic origin within an active intra-arc basin for the igneous complex of Siniktanneyak Mountain.

Six map units, listed from high-level to deep-level intrusive settings, are distinguished in places:

Jsb **Basalt—**Predominantly brown to greenish, vesicular and amygdaloidal basalt containing broken pillow breccia in places; bedded silicic tuff containing soft-sediment deformation features found at one locality

Jsf **Felsic intrusive rocks—**Typically ranges from diorite to hornblende-plagiogranite in composition; alaskite dikes also common. Formed above, and by differentiation from, massive gabbro (unit Jsg). Locally intruded by late-stage diabase dikes. Nearly 2 km thick in places

Jsd **Diabase—**Occurs as localized swarms of subparallel dikes as much as 2 m thick and having chilled margins; two distinct generations of dikes reported by S.W. Nelson (written commun., 1994)

Jsg **Massive gabbro—**Predominantly grayish-weathering, medium- to coarse-grained, hypersthene-bearing hornblende-pyroxene-gabbro having generally directionless texture but well-developed mineral banding in places. Grades downward into layered gabbro (unit Jslg)

Jslg **Layered gabbro—**Predominantly gray-green cumulate gabbro that includes interlayered ultramafic rocks in the lower part; banding typically expressed by melanocratic and leucocratic layers. As much as 4 km thick

Jsdh **Dunite and harzburgite—**Orange-weathering dunite predominates, but harzburgite common in places; also includes lesser amounts of lherzolite, serpentinized peridotite, and olivine pyroxenite; most lithologies typically tectonized and foliated, especially near the structural base of the complex

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BIOSTRATIGRAPHIC DATA FROM THE WEST-CENTRAL PART OF THE HOWARD PASS QUADRANGLE

By Julie A. Dumoulin, Anita G. Harris, Charles D. Blome, *and* Katherine M. Reed

Numerous biostratigraphic collections, mainly conodonts and radiolarians, were made during the 1990's to support geologic mapping in the west-central Howard Pass quadrangle. These collections tightly constrain ages of many of the map units, and they provide additional data on topics ranging from depositional environments to thermal history and tectonic disruption of the rocks in this area. This section presents previously unpublished biostratigraphic data from 128 localities and summarizes previously published data from an additional 61 localities.

DATA SOURCES

Most of the fossil specimens tabulated herein were collected, examined, and identified (chiefly by paleontologists of the U.S. Geological Survey) during the past 20 years; these data are presented in tables 1–4. Data not previously published appear in tables 1 (conodonts), 2 (radiolarians), and 3 (megafossils); previously published data—chiefly conodonts but also some radiolarian and megafossil data—are summarized in table 4. Data in these tables are mostly limited to collections made and identified since 1978, and published since 1982. Primary published sources are Nelson and Nelson (1982), Murchey and others (1988), Dumoulin and others (1993, 1994), Kelley and others (1993), Baxter and Blodgett (1994), Dumoulin and Harris (1997), and Mull and others (1997). Mayfield and others (1984; table 2) summarized paleontologic data from the eastern Misheguk Mountain quadrangle; these data are referred to where appropriate under unit descriptions for the geologic map but are not reprinted below.

About 100 fossil collections (chiefly megafossils) were made during previous mapping efforts in the west-central Howard Pass quadrangle, mainly during the 1950's. The sites of many of these older collections can be only approximately located on modern topographic maps, and the rock units sampled by some collections are uncertain. Table 5 presents the most useful of these early collections that could be accurately located by using original field station maps; most of the fossils were identified by paleontologists of the U.S. Geological Survey during the 1950's and have not been re-examined since that time. About half of the collections have never been previously published. Sixteen collections are Mesozoic pelecypods that were included in a regional data base compiled by Elder and others (1989); these authors did not re-examine the collections to verify the original identifications.

Fossil data from the west-central Howard Pass quadrangle published prior to 1982 are limited. Several Mississippian cephalopod collections were described by Gordon (1957), a few Mississippian coral collections were listed by Armstrong (1970, 1975), several localities yielding fragments of Triassic vertebrate fossils were mentioned by Tailleur and others (1973), and a single Jurassic pelecypod collection was described by Imlay and Detterman (1973). Where original collection localities could be verified, data from these publications are included in table 5.

All tables presenting previously unpublished fossil data (tables 1–3, 5) include lithologic descriptions of the rocks that contained the fossils if these data were available. Petrographic descriptions based on thin section examinations of the sampled lithologies (by J.A. Dumoulin) are also provided for most of the conodont and a few of the radiolarian collections (tables 1, 2). Table 1 also includes weights of most of the samples processed for conodonts and any unusual features noted in the heavy mineral residues. Localities of virtually all fossil collections presented here were verified using original field maps and notes of the geologists that collected them; the verified points were then digitized and latitudes and longitudes of the locations were generated. In some cases, previously published latitudes and longitudes and (or) map locations were incorrect; corrected locations are noted by an asterisk in tables 4 and 5.

IMPLICATIONS OF DATA

It is beyond the scope of this text to discuss all the implications of the fossil data contained in these tables, but a few key findings concerning depositional environments, biogeography, and thermal and tectonic history are summarized here. Conodonts and radiolarians in particular provide information on depositional environments of the rocks in which they occur. Conodonts in the Howard Pass quadrangle have been found chiefly in carbonate rocks of Devonian and Mississippian age. Biofacies of Devonian conodonts indicate shallow-water carbonate platform settings, but Mississippian biofacies reflect a wide range of depositional environments. These include high-energy shallow

marine (Isikut unit), carbonate platform (Bupto facies, Rough Mountain Creek unit), and deep-water slope and basin (Kuna Formation, Akmalik Chert, Rim Butte unit) (Dumoulin and others, 1993, 1994; Dumoulin and Harris, 1997; Mull and others, 1997) and imply a complex paleogeography for this area during Mississippian time. In the west-central Howard Pass quadrangle, Mississippian shallow-water carbonate build-ups are short-lived (Rough Mountain Creek unit) and (or) areally restricted (Bupto facies) and occur only locally within the Endicott sequence. Coeval neritic carbonate rocks are much more abundant west of the map area, in the Kelly River sequence, and to the east, in the Endicott sequence.

Mississippian through Jurassic rocks in the Picnic Creek and Ipnavik River sequences consist mainly of chert and siliceous mudstone, but tightly-dated radiolarian faunas recovered from these rocks represent relatively restricted time intervals. Faunas are mainly of Late Mississippian, middle Permian, and Middle and Late Triassic ages; the oldest faunas are late Early–early Late Mississippian (Osagean-Meramecian; table 2, locs. 1, 9, 28; table 4, loc. 160) and the youngest are late Early Jurassic (Pliensbachian or Toarcian; table 2, locs. 81, 82). Radiolarian distribution throughout the Brooks Range (for example, Murchey and others, 1988) shows similar patterns and may have had both global (oceanographic) and local (tectonic and paleogeographic) controls. Radiolarian-rich strata in Paleozoic and Mesozoic oceans formed beneath high-productivity zones with little siliciclastic dilution (Murchey and others, 1988). Thus, intervals not represented by radiolarian faunas in the map area (middle Pennsylvanian–early Early Permian; Early Triassic) could reflect times of increased siliciclastic input due to uplift and erosion of adjacent landmasses and (or) reduced nutrient availability caused by changes in oceanic circulation. Closely spaced biostratigraphic samples through chert-rich sections are needed to address these questions.

Chert sequences throughout the Brooks Range record a pronounced lithologic change during Carboniferous time. Black or dark-gray chert interbedded with pelagic limestone (Akmalik Chert, upper parts of the Kuna Formation and Rim Butte unit) are overlain by medium- or light-gray, green, and locally maroon chert interbedded with noncalcareous mudstone (Siksikpuk Formation, Imnaitchiak Chert). Radiolarian data from the west-central Howard Pass quadrangle support the contention of Murchey and others (1988) that this lithologic change is diachronous and occurs earlier in structurally higher allochthons (sequences). Gray, green, and red chert as old as late Early–early Late Mississippian is found locally in the Picnic Creek and Ipnavik River sequences (for example, table 2, locs. 1, 20, 28, 128), whereas in the Endicott sequence, this lithologic transition generally takes place in rocks no older than latest Mississippian or Early Pennsylvanian (table 2, loc. 115).

Paleozoic fossils elsewhere in Alaska have yielded abundant biogeographic data; for example, lower Paleozoic strata from the southern Brooks Range contain microfossils and megafossils characteristic of both Siberian and Laurentian (North American) biotic provinces (Blodgett, 1998; Dumoulin and others, 2002). The Howard Pass fossils documented here yield only limited data of this type. Deep-water faunas, and most conodont faunas of Devonian and Carboniferous age, are relatively cosmopolitan. Megafossils from the map area do provide some evidence of the "mixed" biogeographic affinities seen in southern Brooks Range faunas. Middle Devonian brachiopods (table 3, loc. 74) have Siberian affinities (Baxter and Blodgett, 1994), but Early Devonian (Pragian?) corals (table 3, loc. 23) are known elsewhere only from cratonal North America (Road River Formation, Yukon Territory; W.A. Oliver, written commun., 1993). Mississippian plants found in chert and sandstone of the Kelly River and Picnic Creek sequences east and west of the map area have Angaran (Siberian) affinities (Spicer and Thomas, 1987).

Biogeography of Mesozoic fossils from the map area has been little studied, but some forms do provide useful data. Late Triassic bivalves (various species of *Monotis*) found in the Howard Pass quadrangle and in coeval strata throughout the Brooks Range represent middle, possibly high-middle, northern paleolatitudes (Silberling and others, 1997). Jurassic ammonites (Pliensbachian and younger) found west of the map area and in the northeastern Brooks Range belong mostly to the Boreal realm (Imlay and Detterman, 1973).

Conodonts provide data on thermal history of the rocks that contain them (Epstein and others, 1977). Values of conodont color alteration indices (CAI) for Devonian and Carboniferous strata in the west-central Howard Pass quadrangle range from 1 to 4, and have a bimodal distribution; about half of the ≈100 values determined fall in the range 1–2, and the other half have values of 3–4. Howard Pass CAI values include some of the lowest reported for Paleozoic strata in the western and central Brooks Range; Paleozoic CAI values < 2 are rare west of the eastern Misheguk Mountain quadrangle and east of

the western Killik River quadrangle. A CAI value of 1 indicates a temperature range of <50–80° C; a CAI value of 4 indicates a range of 190–250° C (the temperature ranges for CAI values were determined from the Ahrrenius plot of the experimental data of Epstein and others, 1977). CAI temperature values can be converted to equivalent burial depths for a given vertical geothermal gradient; for example, in the Appalachian basin, overburden of <1,220 m produced CAI values of 1 in Ordovician rocks whereas overburden of 5,490–7,930 m produced CAI values of 4 (Harris and others, 1987). Total stratigraphic thickness of the Pennsylvanian through Lower Cretaceous section overlying Mississippian strata in the Howard Pass area has been estimated as generally less than 1,500 m, although locally (in the Ipnavik River sequence) thicknesses as great as 3,200 m may have been reached (Mayfield and others, 1988).

Harris and others (1987) interpreted CAI values for the western parts of the Misheguk Mountain and Baird Mountains quadrangles as related to tectonic burial and not to prethrust burial metamorphism, because CAI values for coeval rocks in these areas increase downward through the stack of thrust sheets. CAI data from the Howard Pass quadrangle appear to show no such pattern; conodont CAI values for Mississippian rocks are not generally higher in lower thrust sheets. Both low (1–1.5) and high (3–4) values have been determined for conodonts from thrust sheets interpreted by Mayfield and others (1988) as representing low and high structural levels. For example, conodonts from the Kuna Formation (Endicott sequence; presumed low structural level) have CAI values of 1.5–2 at locality 21 (table 1) but CAI values of ≈3 at locality 146 (table 1). Conodont CAI values for the Rim Butte unit (Ipnavik River sequence, high structural level) range from 1 (table 1, loc. 27) to 3–4 (table 4, loc. 50). Conodont CAI values for the map area do appear to reflect a rough geographic gradient; values for a given unit in the same sequence are generally higher in the south and lower to the north-northwest. Igneous activity may have produced anomalously high CAI values locally (for example, Rim Butte unit samples near mafic sills, table 4, loc. 47; limestone intercalated with basalt in the Copter Peak sequence, table 4, loc. 112) and may indicate regional increases in the geothermal gradient during certain time intervals.

Paleontologic data from the west-central Howard Pass quadrangle also bears on the tectonic history of this area. For example, Mississippian conodonts from the Ipnavik River sequence support the hypothesis of large-scale transport of thrust sheets. The Rim Butte unit represents a large volume of carbonate turbidites of middle Osagean age that also contain redeposited Kinderhookian and Famennian conodonts; conodonts of all three ages are (at least in part) derived from a shallow-water setting. But there are few shallow-water rocks of appropriate age presently exposed in the map area that could have been a source for these abundant turbidites. The Kelly River sequence, however, widely exposed west of the Howard Pass quadrangle, contains strata of suitable age, biofacies, and lithofacies to produce the Rim Butte turbidites (Dumoulin and others, 1993). Because the easternmost exposures of the Rim Butte unit in the map area are at least 75 km east of the easternmost exposures of the Kelly River sequence, this interpretation of the provenance of the Rim Butte unit supports the idea of significant (and at least partly east-directed) thrust sheet movement.

Mesozoic bivalves also have implications for tectonic reconstruction of rocks in the Howard Pass area. *Buchia* species—widely distributed in Upper Jurassic and Lower Cretaceous strata throughout the northern Brooks Range—are useful stratigraphic markers in rocks of late Oxfordian through late Valanginian age (Imlay, 1955, 1961). *Buchia* species of Late Jurassic, Berriasian, and early and middle to late Valanginian ages have been found in the Okpikruak Formation in the west-central Howard Pass quadrangle (table 5, locs. 162, 167–172, 178, 179, 181–185, 188) and in the Misheguk Mountain and De Long Mountains quadrangles to the west (Elder and others, 1989). A preliminary comparison of *Buchia* species distribution (Elder and others, 1989) in the Okpikruak Formation of various thrust sheets in these quadrangles (Curtis and others, 1984; Ellersieck and others, 1984, 1990; Mayfield and others, 1984; 1990) suggests some interesting patterns. *Buchia* species of Berriasian and Valanginian age occur in thrust sheets of the Endicott Mountains, Kelly River, and Ipnavik River sequences; only Valanginian species are reported in samples from the Picnic Creek and Nuka Ridge sequences. Pelecypods that may be as old as Jurassic are reported from thrust sheets of the Endicott sequence in the Howard Pass quadrangle (table 5, loc. 188; Imlay and Detterman, 1973; Elder and others, 1989), and also from thrust sheets of uncertain structural position to the west (for example, Mayfield and others,1990, table 3, loc. 5). Within thrust sheets of the same sequence, however, younger species of *Buchia* generally occur to the north and east.

Mayfield and others (1988, p. 166) stated that the lowermost part of the Okpikruak Formation appears to be older in structurally higher thrust sheets

and younger in structurally lower sheets. The data outlined above do not support this contention, although it must be noted that stratigraphic position of most of the pelecypod collections we considered was not specified, and species identification (and thus age assignment) of some of the older collections is uncertain. Jones and Grantz (1964) suggested that some *Buchia* specimens previously identified as late Valanginian forms may actually be Berriasian species, and species assignment of some specimens that may be as old as Jurassic is uncertain (for example, table 5, loc. 188). A thorough study of the composition and stratigraphic and structural position of the *Buchia* faunas in the western Brooks Range would be very useful in establishing regional patterns of distribution and age, and more precise timing of deformation.

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TABLES 1–5

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
2 Mlri	**Howard Pass C-5** 68°44'45"/ 158°55'35"	1 Pa element fragment *Bactrognathus excavatus* Branson and Mehl. 16 Pa elements *Bispathodus stabilis* (Branson and Mehl) or *Bi. utahensis* Sandberg and Gutschick. 1 "*Hindeodella*" *segaformis* Bischoff s.f. bar fragment. *Idioprioniodus conjunctus* (Gunnell), 6 Pa, 3 M, 6 Sa, and 18 Sb-Sc elements. *Kladognathus* sp., 3 P, 8 M, 4 Sa, and 7 Sb-Sc elements. 17 Pa elements *Polygnathus communis cairna* Hass. 2 Pa fragments *Polygnathus* spp. indet. 1 Pa element fragment *Pseudopolygnathus pinnatus* (Voges). 2 *Scaliognathus praeanchoralis* Lane, Sandberg, and Ziegler fragments. 6 Pb elements *Scaliognathus* sp. indet. 48 indet. bar, blade, and platform fragments. <u>Redeposited late Kinderhookian conodonts</u>: 13 Pa elements *Pseudopolygnathus primus* Branson and Mehl. 3 incomplete Pa elements *Siphonodella isosticha* (Cooper). 5 Pa element fragments *Siphonodella* sp. indet. <u>Redeposited late Kinderhookian or early Osagean conodonts</u>: 8 Pa elements *Gnathodus punctatus* (Cooper). <u>Unassigned elements</u>: 5 Pb (3 morphotypes) and 9 M (4 morphotypes). CAI=1.5–2 [92AD50C; 32447–PC]	No older than late Early Mississippian; *Sc. anchoralis-Do. latus* Zone (middle Osagean) along with redeposited Kinderhookian and possibly early Osagean conodonts. This species association and mixture of biofacies and ages is characteristic of the Rim Butte unit.	Mixed biofacies and age; outer shelf or deeper water depositional setting, probably a turbidite.	Possibly graded-bedded, partly silicified limestone rich in crinoid columnals. Thin section is medium- to coarse-grained, poorly sorted, diverse skeletal grainstone. Bioclasts chiefly crinoid ossicles (20–40 percent), along with lesser bryozoans, foraminifers, siliceous sponge spicules, brachiopod fragments, and ostracodes; lithoclasts include glauconite, micrite, noncalcareous (locally spiculitic) mudstone, and phosphate. Collected ≈15 m below top of ≈50- to 60-m-thick section of unit Mlri. Stratigraphic up seems to be to the south, based on sedimentary structures; section could be structurally thickened. If section is depositionally continuous, 92AD52A (loc. 3) should be near top and 50C should be near bottom. This is the furthest northwest exposure of unit Mlri in the Howard Pass 1:250,000 quadrangle. Heavy-mineral concentrate includes phosphatic brachiopod fragments. Processed 10.1 kg of rock.

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
3 Mlri	**Howard Pass C-5** 68°43'55"/ 158°55'00"	57 Pa elements *Bispathodus utahensis* Sandberg and Gutschick? 7 "*Hindeodella*" *segaformis* Bischoff s.f. bar fragments. *Idioprioniodus conjunctus* (Gunnell), 2 Pa, 6 Pb, 5 M, 2 Sa, and 8 Sb-Sc elements. *Kladognathus* sp., 6 P, 12 M, 6 Sa, and 20 Sb-Sc elements. 20 Pa elements *Polygnathus communis* Branson and Mehl. 1 *Scaliognathus praeanchoralis* Lane, Sandberg, and Ziegler? fragment. 20 indet. bar, blade, and platform fragments. <u>Redeposited late Kinderhookian conodonts</u>: *Siphonodella* sp. indet., 4 juvenile Pa and 2 Pb elements. <u>Unassigned elements</u>: 6 Pb (3 morphotypes), 11 M (3 morphotypes), and 3 Sc (3 morphotypes). CAI=1.5–2 [92AD52A; 32448–PC]	No older than late Early Mississippian; *Sc. anchoralis-Do. latus* Zone (middle Osagean) along with redeposited Kinderhookian conodonts. This species association and mixture of biofacies and ages is characteristic of the Rim Butte unit.	Mixed biofacies and age; outer shelf or deeper water depositional setting, probably a turbidite.	Very fine grained, medium- to medium-dark-gray limestone containing fine-grained skeletal debris. Thin section is skeletal pack/grainstone; bioclasts mostly (80 percent) calcareous sponge spicules (to 3 mm long). Other grains include bryozoan, brachiopod and crinoid fragments, ostracode valves, and rounded clasts of noncalcareous mudstone. Collected from ≈10 m below rubble of mafic igneous sill, stratigraphically above(?) 92AD50C (loc. 2). Heavy-mineral concentrate includes ferruginous spines and spicules. Processed 11.2 kg of rock.
7 IPMap	**Howard Pass C-5** 68°39'15"/ 158°46'05"	2 Pa fragments *Bispathodus utahensis* Sandberg and Gutschick. 1 Pa element *Gnathodus pseudosemiglaber* Thompson and Fellows. 2 Pa element fragments *Gnathodus* sp. indet. 1 small bar fragment "*Hindeodella*" *segaformis* Bischoff s.f. 43 indet. bar, blade, and platform fragments. CAI=1.5 [92ADo274B; 32466–PC]	late Early Mississippian; within upper part of *Sc. anchoralis-Do. latus* Zone (middle Osagean).	Indeterminate (too few conodonts); slope or deeper water winnow.	Fine-grained, reddish-brown-weathering dolostone interbedded with ≈50 percent medium-dark-gray, ≈0.5-cm-thick (or less) chert layers containing sponge spicules. Thin section is dolomite crystal mosaic (crystals euhedral to subhedral; 20–150 µm in diameter) with irregular zones of chert locally rich in siliceous sponge spicules. Rocks here are an unusually carbonate-rich facies of unit IPMap. Lithologically similar to 92ABs180A (loc. 10) and to thin-bedded chert/dolostone at Lisburne Ridge (northeastern Howard Pass 1:250,000 quadrangle). Processed 9.6 kg of rock. Interbeds of medium- to dark gray chert (92ADo274A) contained corroded fragments of sponge spicules but no identifiable radiolarians.

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
10 PMap	**Howard Pass C-5** 68°37'50"/ 158°52'40"	All conodonts are small fragments and heavily coated and invaded by organic matter making CAI difficult to determine. 3 Pa element fragments *Bispathodus stabilis* (Branson and Mehl) or *Bi. utahensis* Sandberg and Gutschick. 51 indet. bar, blade, and platform fragments. CAI= ≈2 [92ABs180A; 32467–PC]	Mississippian; Kinderhookian-Meramecian (the age of sample 92ADo274B is middle Osagean).	Indeterminate (too few conodonts).	Dark-brownish-gray to brownish-black, light-gray- to slightly brownish-weathering, mostly micritic dolostone (some skeletal supportstone with clasts of brown mudstone) and dark-gray to black chert containing locally preserved, rare to abundant crinoid fragments; chert and dolostone interlayered (50:50) in 2- to 7-cm-thick beds. Sample from rubble at very top of ≈100-m-thick section of unusually carbonate-rich facies of unit PMap. Rocks are similar to basal part of section at Lisburne Ridge; also resembles unit Mlri but is dolomitized and does not contain sills. Samples 92ADo274B (loc. 7) and 92ADo275 (table 2, loc. 8) are also from this facies. Heavy-mineral concentrate is chiefly barite(?) euhedra with intergrowths of dolomite rhombs. Processed 11.5 kg of rock. Chert overlying(?) this facies at this locality (92ABs180B; table 2) produced Late? Triassic radiolarians
21 PMk	**Howard Pass C-5** 68°35'45"/ 158°27'20"	All conodonts partly coated and invaded by organic matter. 2 Pa element fragments *Gnathodus pseudosemiglaber* Thompson and Fellows? <u>Unassigned elements</u>: 2 Pb (2 morphotypes), 1 digyrate Pb? of Osagean morphotype, 1 Sa, and 1 Sc 42 indet. bar, blade, and platform fragments CAI=1.5–2 [92AD59A; 32452–PC]	late Early–early Late Mississippian; *Po. mehli*–lower *G. texanus* Zone through Lower *Cavusgnathus* Zone (late Osagean through Meramecian) on the basis of conodonts in underlying sample (92AD59AA); probably late Osagean.	Indeterminate (too few conodonts); mid-shelf or deeper water depositional environment.	Sample from 3- to 6-cm-thick bed of fine-grained, dark-gray, very light gray to medium-gray-weathering, very fetid limestone that has a ghostly texture of black spheroids (calcitized radiolarians?). Thin section is calcite crystal mosaic that contains relict, carbonate-replaced radiolarians. Sample taken ≈3 m below top of ≈30-m-thick section (poorly exposed and could be folded) mostly black chert (and (or) silicified mudstone) but including silty bands and spicules and ≈20–30 percent limestone. Uppermost part of section is light-gray chert that contains radiolarians of Mississippian? age (92AD59G, table 2). Processed 8.8 kg of rock.
		All conodonts partly coated and invaded by organic matter. 3 Pa elements *Gnathodus texanus* Roundy. 23 indet. bar, blade, and platform fragments. CAI=1.5–2 [92AD59AA; 32453–PC]	late Early–early Late Mississippian; *Po. mehli*–lower *G. texanus* Zone through Lower *Cavusgnathus* Zone (late Osagean through Meramecian); probably late Osagean.	Indeterminate (too few conodonts); mid-shelf or deeper water depositional environment.	Lithologically similar to 92AD59A, but a thicker bed (15–35 cm) that has obvious parallel and cross laminae on weathered surface. Thin section is calcite-replaced-radiolarian packstone that contains lesser sponge spicules; matrix is noncalcareous mud. Collected ≈15 m below 92AD59A. Heavy-mineral concentrate includes barite(?) and minor fluorite. Processed 9.3 kg of rock.

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
23 Dl	**Howard Pass C-4** 68°32'53"/ 158°06'35"	Unassigned elements: 1 Pb (Devonian and Mississippian morphotype), 1 M, 1 Sb, and 1 Sc elements. 11 indet. bar, blade, and platform fragments. CAI=1.5 [92AD43D]	Devonian-Mississippian	Indeterminate (too few conodonts).	Sample from 4-cm-thick, evenly bedded, brownish-gray, peloidal lime grainstone containing possible mud intraclasts. Thin section is peloid-skeletal grainstone with abundant calcispheres and local fenestral fabric. Collected from unnamed Devonian limestone unit (Dl), near base of ≈20-m-thick section of carbonate mudstone overlying less resistant, ≈4-m-thick fossiliferous interval. Processed 9.6 kg of rock.
		3 *Dvorakia* sp. elements. 6 Pa fragments of an ozarkodinid. 91 *Panderodus* spp. elements. 2 S (coniform) elements *Pelekysgnathus* sp. indet. 6 indet. bar, blade, and platform fragments. CAI=1.5 [92AD43E; 12466–SD]	Early–Middle Devonian; corals restrict age to Pragian-Eifelian (middle Early–early Middle Devonian).	Panderodid biofacies; shallow-water shelf, relatively normal-marine depositional environment.	Brownish-gray, grayish-orange-weathering, fossiliferous lime wackestone to packstone containing bryozoans and corals. Forms matrix to abundant large colonial corals of Pragian-Eifelian age (see table 3 for megafossil data). Thin section is coralline pack/wackestone that has a dolomitic matrix. Collected from unnamed Devonian limestone unit (Dl), at about middle of ≈4-m-thick fossiliferous interval underlying carbonate mudstone. Processed 9.2 kg of rock.
24 Mlri	**Howard Pass C-3** 68°38'20"/ 157°32'30"	1 Pa element *Bispathodus stabilis* (Branson and Mehl) or *B. utahensis* Sandberg and Gutschick. 1 Pa element *Polygnathus purus* Voges. Unassigned elements: 1 M and 1 Sa. 9 indet. bar, blade, and platform fragments. CAI=1–1.5 [92AD22A; 32428–PC]	early Early Mississippian (Kinderhookian).	Indeterminate (too few conodonts); normal-marine depositional environment.	Fine-grained limestone with abundant small burrows. Thin section is calcareous peloidal spiculite that contains calcispheres and brown mud clasts. Sample collected from very fine grained rock (periplatform ooze?) and may contain relatively indigenous faunas. Probably stratigraphically below samples at locality 27. If fauna is not reworked, this sample and that from locality 52 are the oldest recovered from unit Mlri.
27 Mlri	**Howard Pass C-3** 68°38'10"/ 157°31'40"	1 juvenile Pa element *Gnathodus texanus* Roundy? 1 unassigned Pb element. 4 indet. bar, blade, and platform fragments. CAI=1 [92AD20–4.5; 32425–PC]	latest Early–Late Mississippian; late Osagean (*Po. mehli*–Lower *G. texanus* Zone)–early Chesterian.	Indeterminate (too few conodonts); normal-marine depositional environment.	Platy, dark-brownish-gray, grayish-orange-weathering, fine-grained limestone riddled with tiny burrows; about 4.5 m below top of 42-m-thick section of unit Mlri. Thin section is spiculite; spicules chiefly siliceous (some calcareous) in a fine-grained carbonate matrix containing muddy wisps and burrow fills and minor radiolarians. Sample collected from very fine grained rock (periplatform ooze?) and may contain relatively indigenous faunas. Processed 8.5 kg of rock.

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
27 Mlri [cont.]	**Howard Pass C-3** 68°38'10"/ 157°31'40"	121 Pa elements *Bispathodus utahensis* Sandberg and Gutschick (all large and partly incomplete). 1 Pa element *Doliognathus latus* Branson and Mehl. 5 *Idioprioniodus* sp. indet. element fragments. 17 incomplete Pa elements of *Pseudopolygnathus* spp. <u>Unassigned elements</u>: 7 robust Pb (Osagean morphotype) and 1 M. 11 indet. bar, blade, and platform fragments. <u>Redeposited middle-late Kinderhookian conodonts</u>: 1 Pa element *Polygnathus inornatus* E.R. Branson. 2 Pa element fragments *Siphonodella* sp. indet. <u>Redeposited Famennian conodonts</u>: 1 Pa element *Palmatolepis* sp. CAI=1.5 [92AD20–14.5; 32426–PC]	No older than late Early Mississippian; *Sc. anchoralis-Do. latus* Zone (middle Osagean or younger) along with redeposited Famennian (late Late Devonian) and middle-late Kinderhookian conodonts. This assemblage is typical of the Rim Butte unit of the Lisburne Group.	Lag concentrate or turbidite. Postmortem transport from or within the bispathodid biofacies.	Crinoidal lime pack/grainstone (probable gravity flow deposit) about 14.5 m below top of 42-m-thick section. Thin section is crinoidal pack/grainstone with lesser bryozoans, siliceous sponge spicules, ostracodes, gastropods, brachipod fragments, echinoderm spines, and phosphatic bioclasts; minor noncalcareous mud clasts, glauconite, and dolomite. Sample collected from carbonate turbidites (and thus may contain reworked faunas). Processed 7.0 kg of rock.
	Howard Pass C-3 68°38'10"/ 157°31'50"	10 Pa elements *Bispathodus utahensis* Sandberg and Gutschick (all large and partly incomplete). 2 Pa elements *Gnathodus punctatus* (Cooper). 2 Pa element fragments *Polygnathus* spp. indet. 6 incomplete Pa elements *Pseudopolygnathus* spp. 2 M elements of Osagean morphotype. 62 indet. bar, blade, and platform fragments. CAI=1.5 [92AD220–23; 32427–PC]	Early Mississippian; late Kinderhookian to earliest Osagean (Lower *G. typicus* Zone) if *G. punctatus* is indigenous.	Bispathodid-pseudopolygnathid; open-marine, middle shelf or deeper water depositional environment.	Sample from 60-cm-thick graded bed of crinoid-rich limestone about 40 m below top of 42-m-thick section; fault cuts section about 25 m above base. Thin section is skeletal grainstone containing 5–10 percent lithic clasts. Bioclasts are 90 percent crinoid ossicles, minor fragments of bryozoans, brachiopods, and ostracodes, and rare echinoderm spines. Lithic clasts include calcareous and siliceous spiculite, lime mudstone, and peloidal-calcisphere pack/grainstone. Sample collected from carbonate turbidites (may contain reworked faunas). Processed 6.3 kg of rock.
29 Mlri	**Howard Pass C-3** 68°35'55"/ 157°41'00"	3 Pa elements of *Bispathodus stabilis* (Branson and Mehl). 1 incomplete juvenile Pa element of *Gnathodus* sp. indet. 1 Sa element fragment of *Kladognathus* sp. indet. 2 unassigned Pb elements. 21 indet. bar, blade, and platform fragments. CAI=2 [91AD11J; 31744–PC]	late Early Mississippian (late Kinderhookian–middle Osagean).	Indeterminate	Sample from cross- and parallel-laminated, fine-grained limestone bed (70 cm thick), 1 m above base of 80-m-thick measured section of unit Mlri. Thin section is calcareous spiculite containing lesser siliceous spicules, calcite-replaced radiolarians, and laminae of noncalcareous mud. Table 4 contains additional data from this locality.

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
33 Mlb	**Howard Pass C-3** 68°37'/ 157°34.5'	11 Pa element fragments *Gnathodus texanus* Roundy. 1 Pa element fragment of a rhachistognathid(?) 66 indet. bar, blade, and platform fragments. CAI=2 [91Tr32C; 31845–PC]	latest Early–Late Mississippian; late Osagean to early Chesterian; if the form identified as rhachistognathid(?) is indeed a rhachistognathid, then the age could be restricted to late Meramecian to early Chesterian.	Indeterminate, but assemblage strongly suggests postmortem transport from or within the gnathodid biofacies; moderate- to deep-water depositional setting.	Vuggy, fine- to medium-grained dolomite; sample from two large blocks (possible subcrop) on shoulder of slope. Thin section is dolomite crystal mosaic containing rare siliceous sponge spicules and <1 percent brown mudstone clasts.
35 Mu?	**Howard Pass C-3** 68°36.3'/ 157°34.3'	1 apatognathiform(?) element. 1 unassigned coniform element. 2 Pa element fragments of a hindeodid(?) 4 Pa elements *Polygnathus communis* Branson and Mehl. 1 juvenile Pa element *Polygnathus* sp. indet. Unassigned elements: 4 Pb (2 morphotypes), 3 M, and 4 Sc (2 morphotypes). 33 indet. bar, blade, and platform fragments. CAI=1–1.5 [91Tr35]	late Late Devonian (Famennian) or Early Mississippian (middle Kinderhookian to Osagean). If the elements designated hindeodid(?) are truly hindeodids, then the sample age is middle Kinderhookian to Osagean and the coniform element must be considered redeposited. If the elements designated hindeodid(?) are Famennian carminate ozarkodinids, then the age of the sample is Famennian.	Indeterminate	Sample from ≈1-ft-thick bed of medium-orange-weathering, sandy limestone to limy sandstone. Thin section is very fine grained, equigranular, angular, calcareous sandstone cemented with calcite. Calcareous clasts (30–40 percent of slide) include crinoid ossicles and brachiopod fragments; other clasts chiefly quartz (20 percent), and minor plagioclase feldspar, chert, biotite, opaque minerals, white mica, and chlorite. Sandy limestone is a common component of the Utukok Fm., but structural complexity at this locality makes unit assignment uncertain.
37 Mlb	**Howard Pass C-3** 68°36.6'/ 157°31.9'	*Hindeodus* aff. *H. crassidentatus* (Branson and Mehl), 1 Pb, 3 Sa, 2 Sb, and 16 Sc elements. *Kladognathus* sp. indet., 4 Sa, 2 Sb, and 13 Sc elements. *Synclydognathus geminus* (Hinde), 16 Pa, 12 Pb and 20 M and S elements. Unassigned elements: 1 Pb and 2 Sc. 143 indet. bar, blade, and platform fragments. CAI=1.5–2 [91Tr28A; 31844–PC]	late Early Mississippian; Osagean to early Meramecian, probably Osagean. This species association is similar to that found in the lower part of the Wachsmuth Limestone in its type area (Chandler Lake quadrangle).	Postmortem transport within or from the synclydognathid-hindeodid biofacies; relatively shallow to moderate water depth depositional environment.	Thick-bedded, medium-gray, fine-grained dolostone containing irregular black chert layers, interbedded with grayish-black, very fine grained, baritic(?) dolostone. Thin section is dolostone having relict peloidal-skeletal grainstone texture locally preserved; one mud-filled burrow contains siliceous sponge spicules and a few radiolarians.
41 Mlb	**Howard Pass C-3** 68°35.7'/ 157°30'	1 mid Pa fragment of a cavusgnathoid. 2 Sa element fragments of *Kladognathus* sp. indet. Unassigned elements: 1 M and 2 Sb. 25 indet. bar, blade, and platform fragments. CAI=1.5 [91Tr24A.1; 31842–PC]	Mississippian; Osagean to Chesterian.	Indeterminate; too few conodonts.	Talus blocks <1 m in size of very fine grained, medium-yellowish-gray to grayish-yellow, massive carbonate rock. Stratigraphic position within unit uncertain. Thin section is brecciated dolostone containing skeletal fragments. Original texture probably a sparsely skeletal mudstone-wackestone. Bioclasts (5–25 percent of the sample) are crinoid ossicles and possible brachiopod and bryozoan fragments; minor detrital quartz. Heavy-mineral concentrate includes rare phosphatic brachiopod fragments.

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
41 Mlb [cont.]	**Howard Pass C-3** 68°35.7'/ 157°30'	1 Pa element *Bispathodus utahensis* Sandberg and Gutschick. *Kladognathus* sp. indet., 1 Sa and 1 Sc element fragments. 1 Pa element *Mestognathus praebeckmanni* Sandberg, Orchard, and von Bitter. 2 Pa elements *Synclydognathus geminus* (Hinde). 1 unassigned Pb element. 5 indet. bar, blade, and platform fragments. CAI=1.5 [91Tr24A.2; 31843–PC]	late Early Mississippian; Upper *G. typicus* Subzone to *Sc. anchoralis-Do. latus* Zone (middle Osagean). This species association is like that found in the lower part of the Wachsmuth Limestone in its type area (Chandler Lake quadrangle). The platform facies of the Lisburne Group at Mount Bupto (locs. 69–72) is, at least in part, the same age as the strata at this locality, but the conodont species association from Mount Bupto is generally representative of a more open-marine, deeper water environment.	Indeterminate, too few conodonts. Postmortem transport (probable lag concentrate) within or from a very shallow water depositional environment.	Talus blocks <1 m in size of very fine grained, medium-yellowish-gray to grayish-yellow, massive carabonate rock. Stratigraphic position within unit uncertain. Thin section is a skeletal packstone to grain-rich wackestone; muddy matrix is dolomitized. Skeletal fragments include crinoid ossicles, foraminifers, bryozoan and brachiopod fragments, echinoderm spines, possible ostracode shells and red algae, and a possible gastropod; <1 percent detrital quartz. Rubble of medium-gray-weathering, black to blackish-brown, petroliferous shale near this locality (91JS31D) may correlate with petroliferous rocks exposed on the north side of Mount Bupto (loc. 58).
44 Mlri	**Howard Pass C-3** 68°35.4'/ 157°37.7'	1 Pa element fragment of *Bispathodus* cf. *B. utahensis* Sandberg and Gutschick. 2 posterior Pa element fragments of a cavusgnathoid. *Idioprioniodus* sp., 2 Pa, 2 Pb, and 2 Sa elements. 62 indet. bar, blade, and platform fragments. <u>Redeposited Late Devonian conodonts:</u> 1 mid Pa element fragment of *Palmatolepis* sp. indet. 1 anterior Pa element fragment of *Polygnathus* sp. indet. CAI=1.5 [91Tr36D; 31846–PC]	No older than late Early Mississippian (late Osagean); the species association includes Late Devonian conodonts, and the youngest elements in this collection could be of late Osagean or younger Mississippian age.	Indeterminate	Talus blocks from subcrop of very dark to brownish-gray, very fine grained, muddy, turbiditic limestone (grainstone and carbonate mudstone?). Thin section is skeletal-peloidal grainstone including bryozoans, crinoid ossicles, brachiopods, and rare foraminifers. Peloids consistent in size (40–80 µm). Rare orange-brown micritic (dolomitic?) clasts; irregular shapes suggest deposition before complete lithification. Minor but notable disseminated siliceous sponge spicules (24–60 µm in diameter).
52 Mlri	**Howard Pass C-3** 68°32.4'/ 157°28.9'	3 Pa element fragments of *Polygnathus* sp. indet. of Middle Devonian to Kinderhookian morphotype (specimens corroded). 1 indet. bar fragment. CAI=1.5 [91Tr50.1]	Middle Devonian–early Early Mississippian (Kinderhookian).	Indeterminate	Carbonate talus block. Thin section is a breccia; matrix is clear, relatively coarse-grained anhedral calcite that has undulatory extinction. "Clasts" include brown, noncalcareous mudstone, dark, clotty micrite, crinoid ossicles, dolostone, and chert. Some of the micrite clasts contain chalcedony-filled radiolarians and siliceous sponge spicules (240 and 60 µm in diameter, respectively). If fauna is not reworked, this sample and that from locality 24 are the oldest recovered from unit Mlri.

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
56 Mlri	**Howard Pass C-3** 68°32.05'/ 157°32.8'	1 Pa element fragment *Bispathodus*? sp. indet. CAI no higher than 2 [91Tr45E]	latest Devonian–Mississippian.	Indeterminate	Sample from dense, grayish-black, dark-buff-weathering, fine-grained limestone in 30-cm-thick interbeds within ≈2-m-thick interval of platy shale; thin section is sponge spiculite, possibly bioturbated. Spicules (10–30 percent of slide) mostly siliceous but some calcareous and others pyritized. Local pale lenses of calcareous spicules and lesser peloids and micritized bioclasts in matrix of sparry calcite cement. Heavy-mineral concentrate includes phosphatic brachiopod fragments.
58 Mlb	**Howard Pass C-3** 68°31.2'/ 157°30.1'	1 unassigned Pb element of Devonian and Mississippian morphotype. 19 indet. bar, blade, and platform fragments; all specimens badly broken and partly to substantially covered with organic matter. CAI=1.5 or 2 [91Tr40A]	Devonian to Mississippian, probably Mississippian.	Indeterminate	Sample from upper part of unit Mlb; ≈25 m below scarp of massive brecciated cherts. From ≈1-ft-thick layer of carbonate within platy mudstone. Grayish-black, grayish-buff-weathering, partly laminated, carbonaceous dolostone. Thin section is carbonaceous dolomite crystal mosaic. Rocks at about this stratigraphic horizon but a few hundred meters northeast (90AD54; 90JS16) include black, very fine-grained, petroliferous, and phosphatic carbonate. Chert overlying carbonate at this locality contains Paleozoic (possibly Permian) radiolarians (table 2.)
59 Mlri	**Howard Pass C-3** 68°31.1'/ 157°35.5'	Only partly picked; conodonts abundant. 1 Pa element *Bispathodus* aff. *B. utahensis* Sandberg and Gutschick. 3 P elements *Eotaphrus burlingtonensis* Pierce and Langenheim. 1 Pa element fragment *Gnathodus* sp. 8 Pa elements *Polygnathus communis* Branson and Mehl. 1 Pa element *Protognathodus cordiformis* Lane, Ziegler, and Sandberg. 3 Pa elements *Pseudopolygnathus nudus* Pierce and Langenheim morphotype 2. 12 Pa element fragments *Pseudopolygnathus* spp. *Scaliognathus anchoralis* Branson and Mehl, 2 Pa and 8 S element fragments. <u>Unassigned elements</u>: 10 Pb (4 morphotypes), 9 M (2 morphotypes), 1 Sa, and 4 Sc (2 morphotypes). 44 indet. bar, blade, and platform fragments. CAI= ≈2 + heavy gray patina. [91Tr13; 31841–PC]	late Early Mississippian; lower half *Sc. anchoralis-Do. latus* Zone (middle Osagean). The species association is typical of Lisburne Group rocks of the Rim Butte unit.	Postmortem hydraulic mixing of mid-shelf to deep-water biofacies.	Sample from 2 m of Lisburne Group exposed below diabase sill. Lenticularly interbedded, dark, very fine grained limestone and black chert. Thin section is recrystallized carbonate with little relict texture; one possible crinoid columnal noted and minor disseminated opaque minerals.

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
60 Mlri	**Howard Pass C-3** 68°31.07'/ 157°36.05'	Only partly picked; conodonts abundant. 8 Pa element fragments *Bispathodus utahensis* Sandberg and Gutschick. 2 Pa elements *Doliognathus latus* Branson and Mehl. 1 juvenile Pa element *Dollymae* sp. indet. 4 Pa element fragments and juveniles *Gnathodus* sp. indet. 8 P elements *Geniculatus* sp. 24 "*Hindeodella" segaformis* Bischoff s.f. bar fragments. 15 Pa elements *Polygnathus communis* Branson and Mehl. 5 Pa elements *Pseudopolygnathus oxypageus* Lane, Sandberg, and Ziegler. 20 Pa element fragments *Pseudopolygnathus* spp. indet. Unassigned elements: 3 robust Pb, 17 M (4 morphotypes), 2 Sa, 2 Sb (2 morphotypes), and 7 Sc (+3 morphotypes). 101 indet. bar, blade, and platform fragments. 10 ichthyoliths. Redeposited Kinderhookian conodonts: 2 juvenile Pa fragments *Siphonodella* sp. indet. CAI=1.5-2 [91Tr09B; 31840–PC]	late Early Mississippian; lower half *Sc. anchoralis-Do. latus* Zone (middle Osagean). The species association and the redeposition of Kinderhookian conodonts is typical of the Rim Butte unit.	Mixed biofacies; postmortem hydraulic mixing of moderately deep water biofacies.	Brownish-gray, fine grainstone interlayered with <50 percent black chert. Within 1–2 m of top of underlying diabase sill. Thin section is recrystallized carbonate with little relict texture—chiefly anhedral calcite crystals.
61 IPMk	**Howard Pass C-3** 68°31'/ 157°35.5'	2 indeterminate bar fragments CAI=1.5–2 [91Tr05B]	Silurian-Permian	Indeterminate (too few conodonts).	Sample from 1-m-thick lens of medium-brownish-gray-weathering, calcareous mudstone within black noncalcareous mudstone. Thin-section is carbonaceous dolomite crystal mosaic. Heavy-mineral concentrate includes very minor fluorite and barite(?).
64 Mlri	**Howard Pass C-3** 68°30.7'/ 157°36.0'	3 indeterminate ramiform fragments CAI=1.5 [91Tr08]	Silurian-Permian	Indeterminate (too few conodonts).	Very fine grained, dark-gray, fractured limestone. Thin section is brecciated interlayers of dark, noncalcareous mudstone containing 20–40 percent sponge spicules, and fine-grained limestone containing minor sponge spicules and rare relict radiolarians.

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
66 Mlb	**Howard Pass C-3** 68°30.7'/ 157°34.6'	Only partly picked; conodonts abundant. *Hindeodus crassidentatus* (Branson and Mehl), 36 Pa and 1 Sc elements. *Kladognathus*? sp. indet., 6 Sa and 7 Sc elements. 75 Pa elements *Polygnathus communis communis* Branson and Mehl. 34 *Pseudopolygnathus multistriatus* Mehl and Thomas. <u>Unassigned elements</u>: 9 Pb (2 morphotypes), 23 M (5 morphotypes), 2 Sb (2 morphotypes), and 6 Sc (2 morphotypes). 32 indet. bar, blade, and platform fragments. CAI=1.5 [91Tr07A; 31839–PC]	Early Mississippian (late Kinderhookian through Osagean); equivalent in age to the Kuna Formation and part of the Wachsmuth Limestone.	Postmortem transport from or within the polygnathid-hindeodid-pseudopolygnathid biofacies. Represents normal-marine, mid-shelf to upper-slope depositional environment.	Sample from 1-ft-diameter block of very finely vuggy, fine- to medium-grained, light- to medium-gray-weathering, very light-gray to creamy dolostone containing thin lenses of black chert along with crinoid columnals >¼ inch in diameter. From apparent subcrop near top of 30-m-thick section and within 3 m of contact with overlying black chert. Some vugs contain solid hydrocarbons. Thin-section is coarse-crystalline (0.2–0.4 mm) dolostone containing a few skeletal fragments (mostly crinoid ossicles) that may still be calcite.
67 Mlb	**Howard Pass C-3** 68°30'53"/ 157°32'00"	3 Pa elements (incomplete) *Bispathodus utahensis* Sandberg and Gutschick or *B. stabilis* (Branson and Mehl). *Kladognathus* sp. indet., 1 M and 1 Sb-Sc element fragments. 14 Pa elements *Polygnathus communis communis* Branson and Mehl. 1 unassigned Sc element. 21 indet. bar, blade, and platform fragments. CAI=1.5 [92AD47A; 32439–PC]	Early Mississippian, probably no older than late Kinderhookian.	Indeterminate (too few conodonts); probably normal-marine depositional environment. Conodont species association is similar to that found in some samples of the Rough Mountain Creek unit (Mlr).	Sample from 5-cm-thick undulatory beds of lime crinoidal packstone-grainstone with millimeter-thick shaly partings. Thin section is crinoidal grainstone along with minor dolomite and chert. Collected ≈20 m stratigraphically below 92AD49A (loc. 68) and ≈340 m below the top of the Mlb unit. Heavy-mineral concentrate includes gastropod steinkerns. Processed 9.0 kg of rock.
		16 Pa elements (mostly incomplete) *Bispathodus utahensis* Sandberg and Gutschick or *B. stabilis* (Branson and Mehl). 48 Pa elements *Polygnathus communis communis* Branson and Mehl (small juveniles to adults). <u>Unassigned elements:</u> 9 M (4 morphotypes), 1 Sa, 1 Sb, and 4 Sc (2 morphotypes). 46 indet. bar, blade, and platform fragments. CAI=1.5 [92AD47E; 32440–PC]	Early Mississippian, probably no older than late Kinderhookian.	Polygnathid. Normal-marine depositional environment; *Po. communis communis* was eurytopic but did not occur in large numbers in restricted marine environments. Conodont species association is similar to that found in some samples of the Rough Mountain Creek unit (Mlr).	Thin (4- to 8-cm-thick), nodular-bedded to evenly bedded, skeletal (crinoidal-bryozoan?) lime pack/grainstone with local shaly partings. Thin section is partly silicified skeletal supportstone; bioclasts include abundant crinoid ossicles, brachiopod and bryozoan fragments, and siliceous sponge spicules. Collected at the lowest exposed beds here, ≈20 m stratigraphically below 92AD47A and ≈360 m below the top of unit Mlb. Processed 10.9 kg of rock.

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
68 Mlb	**Howard Pass C-3** 68°30'55"/ 157°31'45"	3 Pa elements (incomplete) *Bispathodus utahensis* Sandberg and Gutschick or *B. stabilis* (Branson and Mehl). 3 Sb-Sc element fragments *Kladognathus* sp. indet. <u>Unassigned elements:</u> 3 Pb and 3 M (2 morphotypes). 19 indet. bar, blade, and platform fragments. CAI=1.5 [92AD49A; 32438–PC]	Early Mississippian, probably no older than late Kinderhookian.	Indeterminate (too few conodonts); probably normal-marine depositional environment. Conodont species association is similar to that found in some samples of the Rough Mountain Creek unit (Mlr).	Sample from 5–15 cm-thick layers and lenses of dolostone intercalated with similarly thick layers and lenses of chert showing skeletal wackestone to packstone texture. Thin section is dolomite crystal mosaic containing rare relict crinoid ossicles and spicules. Collected from lowest outcrop of dolostone and chert, ≈155 m below 92AD33–120 (loc. 71) and ≈320 m below the top of unit Mlb. Heavy-mineral concentrate is chiefly fluorite. Processed 10.1 kg of rock.
69 Mlb	**Howard Pass C-3** North-south traverse through section of unit Mlb; 68°30.6'/ 157°32.45' (base, 47A) to 68°30.5'/ 157°32.45' (top, 47F)	*Hindeodus* aff. *H. crassidentatus* (Branson and Mehl), 2 Pa and 1 M elements. 1 Sc element *Kladognathus* sp. indet. 2 Pa elements *Polygnathus communis* Branson and Mehl. 2 unassigned M elements. 12 indet. bar, blade, and platform fragments. CAI=1.5 [91Tr47A; 31847–PC]	late Early Mississippian (Osagean)	Indeterminate	Samples at this locality from traverse through section of unit Mlb exposed along creek bisecting Mount Bupto. Sample 47A from base of section; approximately equivalent to strata at loc. 67. >3 m of massive, medium- to fine-grained, dark-brownish-gray, medium-gray-weathering limestone (probable encrinite) in 5- to 45-cm-thick beds. Thin section is skeletal packstone. Bioclasts (as much as 3 mm in diameter) include crinoid ossicles, bryozoans, small bivalves (brachiopods and (or) ostracodes), and siliceous sponge spicules; some bioclasts partly micritized. A few thin seams of noncalcareous mud contain very abundant sponge spicules. Heavy-mineral concentrate includes pyritized spine steinkerns.
		1 mid-Pa element fragment of a bispathodid? 1 Pa fragment *Hindeodus* aff. *H. crassidentatus* (Branson and Mehl). 1 Pa fragment mestognathid? 1 juvenile Pa element *Mestognathus* aff. *M. harmalai* von Bitter, Sandberg, and Orchard. <u>Unassigned elements</u>: 2 Pb and 2 Sc. 7 indet. bar, blade, and platform fragments. CAI=1.5–2 [91Tr47B; 31848–PC]	Early Mississippian (late Kinderhookian–early Osagean).	Indeterminate	Sample from <5- m-thick interval of thick-bedded, dark-gray to brownish-gray, fine-grained, encrinitic limestone. Thin section is skeletal grainstone; bioclasts mostly bryozoans and lesser crinoid ossicles and brachiopods. Some bioclasts partly silicified; others have micritized rims. Local areas of dolomitic mud rich in calcareous spicules; some muddy zones may be burrows. Heavy-mineral concentrate includes phosphatic brachiopod fragments.

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
69 Mlb [cont.]	**Howard Pass C-3** North-south traverse through section of unit Mlb; 68°30.6'/ 157°32.45' (base, 47A) to 68°30.5'/ 157°32.45' (top, 47F)	**Only +60-mesh fraction picked** 46 Pa elements (all incomplete) *Bispathodus utahensis* Sandberg and Gutschick. *Idioprioniodus* sp., 2 Pb, 3 Sa, and 8 Sc elements. 1 Pa element fragment *Pseudopolygnathus* sp. Unassigned elements: 2 Pb, 65 M (+4 morphotypes), 5 Sa, and 10 Sc (2 morphotypes). 94 indet. bar, blade, and platform fragments. CAI=1.5–2 [91Tr47C; 31849–PC]	late Early Mississippian (Osagean)	Bispathodid biofacies; normal-marine, outer shelf to basin depositional environment.	Sample from ≈15-m-thick ribbed outcrop consisting chiefly of grayish-black chert in 5- to 10-cm-thick beds; locally abundant lenses of very fine grained, medium-brownish-gray, medium-buff-weathering dolostone within chert. Thin section is skeletal supportstone. Most of slide is silicified; one end is dolomitized. Relict skeletal grains include bryozoans, crinoid ossicles, ostracodes and minor siliceous sponge spicules. Heavy-mineral concentrate includes phosphatic brachiopod fragments.
		Bispathodus aff. *B. utahensis* Sandberg and Gutschick, 5 Pa and 1 Pb elements. 2 Pa elements *Hindeodus* aff. *H. crassidentatus* (Branson and Mehl). *Idioprioniodus* sp. indet., 2 Sa and 9 Sc elements. Unassigned elements: 2 Pb (2 morphotypes) and 8 M (3 morphotypes). 78 indet. bar, blade, and platform fragments. CAI=1.5–2 [91Tr47D; 31851–PC]	Early Mississippian (late Kinderhookian–Osagean).	Indeterminate	Interlayered black chert and carbonate containing some fossil fragments. Thin section is dolostone (crystals 0.1–1.0 mm) with little relict texture.
		9 Pa element fragments *Bispathodus utahensis* Sandberg and Gutschick. 1 P element *Eotaphrus burlingtonensis* Pierce and Langenheim. 2 Sb elements *Synclydognathus geminus* (Hinde). Unassigned elements: 7 Pb (3 morphotypes), 26 M (+3 morphotypes), 2 Sa, 1 Sb, and 18 Sc (2 morphotypes). 125 indet. bar, blade, and platform fragments. CAI=1.5–2 [91Tr47E; 31852–PC]	late Early Mississippian; middle (*Sc. anchoralis-Do. latus* Zone) to late (*Po. mehli*–Lower *G. texanus* Zone) Osagean.	Indeterminate (too few generically identifiable conodonts).	Sample from ≈5 m of interbedded dolostone and chert. Chert, in beds as much as 25 cm thick, appears to be silicified encrinite; dolostone in undulous beds that locally contain wavy laminations. Thin section mostly dolostone (crystals 30–160 µm) with some relict, locally silicified bioclasts (bryozoans and possible crinoid ossicles and brachiopod fragments). Several layers of dark brown, noncalcareous mud rich in siliceous sponge spicules. Lithofacies and biofacies of these strata suggest correlation with 92AD33–91 (loc. 71).

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
69 Mlb [cont.]	**Howard Pass C-3** North-south traverse through section of unit Mlb; 68°30.6'/ 157°32.45' (base, 47A) to 68°30.5'/ 157°32.45' (top, 47F)	*Bispathodus* aff. *B. utahensis* Sandberg and Gutschick, 7 Pa and 1 Pb elements. Digyrate apparatus, 1 Pa and 1 Sa elements. <u>Unassigned elements</u>: 2 Pb (2 morphotypes), 1 M, 1 Sb, and 6 Sc. 19 indet. bar, blade, and platform fragments. CAI=1.5 [91Tr47F; 31853–PC]	Early–early Late Mississippian (late Kinderhookian–Meramecian).	Indeterminate	Outcrop of chiefly light-gray chert, but collection is encrinitic dolomite from mostly cherty talus block. Sample is stratigraphically highest collection made at this locality. Thin section is mostly dolostone but contains relict calcite crinoid ossicles (2–5 mm in diameter); original texture probably crinoidal grainstone.
70 Mlb	**Howard Pass C-3** 68°30'14"/ 157°32'35"	3 Pa element fragments *Bispathodus* sp. indet. 1 juvenile Pa element *Clydognathus?* sp. indet. *Kladognathus* sp., 2 Sa and 3 Sc elements. 5 Pa elements *Polygnathus communis communis* Branson and Mehl. <u>Unassigned elements</u>: 2 Pb (2 morphotypes) and 2 M (2 morphotypes). 21 indet. bar, blade and platform fragments. CAI=1.5–2 [91Tr47G; 31854–PC]	late Early Mississippian (Osagean)	Indeterminate	Distinctly bedded bioclastic limestone resembling 91Tr47A and B (loc. 69) and probably a structural repeat of the interval that produced those samples. Thin section is skeletal grainstone; bioclasts include crinoid ossicles, echinoderm spines, bryozoans, and brachiopods. Heavy-mineral concentrate includes phosphatized bioclasts and steinkerns, and phosphatic brachiopod fragments.
71 Mlb	**Howard Pass C-3** Measured section extends from 68°30'40"/ 157°31'00" (top) to 68°30'32"/ 157°31'34" (base)	This is an extremely abundant sample; only part of the +60 mesh nonmagnetic heavy-mineral concentrate was picked. *Bispathodus utahensis* Sandberg and Gutschick 413 Pa, 37 Pb, and 8 Sc elements. 2 incomplete Pa elements *Embsaygnathus* sp. indet. 1 juvenile Pa element *Gnathodus* sp. indet. *Hindeodus cristulus* (Youngquist and Miller), 2 Pa and 3 Pb elements. *Idioprioniodus conjunctus* (Gunnell), 7 Pa, 1 Pb, 5 M, 3 Sa, and 1 Sb elements. *Kladognathus tenuis* (Rexroad), 67 P, 102 M, 16 Sa, and 147 Sb-Sc elements. *Synclydognathus geminus* (Hinde), 1 Pa and 5 S elements. 34 Pa *Vogelgnathus postcampbelli* (Austin and Husri). <u>Unassigned elements:</u> 3 Pb (2 morphotypes), and 2 Sc. +200 indet. bar, blade, and platform fragments. CAI=1.5 [92AD33–0.2; 32433–PC]	early Late Mississippian (late Meramecian) based on stratigraphic position above 92AD33–30.	Bispathodid-kladognathid: open-marine, outer shelf (platform) or deeper water depositional environment (based on absence of cavusgnathids and common hindeodids and synclydognathids).	Samples at this locality from a 165-m-thick measured section of unit Mlb (upper part); on trend with (and <0.25 mi south of) section measured by Armstrong (1970). Sample from 3-m-thick interval of >80 percent chert. Collected from less cherty, uppermost 0.5 m of dolostone in 5- to 8-cm-thick beds interlayered with cherty bands (10–15 percent) that preserve crinoidal pack/grainstone texture. Thin section is dolomitized crinoidal packstone. Collected 0.2 m below top of measured section; ≈30 m below top of unit Mlb. Heavy-mineral concentrate: chiefly fluorite, phosphatic brachiopod fragments, conodonts, and lesser ichthyoliths. Processed 10.5 kg of rock. Section contains brachiopods and rugose corals of late Osagean or Meramecian age, and colonial corals (*Lithostrotion* (*Siphonodendron*) *sinuosum* (Kelly)) and endothyrid foraminifers of Meramecian age (Armstrong, 1970, 1975).

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
71 Mlb [cont.]	**Howard Pass C-3** Measured section extends from 68°30'40"/ 157°31'00" (top) to 68°30'32"/ 157°31'34" (base)	10 Pa elements *Cavusgnathus unicornis* Youngquist and Miller. *Bispathodus utahensis* Sandberg and Gutschick, 14 Pa (all incomplete) and 1 Pb elements. *Kladognathus tenuis* (Rexroad), 4 P, 25 M, 3 Sa, and 17 Sb-Sc elements. 1 Pa *Synclydognathus geminus* (Hinde). <u>Unassigned elements:</u> 2 M (2 morphotypes). 201 indet. bar, blade, and platform fragments. CAI=1.5 [92AD33–30; 32434–PC]	early Late Mississippian (late Meramecian); thus far, *Bispathodus utahensis* does not seem to extend beyond the Meramecian and *Cavusgnathus* first appears in the late Meramecian.	Postmortem transport within or from the kladognathid biofacies; probably a mixture of shallow (cavusgnathid and synclydognathid) and somewhat deeper platform (bispathodid and kladognathid) biofacies. Open-marine depositional environment.	Sample from 60-cm-thick massive bed (with irregular laminae due to silicified bioclasts) of fetid dolostone containing hydrocarbon-filled vugs and 5–10 percent chert nodules preserving skeletal (including crinoidal) wackestone and packstone textures. Thin section is dolomite crystal mosaic containing 10–15 percent elongate vugs, some of which are lined with solid hydrocarbons. Collected 30 m below top of measured section. Processed 7.0 kg of rock.
		Mostly broken conodonts—all the +60 mesh heavy-mineral concentrate was picked, but only part of the 60- to 100-mesh fraction was picked. *Bispathodus utahensis* Sandberg and Gutschick, 7 Pa (all incomplete) and 1 Pb elements. 16 small Pa element fragments *Bispathodus utahensis* Sandberg and Gutschick? *Kladognathus* sp. indet., 3 P, 9 M, 2 Sa, and 11 Sb-Sc elements (all fragments). 41 indet. bar, blade, and platform fragments. CAI=1.5 [92AD33–61.5A; 32435–PC]	late Early–early Late Mississippian (middle Osagean–Meramecian); based on constraints from under- and overlying collections.	Postmortem transport within or from the bispathodid-kladognathid biofacies; open-marine depositional environment.	Sample from 50-cm-thick bed of dolostone immediately underlying chert that has crinoidal grainstone texture. Thin section is dolomite-crystal mosaic containing a few relict crinoid ossicles and having 5–10 percent chiefly intercrystalline porosity. Collected 61.5 m below top of measured section. Processed 7.7 kg of rock.
		2 P element fragments *Eotaphrus burlingtonensis* Pierce and Langenheim. *Kladognathus* sp. indet., 9 M, 3 Sa, and 6 Sb-Sc elements (all fragments). 33 indet. bar, blade, and platform fragments. CAI=1.5 [92AD33–91; 32436–PC]	late Early Mississippian; *Sc. anchoralis-Do. latus* Zone through *Po. mehli*–Lower *G. texanus* Zone (middle-late Osagean).	Postmortem transport from the kladognathid biofacies; eotaphrids are shallow-water, high-energy forms, thus this collection suggests proximity to a high-energy depositional regime.	Sample from 30 cm × 2 m-long lens of dolostone within chert that has crinoidal-skeletal packstone-grainstone texture. Thin section is dolomite crystal mosaic that contains a chert lens displaying relict bioclasts (chiefly crinoid ossicles). Collected 91 m below top of measured section. Heavy-mineral concentrate is chiefly fluorite. Processed 7.5 kg of rock.
		3 incomplete Pa elements *Polygnathus communis communis* Branson and Mehl. 2 Sb-Sc element fragments *Kladognathus* sp. indet. 4 indet. bar, blade, and platform fragments. CAI=1.5 [92AD33–120; 32437–PC]	Early Mississippian, probably Osagean.	Indeterminate (too few conodonts).	Sample from 50-cm-thick bed of fetid dolostone containing relict crinoids and solid hydrocarbons in vugs. Thin section is dolomite crystal mosaic that contains rare relict crinoid ossicles. Collected 120 m below top of measured section. Heavy-mineral concentrate is chiefly fluorite. Processed 6.8 kg of rock.

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
72 Mlb	**Howard Pass C-3** 68°30'40"/ 157°30'55"	All conodonts are partly to extensively coated with organic matter. 1 Pa element *Bispathodus utahensis* Sandberg and Gutschick. 4 Pa elements *Gnathodus texanus* Roundy. 107 indet. bar, blade, and platform fragments. CAI=1.5 [92AD32A; 32432–PC]	late Early–early Late Mississippian; late Osagean (*Po. mehli*–Lower *G. texanus* Zone) through Meramecian.	Indeterminate (too few generically determinate conodonts).	Buff-weathering, very fine grained dolostone intercalated with black siliceous mudstone; uppermost part of unit Mlb. Stratigraphically above strata at loc. 71; equivalent to, or slightly stratigraphically below, strata at loc. 58. Thin section is fine-crystalline dolostone, with lenses of chert that contain siliceous sponge spicules and lesser radiolarians. Processed 6.4 kg of rock.
73 Dl	**Howard Pass B-5** 68°29'57"/ 158°35'35"	140 *Belodella devonica* (Stauffer) elements. *Polygnathus parawebbi* Chatterton, 38 Pa, 16 Pb, 7 M, 6 Sa, 4 Sb, and 6 Sc elements (all Pa elements have their basal plate still attached). 46 indet. bar, blade, and platform fragments. 6 ichthyoliths. CAI=3 [92AD45B; 12464–SD]	early to middle Middle Devonian; *Po. costatus costatus* Zone through Lower *Po. varcus* Subzone; Eifelian, but not very earliest, through early Givetian. According to R. Blodgett (table 3) brachiopods from this locality suggest an early Eifelian age.	Belodellid-polygnathid biofacies, probably polygnathid biofacies as belodellids were probably surface swimmers. Because belodellids are abundant and the Pa elements of the *Po. parawebbi* still have their basal plate attached, the environment of deposition was probably below or near wave base in a shelf depositional setting.	Dolomitic brachiopod packstone. Thin section is dolomite crystal mosaic containing a few silicified bioclasts, including probable brachiopod fragments and crinoid ossicles. Collected from unnamed Devonian limestone, stratigraphically equivalent(?) to 92AD45C but in different facies. These rocks stratigraphically underlie strata at loc. 74; ≈130 m of total section exposed at the two localities. Heavy-mineral concentrate is chiefly phosphatic brachiopod fragments. Brachiopods of early Eifelian age collected from this locality (see table 3).
		1 *Belodella* sp. indet. element. *Polygnathus parawebbi* Chatterton, 15 Pa, 1 Pb, 1 M, and 1 Sb elements. 3 Pa element fragments *Polygnathus* sp. indet. 24 indet. bar, blade, and platform fragments. CAI=3 [92AD45C; 12465–SD]	early to middle Middle Devonian; *Po. costatus costatus* Zone through Lower *Po. varcus* Subzone; Eifelian, but not very earliest, through early Givetian. According to R. Blodgett (table 3) brachiopods here suggest an early Eifelian age.	Polygnathid biofacies; shelfal depositional environment; higher energy environment than 92AD45B.	Limy brachiopod packstone. Thin section is brachiopod-crinoid wackestone; matrix dolomitized and bioclasts largely silicified. Collected from unnamed Devonian limestone, stratigraphically equivalent(?) to 92AD 45B, but in different facies. Brachiopods of early Eifelian age collected from this locality (see table 3).

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
74 Dl	**Howard Pass B-5** 68°29'43"/ 158°35'00"	3 *Belodella* sp. elements. 1 *Dvorakia* sp. element. 4 *Neopanderodus* sp. elements. 1 Pb *Oulodus* sp. indet. element. 1 Pa element *Polygnathus* aff. *Po. eifelius* Bischoff and Ziegler. 6 Pa elements *Polygnathus linguiformis linguiformis* Hinde gamma morphotype. 15 Pa elements *Polygnathus parawebbi* Chatterton. 15 Pa element fragments or juveniles *Polygnathus* spp. indet. Unassigned elements: 1 Pb, 1 M, and 3 Sc (2 morphotypes). 26 indet. bar, blade, and platform fragments. CAI=3 [92AD28A–22; 12460–SD]	middle Middle Devonian; *Po. ensensis* Zone on the basis of aff. *Po. eifelius* and the age of underlying collection 92AD28A–4; Eifelian-Givetian boundary interval.	Polygnathid biofacies: the taphonomy of the conodonts indicates postmortem transport within this biofacies as most ramiform elements have been winnowed out; relatively high-energy shallow- to mid-shelf depositional setting.	Skeletal lime grainstone lenses containing crinoid ossicles and bryozoans. Thin section is skeletal packstone with locally well developed geopetal fabric and minor peloids. Diverse bioclasts include crinoid ossicles, foraminifers, and fragments of bryozoans, brachiopods, gastropods, and ostracodes; many bioclasts are micritized. Collected from locally youngest(?) part of unnamed Devonian limestone; 130 m of total section exposed here and at loc. 73. Heavy-mineral concentrate includes phosphatic brachiopod fragments, phosphatized bryozoan and gastropod fragments, and conodont pearls.
		8 *Belodella* sp. elements. 5 *Neopanderodus* sp. elements. 1 Pa element *Polygnathus linguiformis linguiformis* Hinde epsilon morphotype. 10 Pa elements *Polygnathus parawebbi* Chatterton. *Polygnathus* spp. indet., 23 Pa and 4 M elements. Unassigned elements: 8 Pb (3 morphotypes), 1 Sa, 1 Sb and 9 Sc (3 morphotypes). 70 indet. bar, blade, and platform fragments. 1 phosphatized gastropod steinkern. CAI=3 [92AD28A–4; 12461–SD]	middle Middle Devonian; *Po. ensensis* Zone on the basis of conodonts in this and in overlying sample 92AD28A–22; Eifelian-Givetian boundary interval.	Polygnathid biofacies: the taphonomy of the conodonts indicates postmortem transport within this biofacies as most ramiform elements have been winnowed out; the polygnathid species suggest a relatively high-energy, shallow to mid-shelf depositional setting.	Skeletal lime grainstone lenses containing crinoid ossicles. Thin section is crinoidal pack/grainstone with brachiopod and coral fragments, ostracodes, and minor carbonate intraclasts; many bioclasts are micritized. Collected from unnamed Devonian limestone, 18 m stratigraphically below 92AD28A–22.
		3 *Belodella* sp. elements. *Polygnathus linguiformis linguiformis* Hinde, 7 Pa, 2 Pb, 3 M, 1 Sa and 1 Sb elements. 41 indet. bar, blade, and platform fragments. CAI=3 [92AD29–8; 12462–SD]	middle Middle Devonian; *Po. costatus costatus* Zone through *Po. ensensis* Zone (upper part of range limited by age of overlying collections); Eifelian, but not very earliest Eifelian, into earliest Givetian.	Indeterminate (too few conodonts); undoubtedly within, or transported from, polygnathid biofacies; possibly near limit of environmental tolerance of polygnathids as all conodonts are small.	Sandy(?) dolostone interlayered with chert bands. Thin section is dolostone containing rare relict crinoid ossicles and thin phosphatic shells; dolomite crystals ≤120 µm. Collected from unnamed Devonian limestone, at least 12 m stratigraphically below 92AD28A–4.

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
74 Dl [cont.]	**Howard Pass B-5** 68°29'43"/ 158°35'00"	*Polygnathus linguiformis linguiformis* Hinde gamma morphotype, 3 Pa, 1 Pb 1 M, and 1 Sc elements. 3 Pa element fragments *Polygnathus* sp. indet. 10 indet. bar, blade, and platform fragments. CAI=3 [92AD30B; 12463–SD]	middle Middle Devonian; *Po. costatus costatus* Zone through *Po. ensensis* Zone (upper part of range limited by age of overlying collections); Eifelian, but not very earliest Eifelian, into earliest Givetian.	Indeterminate (too few conodonts); probably from or within polygnathid biofacies; normal-marine, shelfal depositional environment.	Partly silicified brachiopod packstone. Thin section is brachiopod packstone containing crinoid ossicles and gastropods; many bioclasts silicified and matrix largely dolomitized. Collected from unnamed Devonian limestone, about 10 m above 92AD29–8 and slightly lower(?) than 928AD28A–4. Brachiopods of early Eifelian age collected from this locality (see table 3). Heavy-mineral concentrate includes 7 gastropod, 1 ostracode, and 3 tentaculitid phosphatized steinkerns.
75 Mlri	**Howard Pass B-5** 68°29.6'/ 158°35.1'	2 Pb and 1 Sc elements *Bactrognathus*? sp. indet. 3 Pa elements *Hindeodus crassidentatus* (Branson and Mehl). 1 unassigned Sc element. 23 indet. bar, blade, and platform fragments. CAI=3.5–4 [92AD26D; 32431–PC]	Probably late Early Mississippian (Osagean).	Indeterminate (too few conodonts).	Probable turbidite; 10-cm-thick, parallel- and cross-laminated, light- to medium-gray-weathering (locally yellow-tan), dark-gray limestone intercalated with black mudstone and chert. Thin section is laminated spiculite that contains roughly equal amounts of calcareous and siliceous spicules. Collected ≈1.5 m above base of outcrop and 15 m below mafic sill. Heavy-mineral concentrate: chiefly fused clusters of spines and (or) spicules with druses of phosphate. Processed 7.3 kg of rock.
87 Dl	**Howard Pass B-5** 68°24'40"/ 158°54'00"	All conodonts have a substantial amount of adhering organic matter so that CAI is difficult to determine. 2 P elements *Icriodus symmetricus* Branson and Mehl. 8 Pa elements (incomplete) *Polygnathus dubius* Hinde. 10 Pa element fragments *Polygnathus* sp. indet. Unassigned elements: 4 Pb (2 morphotypes), 3 M, 1 Sb, and 3 Sc (2 morphotypes). 56 indet. bar, blade, platform, and coniform fragments. CAI=3 [92AD69B; 12468–SD]	early Late Devonian; *Pa. transitans* Zone through Lower *Pa. hassi* Zone (early, but not very earliest, Frasnian).	Polygnathid; most conodonts are incomplete, suggesting moderate- to high-energy, middle- to shallow-shelf, normal-marine depositional environment.	Massive, unbedded, crinoidal lime wacke/ packstone with stromatoporoids. Thin section is partly dolomitized stromatoporoid wackestone; subordinate bioclasts include crinoid ossicles and brachiopod fragments. Collected from isolated outcrop (fault block?) topographically (and stratigraphically?) below 92AD68C. Table 3 contains megafossil data from this locality. Processed 11.1 kg of rock.

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
88 Dl	**Howard Pass B-5** 68°24'47"/ 158°53'30"	4 *Belodella devonica* (Stauffer) elements. 1 *Dvorakia* sp. indet. element. 20 juvenile to gerontic Pa elements *Polygnathus linguiformis linguiformis* Hinde γ morphotype. 22 juvenile to subadult Pa elements *Polygnathus parawebbi* Chatterton. *Polygnathus* spp. indet., 33 Pa (fragments), 27 Pb, 12 M, 4 Sa, 33 Sb (2 morphotypes), and 15 Sc (2 morphotypes). +100 indet. long bar and blade fragments. CAI=3 [92AD70A; 12469–SD]	early–middle Middle Devonian; *To. k. australis* Zone to Lower *Po. varcus* Subzone (middle Eifelian–early Givetian). This sample matches the conodont assemblages in 92AD28A–4 and 92AD28A–22 (loc. 74) rather well. Brachiopods of Late Devonian age (station 51T123, colln. 51ATr441; USGS colln. 3367) reported from this general locality by J.T. Dutro, Jr., USGS, 1953, unpub. report.	Polygnathid. The polygnathids are abundant, relatively well preserved, and all elements of the apparatus are present. The conodonts have not been hydraulically sorted. Probably quiet-water, middle-shelf depositional environment.	Sample from 25-cm-thick bed of very sooty, fossiliferous (sparse crinoids and gastropods) micritic limestone with limy shale partings. Thin section is lime mudstone containing sparse, 2-mm-thick laminae of skeletal wacke/ packstone; bioclasts include crinoid ossicles and calcareous sponge spicules. Collected ≈4 m above base of ≈10-m-thick outcrop of unnamed Devonian unit. Lithology is similar and age is equivalent to that at 92AD28A (loc. 74). Heavy-mineral concentrate includes phosphatic brachiopod fragments. Processed 11.0 kg of rock.
89 Mlri	**Howard Pass B-5** 68°23'10"/ 158°54'00"	1 juvenile Pa element *Bispathodus utahensis* Sandberg and Gutschick. 4 indet. bar fragments. CAI=2.5 [92AD214–1.5; 32463–PC]	late Early Mississippian; late Kinderhookian–middle Osagean on the basis of conodonts in this and in overlying sample 92AD214–18.5.	Indeterminate (too few conodonts); probably normal-marine depositional environment.	Samples at this locality from ≈85-m-thick measured section of unit Mlri. Section consists of interbedded limestone turbidites and shale (0–47 m), mostly shale (47–60 m), and mostly chert (60–85 m). Turbidites here are similar to those in the Mlri unit in the Howard Pass C-3 quadrangle, 30 mi to the east, but background sediment here is more shaly and less cherty than to the east. Sample 92AD214–1.5 is from 1.5 m above base of section. Sample is fine-grained limestone; 8-cm-thick, parallel- and cross-laminated turbidite that has a scoured base and contains disseminated pyrite. Thin section is very fine-grained, cross-bedded, calcite-cemented quartz-carbonate sandstone. Quartz grains (20–50 percent of slide) are angular, chiefly 40–90 µm in diameter. Carbonate clasts include crinoid ossicles and sponge spicules. Processed 7.3 kg of rock.
		1 juvenile Pa element *Bactrognathus*? sp. 2 Pa elements *Doliognathus latus* Branson and Mehl. 8 bar fragments "*Hindeodella*" *segaformis* Bischoff s.f. 5 Pa elements *Polygnathus communis communis* Branson and Mehl. 3 Pb element fragments *Scaliognathus*? sp. indet. Unassigned elements: 7 M and 2 Sa. 40 indet. bar, blade, and platform fragments. CAI=2.5 [92AD214–18.5; 32464–PC]	late Early Mississippian; *Sc. anchoralis-Do. latus* Zone (middle Osagean).	Indeterminate (too few conodonts); outer shelf or deeper water depositional environment.	Lithology similar to 92AD214–1.5, but collected from a fetid, 40-cm-thick graded bed, a few meters below mafic dike and 18.5 m above base of ≈85-m-thick measured section. Thin section is normally graded, parallel-laminated, quartz-carbonate sandstone cemented with calcite. Quartz grains (20–30 percent of slide) are angular, chiefly 60–90 µm in diameter. Carbonate clasts include crinoid ossicles and sponge spicules (some spicules partly pyritized). Processed 6.0 kg of rock.

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
89 Mlri [cont.]	**Howard Pass B-5** 68°23'10"/ 158°54'00"	13 Pa elements *Bispathodus utahensis* Sandberg and Gutschick. 1 subadult Pa element *Gnathodus typicus* Cooper. 5 bar fragments "*Hindeodella*" *segaformis* Bischoff s.f. 12 Pa elements *Mestognathus praebeckmanni* Sandberg, Johnston, Orchard, and von Bitter. 5 Pa elements *Polygnathus communis communis* Branson and Mehl. 2 subadult Pa elements *Pseudopolygnathus* sp. indet. 2 Pa element fragments *Geniculatus claviger* Hass. 1 Pa element *Synclydognathus geminus* (Hinde). Unassigned elements: 9 Pb (4 morphotypes), 6 M (2 morphotypes), 2 Sb, and 7 Sc (6 morphotypes). 66 indet. bar, blade, and platform fragments. CAI=2.5–3 [92AD214–44; 32465–PC]	late Early Mississippian *Sc. anchoralis-Do. latus* Zone (middle Osagean). *Mestognathus praebeckmanni* is a rare conodont. It occurs in another sample from a turbidite within deeper water facies of the Lisburne Group (Akmalik Chert) in the central Howard Pass quadrangle (table 4, loc. 32; Dumoulin and others, 1993, table 1 and fig. 7*K–M*).	Mixed biofacies; probable slope or deeper water depositional environment with admixture from the shallowest-water mestognathid biofacies.	Similar lithology to 92AD214–1.5, but collected from a 20-cm-thick bed scoured into black, fissile shale; sample taken 44 m above base of ≈85-m-thick measured section. Thin section is fine- to medium-grained skeletal grainstone, cemented chiefly with calcite but locally with chert. Diverse bioclasts include crinoid ossicles (20–50 percent of bioclasts), foraminifers (5–10 percent), ostracodes, brachiopods, and echinoid spines. Some bioclasts are micritized; others are partly or completely replaced by silica or pyrite. Minor brown mud clasts and <1percent disseminated quartz silt. Base of grainstone bed is scoured into dark brown shale containing 5–10 percent disseminated quartz silt. Heavy-mineral concentrate includes a pyritized ostracode steinkern. Processed 6.6 kg of rock.
91 Mlri	**Howard Pass B-5** 68°23'30"/ 158°48'55"	20 Pa elements *Bispathodus utahensis* Sandberg and Gutschick. 1 Pa element *Geniculatus claviger* Hass. 11 Pa elements (all growth stages) *Gnathodus semiglaber* (Bischoff). 1 small bar fragment "*Hindeodella*" *segaformis* Bischoff s.f. 5 *Idioprioniodus* sp. indet. element fragments. 1 juvenile Pa element *Pseudopolygnathus* sp. Unassigned elements: 2 M and 1 Sc. 110 indet. bar, blade, and platform fragments. CAI=3 [92ARm37B; 32471–PC]	late Early Mississippian; *Sc. anchoralis-Do. latus* Zone (middle Osagean).	Bispathodid-gnathodid; outer platform to upper slope depositional environment.	Light-gray limestone interbedded with black and gray chert. Heavy-mineral concentrate includes phosphatized composite grains and bioclasts and phosphatic brachiopod fragments. Processed 5.5 kg of rock.

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
92 Mlri	**Howard Pass B-5** 68°23'/ 158°49'40"	2 Pa elements *Bispathodus utahensis* Sandberg and Gutschick. 3 Pa element fragments *Doliognathus latus* Branson and Mehl. 17 small bar fragments "*Hindeodella*" *segaformis* Bischoff s.f. 6 Pa elements *Polygnathus communis communis* Branson and Mehl. 3 Pa element fragments *Geniculatus claviger* Hass. Unassigned elements: 3 Pb (2 Osagean morphotypes), 9 M, and 2 Sc. 151 indet. bar, blade, and platform fragments. CAI=3 [92ARm31C; 32470–PC]	late Early Mississippian; *Sc. anchoralis-Do. latus* Zone (middle Osagean).	Mixed biofacies typical of unit Mlri turbidites. Slope or deeper water depositional environment.	Platy limestone. Heavy-mineral concentrate includes phosphatized and (or) pyritized bioclasts and grains, and rare phosphatized gastropods. Processed 4.3 kg of rock.
111 JDbc	**Howard Pass B-4** 68°21'00"/ 158°16'15"	1 posterior Pa element fragment *Ancyrodella* sp. indet. 3 *Belodella* sp. indet. elements. 1 Pa element *Palmatolepis hassi* Müller and Müller? *Palmatolepis* spp. indet., 5 Pa and 2 Pb element fragments. 1 Pa element fragment *Polygnathus* aff. *Po. evidens* Klapper and Lane. 39 Pa elements *Polygnathus pacificus* Savage and Funai. 27 Pa element fragments *Polygnathus* spp. indet. Unassigned elements: 3 Pb (2 morphotypes), 8 M (4 morphotypes), 1 Sa, and 3 Sc (2 morphotypes). 104 indet. bar, blade, and platform fragments. 11 conodont pearls. CAI=2–2.5 [92AD25E;12458–SD]	middle early Late Devonian (Lower *Pa. hassi* Zone to Upper *Pa. rhenana* Zone; middle Frasnian).	Polygnathid biofacies. Taphonomy of the conodonts indicates postmortem transport within this biofacies as most ramiform elements have been winnowed out; the characteristics of *Po. pacificus* suggest a middle- to outer-shelf depositional environment. The polygnathids have not moved beyond their biofacies as juveniles, subadults, and adults are present in this assemblage.	Nodular, 1- to 2-cm-thick beds of fine-grained skeletal lime wackestone. Thin section is skeletal wacke/packstone; diverse bioclasts include crinoid ossicles (to 3 mm in diameter), various types of algae (including *Girvanella* sp.), ostracodes, gastropods, calcispheres, echinoid spines, and fragments of stromatoporoids, bryozoans, and trilobites. Matrix is peloidal and locally dolomitized, and contains minor detrital quartz and altered volcanic(?) lithic clasts. Collected from a discrete ≈10 × 20 m block of unnamed Devonian limestone within Copter Peak basalt unit of Siniktanneyak mafic complex. Corals and stromatoporoids of Frasnian age were previously reported from this locality (table 4; fossil loc. 6 of Nelson and Nelson, 1982).
		1 *Belodella resima* (Philip). 8 conodont pearls. CAI=1.5 [78Cx27A1]	Silurian-Devonian	Indeterminate	Collected from discrete carbonate block within Copter Peak basalt unit, slightly northwest of 92AD25E.

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
112 JDbc	**Howard Pass B-4** 68°20'56"/ 158°16'00"	1 posterior Pa element fragment *Ancyrodella* sp. indet. 1 Pa element fragment *Polygnathus* sp. indet. 6 indet. bar, blade, and platform fragments. CAI=3 [92AD25H; 12459–SD]	early Late Devonian (Frasnian)	Indeterminate (too few conodonts). Conodonts suggest normal-marine, shelfal environment.	Massive, stromatoporoid-crinoidal lime packstone. Thin section is skeletal packstone containing <1 percent angular quartz silt; diverse bioclasts include crinoid ossicles, stromatoporoid fragments, and algae(?). Collected from a discrete ≈10 × 20 m block of unnamed Devonian limestone within Copter Peak basalt unit of Siniktanneyak mafic complex. Conodonts of Late Devonian age previously reported from this locality (table 4; fossil locality 7 of Nelson and Nelson, 1982).
146 IPMk	**Howard Pass B-3** 68°20'00"/ 157°44'35"	Organic matter invades or partly covers all conodonts; consequently CAI difficult to determine. 3 Pa elements *Bispathodus utahensis* Sandberg and Gutschick. 2 Pa elements *Gnathodus cuneiformis* Mehl and Thomas. 2 Pa elements *Polygnathus communis communis* Branson and Mehl. *Scaliognathus anchoralis* Branson and Mehl, 30 M, 3 Sc, and 35 S element bar fragments. 1 digyrate Pb element. Unassigned elements: 20 Pb (+4 morphotypes), 5 Sa (2 morphotypes), 7 Sb (2 morphotypes), and 16 Sc (2 morphotypes). +130 indet. bar, blade, and platform fragments. CAI= ≈3 [92AD35C-15.5; 32442–PC]	late Early Mississippian; *Sc. anchoralis-Do. latus* Zone (middle Osagean).	Scaliognathid; basinal depositional environment.	Sample from 80 × 45 cm concretion of fine-grained, sooty, fetid, black, medium-gray-weathering limestone (calcified radiolarite?). Thin section is calcareous radiolarian packstone; radiolarian tests (50–80 percent of slide; replaced and filled with polycrystalline calcite) and lesser calcareous sponge spicules in a matrix of brown, fine-crystalline calcite. Collected from 15.5 m above base of ≈68 m-thick section of Kuna Formation at type locality (as designated in Mull and others, 1982); section is mostly silicified mudstone and <10 percent limestone. Processed 11.1 kg of rock.
	Howard Pass B-3 68°20'02"/ 157°44'32"	Organic matter invades or partly covers all conodonts; consequently CAI difficult to determine. *Bispathodus utahensis* Sandberg and Gutschick, 9 Pa, 1 Pb, 1 M, and 1 Sc elements. 1 Pa element *Gnathodus pseudosemiglaber* Thompson and Fellows (figured in Dumoulin and others, 1994, fig. 3*H*). 68 indet. bar, blade, and platform fragments. CAI= ≈3 [92AD35C-62; 31782–PC]	late Early–early Late Mississippian (late middle Osagean–Meramecian).	Indeterminate (too few conodonts); conodonts suggest basin facies.	Fine-grained, dark-gray to black, locally burrowed(?) limestone rubble (possible concretion). Thin section is dark, very fine grained carbonate containing rare, calcite-replaced radiolarians and locally abundant brown clasts of noncalcareous mud. Collected 62 m above base of section and 46.5 m above 92AD35C-15.5. Processed 8.7 kg of rock.

Table 1. Conodont data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by A.G. Harris. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and Cx, S.M. Curtis. CAI, conodont color alteration index. Lithologic data under remarks are field descriptions unless otherwise indicated; thin section observations by J.A. Dumoulin. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Conodont fauna and CAI [field No.; USGS collection No.]	Age	Biofacies	Remarks
147 IPMk	**Howard Pass B-3** 68°19'55"/ 157°44'10"	Organic matter invades or partly covers all conodonts; consequently CAI difficult to determine. *Bispathodus utahensis* Sandberg and Gutschick (juveniles and adults), 12 Pa, 2 Pb, 7 M, 1 Sa, 3 Sb, and 14 Sc elements. 30 Pa elements (adults and juveniles) *Gnathodus semiglaber* Bischoff. 20 bar fragments (moderately long) "*Hindeodella*" *segaformis* Bischoff s.f. Digyrate apparatus elements: 2 Pa (2 morphotypes), 1 Pb, 1 M, 1 Sa, 2 Sc. Unassigned elements: 1 Pa fragment, 19 Pb (+4 morphotypes), 4 M (2 morphotypes), 3 Sa, and 5 Sc. 70 indet. bar, blade, and platform fragments. CAI= ≈3 [92AD35AA; 32441–PC]	late Early Mississippian; Upper *G. typicus* Subzone or lower part *Sc. anchoralis-Do. latus* Zone (early middle Osagean) on the basis of age constraints from overlying sample.	Bispathodid-gnathodid; slope or basin depositional setting.	Sample from 4- to 10-cm-thick beds of dark- to medium-dark-gray limestone (calcitized radiolarite?). Thin section is dark, finely intergrown carbonate and silica containing locally abundant brown clasts of noncalcareous mud and scattered, variously preserved radiolarians (some calcite replaced, some pyritized, and some filled with chalcedony). Collected at type locality of Kuna Formation (as designated in Mull and others, 1982); from small outcrop at stream level ≈15 m west and 12 m topographically lower than base of 92AD35A measured section. If 92AD35AA strata are in place, they are the lowest exposure at the type locality. Processed 9.8 kg of rock.
		Organic matter invades or partly covers all conodonts; consequently CAI difficult to determine. Collection extremely abundant, only partly picked. *Bispathodus utahensis* Sandberg and Gutschick, 6 Pa, 3 Pb, and 1 M elements. 3 Pa elements *Doliognathus latus* Branson and Mehl morphotype 3. 2 Pa elements *Gnathodus* sp. indet. 9 Pa elements *Polygnathus communis communis* Branson and Mehl. 1 Pa element *Protognathodus cordiformis* Lane, Sandberg, and Ziegler. *Scaliognathus anchoralis* Branson and Mehl, 4 Pa, 54 M, and 174 Sa, Sb, and Sc (moderate to very long bar fragments) elements. Unassigned elements: 69 Pb (+4 morphotypes), 2 Sb, and 1 Sc. 22 indet. bar, blade, and platform fragments. CAI= ≈3 [92AD35A–9A; 31781–PC]	late Early Mississippian; lower part of *Sc. anchoralis-Do. latus* Zone (early middle Osagean).	Scaliognathid; basinal depositional environment.	Sample from 40 × 90-cm concretion of black limestone (calcitized radiolarite?) in fissile black shale. Thin section is calcareous radiolarian packstone; radiolarian tests (replaced and filled with calcite), lesser calcareous sponge spicules, and locally abundant brown clasts of mud and phosphate in a matrix of brown mud. Radiolarians and spicules make up ≈70–80 percent of slide. Collected 9 m above base of 25-m-thick partial section (92AD35A) of Kuna Formation at type locality. Some conodonts from this sample are figured and described in Dumoulin and others (1994, fig. 3*C–G*). Processed 10.5 kg of rock.

Table 2. Radiolarian data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska

[All faunas identified by C.D. Blome and K.M. Reed unless otherwise indicated. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; AK, J.S. Kelley; ANs, S.W. Nelson; ANw, W.H. Nelson; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and SK, S.M. Karl. Lithologic data under remarks are chiefly field descriptions; thin section observations by J.A. Dumoulin. No., number; loc, locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Radiolarian fauna [field No.; USGS collection No.]	Age	Remarks
1 Mlri	**Howard Pass C-5** 68°44'50"/ 158°55'20"	Poorly preserved forms including *Albaillella* sp. aff. *A. cartalla* (fragments only) *Belowea* sp. *Scharfenbergia concentrica* *Scharfenbergia* sp. aff. *S. ruestae*. [92AD51E; USGS DR 1521]	Mississippian (Meramecian to Chesterian).	White-weathering, gray chert, 1 m below(?) mafic sill. In thin section, chert is fine-grained and pale gray, with 5–25 percent radiolarians; tests chiefly filled with chalcedony or, less commonly, opaque material.
		Poorly preserved forms including *Belowea* sp. *Scharfenbergia impella* group (usage of Holdsworth and Murchey, 1988) *Scharfenbergia* sp. cf. *S. tailleurense.* [92AD51I; USGS DR 1522]	late Early to early Late Mississippian (Osagean to Meramecian).	A 5-cm-thick layer of light-gray to light-green chert, within an interval of red chert; ≈13 m stratigraphically below(?) 92AD51E. In thin section, chert is pale-gray and very fine grained, and contains abundant radiolarians; tests filled with coarser crystalline quartz or chalcedony.
4 IPMap	**Howard Pass C-5** 68°38'20"/ 158°57'40"	Poorly preserved forms including *Scharfenbergia impella* group *Scharfenbergia* sp. cf. *S. ruestae* Won. No abaillellids present. Abundant sponge spicules. [92ADo201; USGS DR 1473]	Mississippian (late Osagean to possibly Chesterian).	Black chert, locally orange-weathering.
5 JTro	**Howard Pass C-5** 68°39'08"/ 158°54'35"	Numerous robust-spined, bipolar radiolarians. Abundant spicules (some robust stauracts or hexactines) visible on etched surfaces. Bipolar spines exhibit an internal spicule that extends to the internal shell. Slight torsion of spines suggests *Pseudostylosphaera japonica* (Nakaseko and Nishimura). *Eptingium* sp. (posssibly *E. manfredi* Dumitrica). A nassellarian that strongly resembles *Triassocampe* (possible *T. scalaris* Dumitrica, Kozur and Mostler). Several other nassellarians; in one, the apical chamber was swollen, wider than the upper chambers. *Sarla kretaensis* Kozur and Krahl. [92AK22a; USGS DR 1586]	Middle Triassic (Ladinian undifferentiated).	Chert, greenish gray, locally baritic, very thin and crumpled lens, thicker bedded; some small radiolarians.
		Etched surface shows numerous heavy grooved spines and large bipolar forms. The sample is a radiolarite that also contains abundant sponge spicules. *Eptingium manfredi* Dumitrica. *Triassistephanidium laticorne* Dumitrica. *Pseudostylosphaera compacta* (Nakaseko and Nishimura) (polar spines lacking torsion). All nassellarians poorly preserved. [92AK22b; USGS DR 1587]	Middle Triassic (Ladinian undifferentiated).	Chert, greenish gray, very thin and crumpled lens, thicker bedded; some small radiolarians. Sample from bank about 10 m to east of 92AK22a; chert is rusty weathering, and contains siliceous shale interbeds and no barite.
6 JIPip	**Howard Pass C-5** 68°39'00"/ 158°51'20"	Poorly preserved forms including *Betraccium* cf. *B. deweveri* Blome ?*Livarella* sp. (casts) ?*Pseudoheliodiscus* sp. (broken cortical ring) *Saitoum* sp. (broken). [92ADo297A; USGS DR 1485]	Late Triassic (probably late Norian; *Betraccium deweveri* Zone of Blome, 1984).	Gray, translucent, thin-bedded chert that contains thin argillite partings.

Table 2. Radiolarian data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by C.D. Blome and K.M. Reed unless otherwise indicated. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; AK, J.S. Kelley; ANs, S.W. Nelson; ANw, W.H. Nelson; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and SK, S.M. Karl. Lithologic data under remarks are chiefly field descriptions; thin section observations by J.A. Dumoulin. No., number; loc, locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Radiolarian fauna [field No.; USGS collection No.]	Age	Remarks
8 IPMap	**Howard Pass C-5** 68°39'10"/ 158°45'50"	Poorly preserved forms including ?*Belowea* sp. (fragments) ?*Paleoxyphostyla* sp. (robust spines only) *Scharfenbergia impella* group (flattened and distorted tests of younger morphotypes). [92ADo275A; USGS DR 1482]	Mississippian (possibly Meramecian-Chesterian).	Medium- to dark-gray, thin- to thick-bedded chert containing abundant carbonate interbeds.
9 IPMap	**Howard Pass C-5** 68°38'06"/ 158°42'30"	Poorly preserved forms including *Albaillella* sp. (one broken short-bodied test) *Scharfenbergia impella* group (flattened and distorted tests). Robust sponge spicules. [92ADo272A; USGS DR 1480]	Mississippian (Osagean-Meramecian)	Sample of chert that underlies zone of reddish cherty argillite; some light-weathering bedding surfaces have radiolarians.
10 JIPip	**Howard Pass C-5** 68°37'50"/ 158°52'40"	Poorly preserved forms including Medial and distal parts of spines questionably belonging to ?*Capnuchosphaera* sp. and (or) ?*Icrioma* sp. [92ABs180B; USGS DR 1506]	?Late Triassic	Sample from an interval of unit JIPip too small to show on geologic map; sample is greenish gray chert that overlies unit IPMap. Conodonts (table 1) from dolostone layers in unit IPMap at this locality are Mississippian .
11 JIPip	**Howard Pass C-5** 68°37'30"/ 158°51'50"	Poorly preserved assemblage including ?*Eptingium* sp. (heavy triradiate spine fragments) *Triassocampe* sp. (casts with little ornamentation). 92ADo226B; USGS DR 1477)	Middle Triassic (probably Ladinian)	Grayish-green chert and cherty argillite; fairly radiolarian-rich.
12 IPMap	**Howard Pass C-5** 68°37'30"/ 158°51'40"	Poorly preserved assemblage including *Scharfenbergia impella* group *Scharfenbergia tailleurense* Holdsworth and Murchey Abundant twisted, bladed spines. [92ADo225B; USGS DR 1476]	Probably Mississippian (late Meramecian or slightly younger).	Sample from top of black, locally orange-weathering chert unit, just below contact with red chert and argillite of unit PIPs.
13 JTro	**Howard Pass C-5** 68°34'50"/ 158°55'55"	Poorly preserved assemblage including *Capnuchosphaera* sp. (tumidaspine fragments only) ?*Pseudoheliodiscus* sp. (cortical ring fragments). [92ADo194B; USGS DR 1472]	Late Triassic (late Carnian or Norian)	Radiolarian-rich, medium-gray- to tan-weathering, predominantly cherty rocks; tan color may reflect bleaching and alteration.
15 JIPe	**Howard Pass C-5** 68°35'55"/ 158°48'00"	Poorly preserved forms including ?*Latentifistula* sp. (recrystallized central portions) ?*Nazarovella* sp. (guttered arms only) *Pseudotormentus* sp. (Y-shaped central part and arms) Abundant recrystallized spumellarians with no external meshwork. Large sponge spicules. [92ABs172; USGS DR 1504]	Permian (post-Wolfcampian)	Light-greenish-gray to light-gray chert abundantly stained with iron-oxide; underlies Otuk Formation.
16 JIPe	**Howard Pass C-5** 68°35'30"/ 158°48'05"	Poorly preserved forms including *Eptingium manfredi manfredi* (partial test and spines) *Plafkerium* sp. cf. *P. firmum* *Pseudostylosphaera coccostyla* *Triassocampe* sp. aff. *T. deweveri* *Triassocampe* sp. [92ABs181A; USGS DR 1509]	Middle Triassic (Ladinian)	
		Poorly preserved forms including *Capnodoce* sp. aff. *C. baldiensis* Blome ?*Pseudostylosphaera* sp. (partial tests) Abundant casts of *Triassocampe* spp. [92ABs181B; USGS DR 1510]	Late Triassic (probably Carnian; *Capnodoce* Zone of Blome, 1984, and Blome and others, 1988).	

Table 2. Radiolarian data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

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Locality No., map unit	Quadrangle, latitude/ longitude	Radiolarian fauna [field No.; USGS collection No.]	Age	Remarks
17 PMk	**Howard Pass C-5** 68°35'/ 158°43.5'	Bipolar (two-spine forms). Incomplete robust tests (granular) with ?bifurcating points; also isolated, heavily grooved spines. Unidentifiable entactiniids. [92ATr38A; USGS DR 1583]	Probably Paleozoic	Rubble and subcrop of thick-bedded black chert.
18 JTrO	**Howard Pass C-5** 68°34'55"/ 158°43'15"	Etched surface—granular, with pits and rare casts and molds of spumellarians; no spines seem to be connected to these "molds;" spicules are abundant. The +80 fraction mostly composed of flakes (veinlets), a few coarse-meshed spumellarian fragments preserved. Fragment of a nassellarian that has costae resembling those of *Corum* Blome. Several broken spines assignable to *Capnuchosphaera* De Wever. A few *Khalerosphaera* spine fragments. Heavy grooved spines. A non-age diagnostic and poorly preserved conodont fragment. [92ATr38C; USGS DR 1585]	Late Triassic (late Carnian to late middle Norian).	Chert rubble, just below subcrop contact with *Monotis*-bearing limestone.
19 JTrO	**Howard Pass C-5** 68°36'15"/ 158°37'55"	Poorly preserved forms including ?*Canoptum* sp. (casts only) ?*Capnuchosphaera* sp. (tumidaspine fragments) *Triassocampe* sp. [92ADo264B; USGS DR 1479]	Triassic, undifferentiated (?Carnian)	Grayish-green chert, just below contact with *Monotis*-bearing limestone.
20 PMap	**Howard Pass C-5** 68°37'01"/ 158°35'05"	Poorly preserved forms including ?*Belowea* sp. (fragments) *Scharfenbergia impella* group (sensu Won) Poorly preserved undescribed spumellarians. Rare sponge spicules. [92ADo283A; USGS DR 1484]	Mississippian (Visean, undifferentiated).	Rubble of medium-gray to grayish-green chert; locally orange-weathering, covered with black lichen, and containing abundant radiolarians. No limestone interbeds.
21 PMk	**Howard Pass C-5** 68°35'45"/ 158°27'20"	Poorly preserved forms including Broken arms questionably belonging to the *Scharfenbergia impella* group Large, broken grooved spines. [92AD59G; USGS DR 1524]	Pre-Permian (?Mississippian)	Light-gray chert that contains from few to 25 percent radiolarians; local green-weathering laminae. Thin section is light-brown, fine-grained chert with thin laminae of dark-brown mud and 10–20 percent spicules and radiolarians. Conodonts (table 1) from limestone immediately underlying the chert at this locality are Mississippian (probably late Osagean).
25 JPip	**Howard Pass C-3** 68°38'15"/ 157°32'35"	Spumellarian casts stand out in high relief on etched surfaces. Radiolarite, but radiolarians and spicules pervasively poorly preserved and recrystallized. Spicules are flattened and could be poorly preserved fragments of *Pseudoheliodiscus* Kozur and Mostler. Isolated spines assignable to *Capnuchosphaera* sp. Several poorly preserved nassellarians (interior casts and at least two with numerous chambers; these are questionably assigned to *Latium* Blome or *Canoptum* Pessagno). [92ATr09A; USGS DR 1578]	Late Triassic (late Carnian to late middle Norian).	Ribbon-bedded, medium-greenish-gray-weathering, medium- to dark-gray chert; sample from top 1 ft of north-dipping, ≈5-m-thick section.

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Locality No., map unit	Quadrangle, latitude/ longitude	Radiolarian fauna [field No.; USGS collection No.]	Age	Remarks
25 JPip [cont.]	**Howard Pass C-3** 68°38'15"/ 157°32'35"	Etched surfaces show radiolarian outlines as simple forms. Small spicules and spines are present. The >80 fraction (the smallest residue for the third wash) contains a few featureless spheres. A few fragments of nassellarians exhibit costae similar to *Corum perfectum* Blome. *Corum* sp. ?*Latium* sp. *Triassocampe* sp. *Xipha pessagnoi* (Nakaseko & Nishimura) *Xipha* sp. [92ATr9B; USGS DR 1579]	Late Triassic (Carnian)	Sample from bottom 1 ft of ≈5-m-thick chert section, upper part of which was sampled as 92ATr9A
		The etched surface shows numerous spicules or perhaps broken spines, but radiolarian preservation poor. A fragment of a large spumellarian exhibits a complex mesh and a heavy grooved spine. A spindle-like cast of a nassellarian interior (consisting of six rings that do not change appreciably in diameter). A few hexactine spicules, but spicules are not common. [92ATr9C; USGS DR 1580]	Mesozoic	Sample from 1-ft interval in middle of ≈5-m-thick chert section, upper part of which was sampled as 92ATr9A.
PMap		Etched surfaces show the rock is radiolarian-rich—spines and spicules abundant; large pieces of clear quartz are common. Some matrix fragments exhibit veins(?) that intersect at several angles; interstices are filled with crystalline(?) quartz. One short, grooved primary spine. Rare short fragments of very robust spicules. Fragments of "ladders," both coarse and regular pores. Bladed spines that have spinules on the blade edges. Several poorly preserved fragments of ?latentifistulid centers (suggesting *Paronaella impella* Group forms). Fragments of spicules that have a curved, flattened double head, like a long curved double-bladed axe. [92ATr9X; USGS DR 1581]	Late Paleozoic. (While the forms are poorly preserved and are not identifiable to the species level, the presence of ladder-like forms and bladed spines are consistent with late Paleozoic faunas and probably pre-Permian faunas).	Sample from nodular, concretionary chert mass (probable interval of unit PMap that is too small to show on the geologic map).
26 JPip	**Howard Pass C-3** 68°38'2.4"/ 157°32'45"	Poorly preserved forms including *Capnodoce* sp. (partial tests that have broken primary spines) *Corum* sp. (broken tests) ?*Pseudosaturniforma* sp. (partial cortical ring). [92AD21A; USGS DR 1515]	Late Triassic (late Carnian to middle Norian; *Capnodoce* Zone of Blome, 1984, and Blome and others, 1988).	Sample from uppermost m of ≈5-m-thick chert interval; green, gray, and tan banded chert in 5-cm-thick beds. In thin section, fine-grained, dark, laminated chert containing ~~with~~ a few percent spicules and radiolarians.

Table 2. Radiolarian data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

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Locality No., map unit	Quadrangle, latitude/ longitude	Radiolarian fauna [field No.; USGS collection No.]	Age	Remarks
26 JPip [cont.]	**Howard Pass C-3** 68°38'2.4"/ 157°32'45"	Poorly preserved forms including *Capnuchosphaera* sp. (broken tumidaspines only) *Latium* sp. (casts) ?*Xenorum* sp. (broken spines and partial cortical shells) *Xipha striata* Blome. [92AD21B; USGS DR 1516]	Late Triassic (early to middle Norian; probably *Xipha striata* Subzone of the *Capnodoce* Zone of Blome, 1984).	Sample from 2 m below top of ≈5-m-thick chert interval; green and white banded chert in 5-cm-thick beds. In thin section, chert is fine-grained, greenish-brown, clay-rich(?) and contains minor spicules and radiolarians.
28 PMap	**Howard Pass C-3** 68°37'52"/ 157°30'50"	Etched surfaces show abundant radiolarians and hints of spicules. Quite thoroughly recrystallized, preservation of all radiolarians is poor. Several varieties of spumellarians suggested. Several poor triangular to tetrahedral forms that probably are varieties of *Scharfenbergia.* Coarse forms are probably spumellarians with matrix. A few stubby albaillellids (resembling *A. cartalla* Ormiston and Lane). Fragment of a taller, narower albaillellid. [92ATr8A; USGS DR 1575]	Mississippian (probably Osagean to Meramecian).	Gray to varicolored chert rubble, locally green and glassy.
		Etched surfaces appear uniformly recrystallized; radiolarians are casts only. Fragments of multi-shelled spumellarians possessing simple, thin spines. Fragments of thick spicules, simple and bladed spines with spinules. A long ichnofossil (?worm tube). A few forms resemble scharfenbergids. Multi-spined spumellarians. Scraps of pore mesh and portions of "latentifistulid" rays (not ladders) that have irregular pore patterns; these last suggest the "*Paronaella impella* group" for which Holdsworth and Murchey (1988) indicate a range of late Osagean to Morrowan(?). [92ATr8B1; USGS DR 1576]	Late Paleozoic (probably pre-Permian)	Rubble of dark gray chert ≈20 m downhill from 92ATr8A.

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Locality No., map unit	Quadrangle, latitude/ longitude	Radiolarian fauna [field No.; USGS collection No.]	Age	Remarks
28 IPMap [cont.]	**Howard Pass C-3** 68°37'52"/ 157°30'50"	Etched surface has very well aligned but somewhat squashed radiolarians, granular, heavily recrystallized. Many recrystallized spumellarians that have broken, delicate spines. Numerous flat (not tetrahedral) triangular forms referable to *Scharfenbergia*—possibly *Sharfenbergia ruestae* (Ormiston and Lane) (see Holdsworth and Murchey, 1988, plate 34.4, figs. 16 and 17). Poorly preserved multi-shell spumellarians. Moderately robust spicules. Several very poorly preserved and broken forms assignable to *Albaillella* Deflandre; these appear to be short tests and could be *A.* cf *A. cartalla* Ormiston and Lane, which Holdsworth and Murchey (1988) suggested is a pre-Chesterian taxon. [92ATr8B2; USGS DR 1577]	Mississippian (probably Meramecian)	Chert rubble lithologically identical to, but ≈20 m downslope from, 92ATr8A.
31 JIPe	**Howard Pass C-3** 68°37.5'/ 157°34.4'	Short, blunt spines of *Eptingium* (or possibly a *Pseudostylosphaera*). Bipolar, three- and four-spined forms that have stout spines. Fragmentary nassellarian that has a rounded cephalic area. [91Tr22C; USGS DR 1598]	Triassic (probably Ladinian or Carnian).	Rubble of light-weathering, medium gray chert.
34 JIPip	**Howard Pass C-3** 68°36.5'/ 157°34.75'	Fragment of *Livarella* sp. ?*Capnodoce* sp. Etched pieces contain many thin-rimmed *Pseudoheliodiscus* (cf. the form shown in plate 33.2 of Blome and others, 1988, and some that have broader rims). No nassellarians found. Rare grooved spines (none including main part of test.) Three-spined forms uniformly lacking mesh details. [91Tr15C; USGS DR 1595]	Late Triassic (probably Norian)	Fine rubble of hematitic, red-weathering chert having a somewhat earthy texture and containing impressions of *Monotis*.
		Multishelled, heavy grooved-spine spumellarian. ?*Khalerosphaera* spine tip. Nassellarian fragment. Three-spined form with stubby, slightly twisted spine. [91Tr15CX; USGS DR 1596]	Probably Triassic	Rubble of thin-bedded, medium-gray chert, variable to light-weathering, adjacent to chert sampled as 91Tr15C.
		Emiluvia sp. *Staurodoras* sp. *Eptingium* sp. Stout twisted spines not attached to main part of test. [91Tr15E; USGS DR 1597]	Triassic (probably Ladinian)	Earthy-textured chert associated with dark-gray-weathering, platy, tuffaceous(?) rock; slightly northwest of 91Tr15C and 15CX.

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Locality No., map unit	Quadrangle, latitude/ longitude	Radiolarian fauna [field No.; USGS collection No.]	Age	Remarks
36 JPip	**Howard Pass C-3** 68°36.2'/ 157°34.1'	*Capnuchosphaera* spp. spines. *Castrum perornatum* Blome. Narrow-rimmed cortical ring assignable to *Acanthocircus* sp. *Khalerosphaera* blade fragment. Poorly preserved nassellarian fragments. [91Tr33A; USGS DR 1604]	Late Triassic (late Carnian to late middle Norian).	Rubble of dark-brownish-gray chert, locally glassy luster, weathers medium-greeenish-gray with earthy rinds.
38 JTRo	**Howard Pass C-3** 68°36.3'/ 157°31.1'	*Khalerosphaera* spine tip. *Capnuchosphaera* spine tip. Fragments of either *Acanthocircus* or *Pseudoheliodiscus.* Abundant twisted spines. [91Tr26C; USGS DR 1599]	Triassic (Norian)	Rubble of black, thin-bedded chert associated with cherty paper shale.
39 JPip	**Howard Pass C-3** 68°36'25"/ 157°28'20"	Poorly preserved and recrystallized forms including Latentifistulid-like form (casts only). [92ARm44A; USGS DR 1490]	?Permian	White-weathering, black chert with radiolarians.
42 JTRo	**Howard Pass C-3** 68°35.5'/ 157°29.2'	All radiolarians fragmentary in this residue. Rare tightly twisted spines that resemble those belonging to *Xenorum.* Bipolar forms. Fragment of a nassellarian. Tiny spine tip of *Khalerosphaera.* [91Tr29B; USGS DR 1601]	Triassic (probably Late Triassic)	Buff to orange stream cuts of medium-light-gray-weathering, dark-brownish-gray chert, in 5- to 10-cm-thick beds, underlain by mudstone.
43 JPe	**Howard Pass C-3** 68°35,6'/ 157°36.5'	*Capnuchosphaera* spp. *Corum perfectum* Blome. Fragments of twisted spines. Blades of *Khalerosphaera.* Delicate *Pseudoheliodiscus* with thin rim. [91Tr38C; USGS DR 1612]	Triassic (early to middle Norian)	Relatively thick-bedded, contorted chert, associated with *Monotis*-bearing limestone.
45 JPip	**Howard Pass C-3** 68°35.3'/ 157°37.3	Poor sample. Ring fragments of *Acanthocircus* or *Pseudoheliodiscus.* Possible *Capnuchosphaera* spine. Bladed spine tip of *Khalerosphaera.* [91Tr37A; USGS DR 1608]	Late Triassic (possibly Norian)	Medium-green, medium- to thick-bedded chert; sample from highest part of exposure.
		Robust bladed spines with spinules, some light torsion (see sample 91Tr36A). Ladder ray (?*Pseudotormentus*). Partial *Pseudoalbaillella* sp. possessing a short skirt (perhaps a "*scalprata*" morphotype). *Follicucullus*, more swollen than *F. scholasticus* m. II Ishiga but less swollen than *F. charveti* Caridroit and De Wever. [91Tr37B; USGS DR 1609]	Late Permian. Although this mix is not documented, *Follicuculus* is Guadalupian and this morphotype of *Pseudoalbaillella* may be this young.	Red-weathering, crumpled chert, containing local jasperoid lumps; sample from middle of chert exposure at this locality.
46 JPii	**Howard Pass C-3** 68°35.1'/ 157°37.5'	Several kinds of *Latentifistula* spp. Apical horn of a *Pseudoalbaillella.* Irregular mesh on lattice/ladder ray. Extremely long-bladed spines on etched surfaces. [91Tr36A; USGS DR 1607]	Permian (undifferentiated)	Strongly deformed, thin-bedded, red-weathering chert.

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Locality No., map unit	Quadrangle, latitude/ longitude	Radiolarian fauna [field No.; USGS collection No.]	Age	Remarks
53 JPip	**Howard Pass C-3** 68°32'/ 157°29'	Reddish chert residue containing poorly preserved forms only. Bladed spines exhibiting spinules. Possible *Ormistonella*-like fragments. Arm fragments generically called "ladders." Possible apical tip of *Pseudoalbaillella* sp. [91Tr43B; USGS DR 1615]	Permian (possibly mid-Permian)	Medium-greenish-gray- and red-weathering chert, locally nodular.
57 IPMap	**Howard Pass C-3** 68°31.8'/ 157°28.7'	Tetrahedral or at least inflated *Scharfenbergia* morphotypes. Fragment of an "*impella*" ray. Bladed spine fragments. Heavy grooved spines with some torsion, cf. *Paleoxiphostylus*, some attached to fragments of central part of test and at least one suggesting four-armed forms may be present. [91Tr42C; USGS DR 1614]	Mississippian (probably Meramecian or Chesterian).	Rubble of light-weathering, medium-gray chert.
58 JPe	**Howard Pass C-3** 68°31.3'/ 157°30'	Mostly poorly preserved spumellarians, casts only. Fragments of long primary spines. One latticed, broken ray (arm). Possible fragment that may be the apical tip of *Pseudoalbaillella*. [91Tr40B; USGS DR 1613]	Paleozoic (possibly Permian)	Sample from nodular-bedded, medium-greenish-gray chert (locally red-weathering) that overlies unit Mlb; lithology resembles that of unit PIPs. Conodonts (table 1) from upper part of unit Mlb at this locality are of probable Mississippian age.
62 JPe	**Howard Pass C-3** 68°30.9'/ 157°36.8'	Flattened nassellarian casts (possibly *Corum* Blome). *Capnuchosphaera* spp. spine fragments. Narrow-rim *Pseudoheliodiscus* fragment. [91Tr3A; USGS DR 1592]	Late Triassic (early to late middle Norian).	Medium-gray, dark- to greenish-gray chert in even, 5- to 10-cm-thick beds, exposed along stream cut; sample 91Tr3A from slightly northwest of 91Tr2A.
	68° 30.8'/ 157° 36.0'	Spumellarians that have strong, grooved spines. Poorly preserved casts of nassellarian. [91Tr2A; USGS DR 1591]	Mesozoic, probably Triassic (Ladinian or younger).	
63 JPii	**Howard Pass C-3** 68°30.75'/ 157°36.1'	Poorly preserved sample contains scraps of nassellarians. Bladed spines with tips that resemble those of *Khalerosphaera*. *Pseudoheliodiscus* sp. with narrow rim (indicating that it is not *P. sandspitensis*). Cortical shell fragments that have twisted spines. [91Tr1B; USGS DR 1590]	Late Triassic (Norian, undifferentiated)	Dark-olive-gray chert in distorted, 5- to 25-cm-thick layers, bleached greenish-gray in part.
65 KMp	**Howard Pass C-3** 68°30.1'/ 157°37.0'	*Scharfenbergia* spp. strongly tetrahedral and flatter morphologies. Bipolar forms, possibly *Belowea* or *Paleoxiphostylus* ?*Callela* sp. An "*impella*"-type ray. [91Tr14A; USGS DR 1593]	Possibly Late Mississippian	Medium-bedded, medium-gray, light-greenish-gray- to white-weathering chert.
		Scharfenbergia spp., poorly preserved "*impella*" ray fragments. [91Tr14B; USGS DR 1594]	Possibly Late Mississippian	Hematite-stained, dark-gray to black chert, locally light-weathering; sample from larger, higher ridge a few hundred feet south of 91Tr14A.
76 IPMap	**Howard Pass B-5** 68°29'2.4"/ 158°25'58"	Poorly preserved forms including Forms assignable to *Scharfenbergia impella* group. Rare sponge spicules. [92ADo101B; USGS DR 1470]	Mississippian, undifferentiated	Grayish-green, radiolarian-rich chert.

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Locality No., map unit	Quadrangle, latitude/ longitude	Radiolarian fauna [field No.; USGS collection No.]	Age	Remarks
77 PMap (or JPip)	**Howard Pass B-5** 68°29'2.4"/ 158°25'50"	Poorly preserved forms including *Scharfenbergia impella*-like forms (too recrystallized to positively identify). Also broken bladed spines. Common sponge spicules. [92ADo100B; USGS DR 1469]	?Mississippian, possibly younger	Red siliceous argillite, stratigraphically higher than 92ADo101B (loc. 76). Stratigraphic unit uncertain; sample taken from rocks that appear transitional between unit PMap and overlying unit J Pip.
78 JPip	**Howard Pass B-5** 68°28'55"/ 158°25'50"	Poorly preserved assemblage including ?*Betraccium* sp. (one broken specimen) *Capnuchosphaera* sp. (broken tumidaspines) ?*Khalerosphaera* sp. (broken spines) *Pseudoheliodiscus* sp. (cortical ring fragments). [92ADo99B; USGS DR 1468]	Late Triassic (middle or late Norian)	Bedded, complexly folded, gray chert; sample taken just below zone of red chert.
79 JPip	**Howard Pass B-5** 68°28'55"/ 158°25'37"	Poorly preserved assemblage including *Capnuchosphaera* sp. (isolated tumidaspines) ?*Laxtorum* sp. *Livarella* sp. *Pseudoheliodiscus* sp. cf. *P. finchi* Pessagno *Saitoum* sp. [92ADo98B; USGS DR 1467]	Late Triassic (late middle to early late Norian; *Pantanellium silberlingi* Subzone of the *Betraccium deweveri* Zone, Blome, 1984, and Blome and others, 1988).	Sample from rubble of maroon to grey-green bedded chert, containing abundant radiolarians, underlying unit Kop. The association of *Livarella* sp. with *Capnuchosphaera* sp. suggests that *Livarella* may extend down into the middle Norian, at least in North American rock sequences.
80 JPip	**Howard Pass B-5** 68°28'55"/ 158°25'19"	Poorly preserved assemblage including *Acanthocircus* sp. (cortical ring fragments) *Canoptum* sp. cf. *C. unicum* Pessagno and Whalen *Canoptum* sp. *Droltus* sp. *Pantanellium* cf. *P. kungaense* Pessagno and Blome *Pantanellium* sp. [92ADo96B; USGS DR 1466]	Early Jurassic (Hettangian or Sinemurian).	Green-gray bedded chert; uppermost part of unit J Pip, at contact with unit Kop.
81 JPii	**Howard Pass B-5** 68°27'3.6"/ 158°36'7.2"	Radiolarians poorly preserved; most exhibit little or no external meshwork or pore structure. *Canoptum* sp. cf. *C. dixoni* (Pessagno and Poisson) *Canoptum* sp. ?*Canutus* sp. ?*Katroma* sp. *Orbiculiforma* sp. aff. *O. multifora* Pessagno and Poisson *Orbiculiforma* sp. [91ANs23A; USGS DR 1349]	Early Jurassic (probably Pliensbachian or Toarcian).	Laminated radiolarian chert in apparent fault contact with graywacke of the Okpikruak Formation. Although the fauna is poorly preserved, the co-occurrence of conoptids having 12-14 post-abdominal chambers, such as *Canoptum dixoni*, as well as abundant *Orbiculiforma* sp., indicate a definite Early Jurassic age, and a probable Pliensbachian age.
82 JPii	**Howard Pass B-5** 68°26'42"/ 158°36'50"	Radiolarians poorly preserved, most lacking preserved external meshwork or visible pore structure. ?*Bagotum* sp. *Canutus* sp. cf. *C. hainaensis* Pessagno and Whalen *Hsuum* aff. *H. belliatum* Pessagno and Whalen ?*Parvicingula* sp. *Saitoum* sp. [91ANs23B; USGS DR 1350]	Early Jurassic (Pliensbachian or Toarcian).	Uppermost chert at this locality, in fault(?) contact with Okpikruak Formation; sample includes both red and green-gray chert. Sample 91ANs23B may be slightly younger than 91ANs23A, as the former contains forms possessing a pronounced horn and robust circumferential ridges assignable to ?*Parvicingula* sp. The poor preservation makes an accurate specific assignment impossible.

Table 2. Radiolarian data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by C.D. Blome and K.M. Reed unless otherwise indicated. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; AK, J.S. Kelley; ANs, S.W. Nelson; ANw, W.H. Nelson; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and SK, S.M. Karl. Lithologic data under remarks are chiefly field descriptions; thin section observations by J.A. Dumoulin. No., number; loc, locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Radiolarian fauna [field No.; USGS collection No.]	Age	Remarks
83 JPii	**Howard Pass B-5** 68°26'35"/ 158°37'20"	Radiolarians recrystallized, poorly preserved, all lacking preserved external meshwork or visible pore structure. No nassellarians or cone-shaped casts visible in the coarse or fine dry acid residue. Several large, broken entactiniids preserved that are similar in geometry and spine structure to *Parentactinia itsukaichiensis* Sashida and Tonishi. ?*Pseudoalbaillella* sp. [91ANs23C; USGS DR 1351]	?Paleozoic	Chert south of samples 91ANs23A and 23B. The poor preservation of all forms makes it impossible to assign an accurate age, but the absence of nassellarians and presence of abundant entactiniids suggest a possible pre-Mesozoic (Paleozoic) age.
84 IPMap	**Howard Pass B-5** 68°26'28"/ 158°32'17"	Poorly preserved forms including ?*Albaillella* (?) *undulata* (cast) ?*Albailella* sp. (fragments only) Rare and corroded isolated bladed spines. [92ARm101A; USGS DR 1494]	?Mississippian	Chert, chiefly red, that contains subordinate, irregular greenish layers.
85 JPip	**Howard Pass B-5** 68°25'34"/ 158°37'37"	All radiolarians recrystallized, poorly preserved, lacking preserved external meshwork or visible pore structure. ?nassellarians (several cone-shaped casts that have distinct ridges that may be circumferential ridges). [91ANs24B; USGS DR 1353]	?Mesozoic	Red and green chert that contains visible radiolarians.
90 JPii	**Howard Pass B-5** 68°23'35"/ 158°50'13"	Poorly preserved assemblage including *Capnodoce* sp. (isolated spine) *Capnuchosphaera* sp. (isolated tumidaspines) *Syringocapsa turgida* *Triassocampe* sp. [92ADo29; USGS DR 1457]	Late Triassic (late Carnian to late middle Norian; *Capnodoce* Zone of Blome, 1984, and Blome and others, 1988).	Medium-gray and grayish-green, thin-bedded chert; locally weathers light cream-colored. Sample from white and black banded chert; white layers contain abundant radiolarians.
93 JPii	**Howard Pass B-5** 68°22'40"/ 158°49'50"	Poorly preserved forms including *Albaillella* sp. cf. *A. levis* *Deflandrella* (?) *manica* (arm fragments) ?*Ishigaum* sp. (cast). [92ABs54; USGS DR 1495]	middle Permian (probably Guadalupian).	Sample from interval of whitish-gray-weathering chert; underlain and overlain by black chert.
94 JPip	**Howard Pass B-5** 68°22'23"/ 158°47'2.4"	Poorly preserved forms including *Capnuchosphaera* sp. (individual primary spines and broken shells) *Pseudoheliodiscus* sp. (small fragments of cortical outer ring). [92ADo83B; USGS DR 1463]	Late Triassic (Carnian or Norian)	Medium-gray and grayish-green chert, near rubble of red and brown argillite.
95 JPip	**Howard Pass B-5** 68°22'16"/ 158°47'24"	Poorly preserved assemblage including *Betraccium* sp. *Capnuchosphaera* sp. (broken tumidaspines) *Livarella* sp. *Pantanellium* sp. [92ADo83E$_1$; USGS DR 1464]	Late Triassic (latest middle to early late Norian; *Pantanellium silberlingi* Subzone of the *Betraccium deweveri* Zone of Blome, 1984; also see Blome and others, 1988).	Red chert, about 1,000 ft southwest of 92ADo83B. The association of *Livarella* sp. with *Capnuchosphaera* sp. suggests that *Livarella* may extend down into the middle Norian, at least in North American rock sequences.

Table 2. Radiolarian data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by C.D. Blome and K.M. Reed unless otherwise indicated. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; AK, J.S. Kelley; ANs, S.W. Nelson; ANw, W.H. Nelson; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and SK, S.M. Karl. Lithologic data under remarks are chiefly field descriptions; thin section observations by J.A. Dumoulin. No., number; loc, locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Radiolarian fauna [field No.; USGS collection No.]	Age	Remarks
95 JPip [cont.]	**Howard Pass B-5** 68°22'16"/ 158°47'24"	Poorly preserved assemblage including Cortical ring fragments assigned to either *Acanthocircus* or *Pseudoheliodiscus* sp. (ring fragments missing secondary spines) ?*Corum* sp. (poorly preserved forms with little ornamentation). [92ADo83E$_2$; USGS DR 1465]	Probably Late Triassic	Green chert, about 75 ft south of 92ADo83E$_1$.
96 JDbc	**Howard Pass B-5** 68°22'55"/ 158°38'20"	Poorly preserved and unidentifiable recrystallized casts of nassellarians. [92ARm25A; USGS DR 1487]	Triassic or younger	Radiolarian chert that may be part of a tectonic melange or major fault zone.
102 PMap	**Howard Pass B-4** 68°22'41"/ 158°08'40"	Poorly preserved forms including those questionably assigned to the *Scharfenbergia impella* group. Also poorly preserved undescribed spumellarians and rare spicules. [91AD13A; USGS DR 1513]	Probably Mississippian (Meramecian or younger).	Medium-gray to black, vitreous chert, weathering white to gray and (locally) reddish-brown; 10-15 percent radiolarians visible on most fresh surfaces. Thin section is pale to dark-brown chert that contains 10-40 percent radiolarians; quartz crystals within tests are generally finer grained than those in the matrix.
JPip		Only identifiable forms are spine fragments questionably assignable to ?*Capnuchosphaera* sp. [91AD13J; USGS DR 1514]	?Late Triassic	Tan-weathering, pale- to medium-green, vitreous chert; beds 2- to 10-cm thick. Pyrite locally abundant, radiolarians few to 15 percent. Chert associated with (apparently interbedded with) maroon, green, and black mudstone. Thin section is pale chert with minor, poorly preserved radiolarians (some tests replaced by zeolite?) and trace detrital quartz. Rocks represent interval of unit JPip too small to show on geologic map.
104 JDbc	**Howard Pass B-4** 68°22'01"/ 158°13'05"	All radiolarians recrystallized, poorly preserved as casts and molds only. Cone-shaped ?nassellarians. ?*Pseudostylosphaera* sp. (recrystallized, ellipsoidal cortical shell, nodose, with robust, twisted primary spines). [91ANs18A; USGS DR 1348]	?Middle or Late Triassic	Red interpillow chert in massive, amygdaloidal basalt.
107 JPe	**Howard Pass B-4** 68°21'18"/ 158°00'58"	Poorly preserved forms including Broken *Eptingium*-like inflated spines *Triassocampe* sp. (casts). [92ADo313; USGS DR 1486]	Triassic (questionable Middle Triassic)	Gray to grayish-green chert.
108 JDbc	**Howard Pass B-4** 68°21'14"/ 158°17'20"	All radiolarians recrystallized and poorly preserved as casts and molds. Spherical to ovoid, flattened casts of spumellarians, occasional isolated, broken spines. ?*Bagotum* sp. ?*Pantanellium* sp. (poorly preserved casts that have bipolar primary spines). [91ANs14A; USGS DR 1347]	?Early Jurassic	Gray chert, associated with sheared, amygdaloidal pillow basalt.
109 JDbc	**Howard Pass B-4** 68°21'10"/ 158°17'10"	Few, sparse nassellarians. [86SK238A; USGS MR 7266]	Triassic	Chert associated with red-weathering basalt, in fault contact with vesicular basalt and limestone. Sample identified by B. Murchey, USGS.

Table 2. Radiolarian data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by C.D. Blome and K.M. Reed unless otherwise indicated. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; AK, J.S. Kelley; ANs, S.W. Nelson; ANw, W.H. Nelson; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and SK, S.M. Karl. Lithologic data under remarks are chiefly field descriptions; thin section observations by J.A. Dumoulin. No., number; loc, locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Radiolarian fauna [field No.; USGS collection No.]	Age	Remarks
110 JDbc	**Howard Pass B-4** 68°21'05"/ 158°16'50"	Poorly preserved spumellarians, recrystallized, several pyritized. ?capnuchosphaerid primary spine (broken and poorly preserved; these distinct primary spines that belong in the radiolarian family Capnuchosphaeridae are hollow in their proximal parts, triradiate and sometimes twisting in their medial parts, and are solid and circular in axial section in their distal parts). ?conodont fragment (recrystallized and poorly preserved). [91ANs13A; USGS DR 1346]	?Triassic	Sample from 4-cm-thick layer of gray chert in section of brown-weathering, sheared basalt.
115 JPe (or PMk)	**Howard Pass B-4** 68°19'52"/ 158°16'23"	*Scharfenbergia tailleurense* group Holdsworth and Murchey. [86SK240B; USGS MR 7269]	Late Mississippian–Early Pennsylvanian (Chesterian-Morrowan).	Gray and buff chert, interbedded with siliceous argillite; at base of exposed section. Lithology and fauna appear transitional between those of units PMk and JPe. The robust group *Scharfenbergia tailleurense* commonly occurs near or at the boundary between the Lisburne and Etivluk groups. Sample identified by B. Murchey, USGS.
117 JTro	**Howard Pass B-4** 68°19'15"/ 158°19'10"	Few, sparse nassellarians. [86SK239A; USGS MR 7268]	Triassic	Gray chert. Sample identified by B. Murchey, USGS. Previously published fossil data from approximately this locality (table 4).
127 JTro	**Howard Pass B-3** 68°28'30"/ 157°44'46"	Poorly preserved forms including *Acanthocircus* sp. cf. *A. hexagonus* (Yao) *Capnuchosphaera* sp. (tumidaspine fragments only). [92ADo214B; USGS DR 1475]	Late Triassic (early late Carnian to late middle Norian).	Medium- to thick-bedded, medium-gray chert with light-weathering partings.
128 PMap	**Howard Pass B-3** 68°29'2.4"/ 157°26'06"	Poorly preserved assemblage including ?*Scharfenbergia* spp. *Albaillella* cf. *A. cartalla*. Rare sponge spicules. [92ADo67B; USGS DR 1461]	Mississippian (pre-Chesterian, probably Meramecian).	Thin-bedded, grayish-green to gray radiolarian chert, interbedded with olive to grayish-green siliceous argillite.
129 PMap	**Howard Pass B-3** 68°26'13"/ 157°40'45"	No identifiable forms except for poorly preserved broken arms possibly assignable to the *Scharfenbergia impella* group. Abundant sponge spicules. [92ADo202B; USGS DR 1474]	?Paleozoic (?Mississippian)	Bright reddish-orange-weathering, light- to medium-gray to grayish-green chert; thin bedded with locally abundant radiolarians. Abundant vein quartz in radiolarian sample residue.
130 JTro	**Howard Pass B-3** 68°26'24"/ 157°33'00"	Poorly preserved forms with little external meshwork remaining including unidentifiable spumellarians and a nassellarian questionably identified as ?*Corum* sp. [91ADo48A; USGS DR 1453]	Possibly Late Triassic (Carnian/Norian).	Gray-weathering, brown to gray radiolarian chert in float (no outcrop); probably thin bedded. Overlies *Monotis*-bearing limestone member of Otuk.
134 KJmv	**Howard Pass B-3** 68°26'24"/ 157°26'10"	Poorly preserved assemblage including ?*Canutus* sp. Other recrystallized crushed and distorted nassellarians Rare spumellarian fragments. [92ADo81B; USGS DR 1462]	?Early Jurassic (?Sinemurian or ?Pliensbachian).	Dark chert float associated with volcanic and volcaniclastic rocks.

Table 2. Radiolarian data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by C.D. Blome and K.M. Reed unless otherwise indicated. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; AK, J.S. Kelley; ANs, S.W. Nelson; ANw, W.H. Nelson; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and SK, S.M. Karl. Lithologic data under remarks are chiefly field descriptions; thin section observations by J.A. Dumoulin. No., number; loc, locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Radiolarian fauna [field No.; USGS collection No.]	Age	Remarks
135 JPip	**Howard Pass B-3** 68°25'44"/ 157°17'45"	Poorly preserved forms including *Capnuchosphaera* sp. (tumidaspine fragments) *Pseudoheliodiscus* sp. (fragment of cortical ring) Isolated twisted spines. [92ARm63A; USGS DR 1491]	Late Triassic (late Carnian?, Norian)	Tightly folded, light-gray to green and light-brown to cream-colored chert in beds 1-15 cm thick; structurally below mafic igneous rock.
136 JPip	**Howard Pass B-3** 68°25'48"/ 157°17'05"	Poorly preserved forms including ?*Canoptum* sp. (casts) *Capnuchosphaera* sp. (isolated tumidaspines) *Corum* sp. cf. *C. perfectum* (casts only) *Xenorum* sp. (fragments of cortical shell and primary spines). [92ABs125; USGS DR 1503]	Late Triassic (late Carnian to middle Norian; *Capnodoce* Zone of Blome, 1984, and Blome and others, 1988).	Light-greenish-gray-weathering, dark-gray, vitreous chert with conchoidal fracture, orange-brown iron stain, and locally abundant radiolarians; beds 1-10 cm thick (average ≈6 cm).
137 JDbc	**Howard Pass B-3** 68°24'40"/ 157°28'40"	Poorly preserved forms including Abundant casts of spumellarians with little external meshwork ?*Nazarovella* sp. (guttered rays) ?*Pseudoalbaillella* sp. (poorly preserved fragment). Rare sponge spicules. [92ABs85; USGS DR 1498]	?Permian	Light-reddish-gray and light-blue-green chert in float along with basalt.
138 JDbc	**Howard Pass B-3** 68°24'36"/ 157°27'05"	Poorly preserved assemblage containing abundant radiolarian fragments, isolated bladed spines, and a narrow, undescribed conical albaillellid of Mississippian aspect. [91ADo53B; USGS DR 1454]	pre-Permian (probably Mississippian)	Green chert forms films and masses between volcanic pillows; sample from a persistent chert bed about 3 ft thick that contains abundant radiolarians.
139 JDbc	**Howard Pass B-3** 68°24'22"/ 157°27'36"	Poorly to moderately preserved assemblage including *Emiluvia* (?) *cochleata* *Eptingium manfredi manfredi* *Pseudostylosphaera coccostyla* *Pseudostylosphaera hellenica* *Triassocampe* sp. [92ABs79B; USGS DR 1497]	Middle Triassic (Ladinian)	Bedded chert and thinly laminated limestone in outcrop, rubble, and float. Sample from olive-gray to dark-gray, pale yellow-orange-weathering chert that contains locally abundant radiolarians; beds 0.3-15 cm thick.
141 JDbc	**Howard Pass B-3** 68°23'56"/ 157°27'15"	Poorly preserved casts including ?*Acanthocircus* sp. or ?*Pseudoheliodiscus* sp. (cortical ring fragments) ?*Capnodoce* sp. (broken inflated primary spines) *Capnuchosphaera* sp. (tumidaspines only) ?*Corum* sp. *Pachus* sp. ?*Pseudostylosphaera* sp. (partial test). [92ARm73B; USGS DR 1492]	Late Triassic (late Carnian or early Norian).	Dark-greenish-gray chert containing radiolarians, beneath Memorial Creek volcanic rocks.
151 JPe	**Howard Pass B-3** 68°19'23"/ 157°45'22"	Poorly preserved forms including *Albaillella* (?) *asymmetrica* *Pseudoalbaillella* sp. aff. *P. longicornis* *Entactinia* cf. *E. itsukaichiensis* Small bladed spines in fine (>63 μm) residue. [92ARm41A; USGS DR 1489]	Mid-Permian (Leonardian or Guadalupian).	Chert containing abundant radiolarians.
152 JPe	**Howard Pass B-3** 68°19'23"/ 157°45'11"	Poorly preserved forms including ?*Pseudoalbaillella* sp. (broken and crushed fragments). [92ARm40A; USGS DR 1488]	?Permian (based on questionable occurrence of ?*Pseudoalbaillella* sp.).	Float of light gray chert above Kuna Formation.

Table 2. Radiolarian data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[All faunas identified by C.D. Blome and K.M. Reed unless otherwise indicated. Letters in field number refer to collector: ABs, S. Bie; AD, J.A. Dumoulin; ADo, J.H. Dover; AK, J.S. Kelley; ANs, S.W. Nelson; ANw, W.H. Nelson; ARm, R.T. Miyaoka; (A)Tr, I.L. Tailleur; and SK, S.M. Karl. Lithologic data under remarks are chiefly field descriptions; thin section observations by J.A. Dumoulin. No., number; loc, locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Radiolarian fauna [field No.; USGS collection No.]	Age	Remarks
157 KMp	**Howard Pass C-5** 68°41'53"/ 158°27'50"	? *Latentifistula impella* (Ormiston and Lane) Group. Sponge spicules (abundant, but less abundant than radiolarians; include hexactine spicules [Hexactinellida] and ?anatriaene, strongyle, and large matted monaxon spicules [Demospongiae?]). Preservation = 2 on a scale of 1–5. [86Tr2A; USGS MR 7272]	Mississippian? Poorly preserved stauraxon radiolarians in this sample are more likely Paleozoic (Mississippian?) rather than Mesozoic forms.	Sample from chert closely associated with large slab (or boudin) of tasmanites-bearing rock; chert residue is medium gray. *L. impella* and abundant sponge spicules are common near time-transgressive facies boundary of Kuna Formation and Etivluk Group (for instance, transition zone between limestone and chert at Nigu Bluff, eastern Howard Pass quadrangle). Sample identified by B. Murchey, USGS.
		Capnodoce sp. Nassellarians. Twisted, bladed spines. A few hexactine sponge spicules. Preservation = 2 on a scale of 1–5. [86Tr2F; USGS MR 7275]	Late Triassic	Sample near base of uppermost chert interval at this locality; below (north) of Okpikruak Formation and above oil shale. Chert residue is white and coarse-grained. Sample identified by B. Murchey, USGS.
		Capnodoce or Capnuchosphaera sp. Nassellarians. Preservation = 2 on a scale of 1–5. [86Tr2G; USGS MR 7295]	Late Triassic	Top of uppermost chert interval at this locality; chert residue is black. Sample identified by B. Murchey, USGS.
159 JPip	**Howard Pass B-4** 68°27'0"/ 158°18'18"	Theoperid radiolarians. Conodonts. Poor foraminifers. [79ANw8A; USGS MR 1116]	Triassic (Late?)	Bedded gray chert, associated with black siltstone and dark-gray graywacke. Sample identified by D.L. Jones and B. Murchey, USGS.
189 JPii	**Howard Pass C-3** 68°40'1.2"/ 157°34'8.4"	Poorly preserved "complex" *Paronaell*a sp. Large spherical spumellariina, having three thick but very short, blunt primary spines. This fauna is probably *Pseudoalbaillella* assemblage (Holdsworth and Jones, 1980). [64Tr209R1; USGS MR 3151]	Pennsylvanian or Early Permian; equivalent to or younger than the youngest radiolarian faunas at Nigu Bluff (Murchey and others, 1981).	Red- and green-weathering chert; associated with tasmanite, fine-grained clastic rocks, and mafic rocks. Sample identified by B. Murchey and C.D. Blome, USGS.
		Latenodiotidae fam. nov. ad. int. Nazarov Subfamily Latenofistulinae?: fragments Subfamily Latenodiotinae?: poor specimen. [64Tr209R2; USGS MR 3152]	Late Pennsylvanian (?) or Permian; this fauna is younger than MR 3151, and younger than any known faunas at Nigu Bluff.	Red weathering chert. Sample identified by B. Murchey and C.D. Blome, USGS.

Table 3. Megafossil data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska

[Letters in field number refer to collector: ABe, W.P. Brosgé; AD, J.A. Dumoulin; ADo, J.H. Dover; ANs, S.W. Nelson; ATr, I.L. Tailleur; and JS, J.M. Schmidt. No., number; indet., indeterminate; colln., collection; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Fossils [field No.; USGS collection No.]	Age	Remarks
23 Dl	**Howard Pass C-4** 68°32'53"/ 158°06'35"	Corals: *Cystiphylloides* sp. cf. *C. lenzi* Pedder and McLean, 1982 [43J] "*Radiastraea*"? sp. [43I] *Taimyrophyllum* spp. [43I] *Favosites* sp. [43H] *Pachyfavosites* sp. [43G] Stromatoporoids: *Coenostelodictyon* sp. [43F] [92AD43F, G, H, I and J]	late Early to early Middle Devonian (Pragian to Eifelian).	Corals identified by W.A. Oliver, Jr., USGS; stromatoporoids identified by C.W. Stock, University of Alabama. *C. lenzi* is known only from the Road River Formation in the Royal Creek section, Yukon Territory. Table 1 contains conodont data from this locality.
73 Dl	**Howard Pass B-5** 68°29'57"/ 158°35'35"	Brachiopods: *Schizophoria* sp. *Cassidirostrum*? sp. *Cupularostrum*? sp. *Spinatrypa* (*Isospinatrypa*) sp. [92AD45B; 11950-SD]	early Middle Devonian (early Eifelian).	Identified by R.B. Blodgett, Oregon State University. *Spinatrypa* (*Isospinatrypa*) sp. is conspecific with an undescribed species from the upper part of the Cheeneetnuk Limestone of west-central Alaska. Table 1 contains conodont data from this locality.
		Brachiopods: *Cassidirostrum*? sp. *Spinatrypa* (*Isospinatrypa*) sp. *Costacranaena* n. sp. [92AD45C; 11951-SD]	early Middle Devonian (early Eifelian).	
74 Dl	**Howard Pass B-5** 68°29'43"/ 158°35'00"	Brachiopods: *Spinatrypa* (*Isospinatrypa*) sp. [92AD30B; 11949-SD]	early Middle Devonian (early Eifelian).	Identified by R.B. Blodgett, Oregon State University. *Spinatrypa* (*Isospinatrypa*) sp. is conspecific with an undescribed species from the upper part of the Cheeneetnuk Limestone of west-central Alaska. Baxter and Blodgett (1994) reported the brachiopod *Droharhynchia rzhonsnitskayae* n. sp. from this general locality (50ABe53; USGS colln. 3370-SD); brachiopods of this genus may also occur in the Kolyma region of northeastern Siberia. Table 1 contains conodont data from this locality.
86 Dl	**Howard Pass B-5** 68°25'12"/ 158°56'06"	Stromatoporoids: *Actinostroma* of a rather robust sort. [92ADo19A, B]	Probably early Late Devonian (Frasnian).	Identified by C.W. Stock, University of Alabama. Corals of possible early Late Devonian (Frasnian) age (station 51T118, colln. 51ATr424; USGS colln. 3375) reported from this general locality by J.T. Dutro, Jr., USGS, 1953, unpub. report.
87 Dl	**Howard Pass B-5** 68°24'40"/ 158°54'00"	Stromatoporoids [69A, D] and corals [69C]: Poorly preserved specimens of a ramose stromatoporoid, most likely *Stachyodes* sp. [69A] alveolitid coral [69C] Probably *Stictostroma* sp.; possibly the closely related *Stromatoporella* sp. [69D] [92AD69A, C, and D]	early Late Devonian*; Pa. transitans* Zone through Lower *Pa. hassi* Zone (early, but not very earliest, Frasnian) based on conodonts; stromatoporoids are compatible with this age.	Identified by C.W. Stock, University of Alabama. Table 1 contains conodont data from this locality. Tentaculitids, ostracodes and an ammonite cephalopod of probable late Middle-early Late Devonian age (station 51T122, colln. 51ATr439; USGS colln. 3377) reported from this general locality by J.T. Dutro, Jr., USGS, 1953, unpub. report.
98 PDlc	**Howard Pass B-5** 68°23'35"/ 158°36'32"	Numerous prisms apparently derived from shells of the bivalve *Atomodesma* sp. are visible in thin section [92AD23]	Permian? (*Atomodesma* is of Permian age).	Identified by J.A. Dumoulin; identical prisms occur in unnamed limestone of Permian age in the Medfra quadrangle, west-central Alaska
103 JDbc	**Howard Pass B-4** 68°22'20"/ 158°13'05"	Molds and casts of *Neospirifer* sp., a spiriferid brachiopod [91ANs17A]	Early Pennsylvanian–Permian; probably Early Permian.	Identified by J.T. Dutro, Jr., USGS. Sample from volcaniclastic(?) sandstone interlayered with basalt.

Table 3. Megafossil data (previously unpublished) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[Letters in field number refer to collector: ABe, W.P. Brosgé; AD, J.A. Dumoulin; ADo, J.H. Dover; ANs, S.W. Nelson; ATr, I.L. Tailleur; and JS, J.M. Schmidt. No., number; indet., indeterminate; colln., collection; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Fossils [field No.; USGS collection No.]	Age	Remarks
125 Mik	**Howard Pass B-4** 68°19'40"/ 157°52'35"	Disarticulated valve of a nuculoid pelecypod. Indet. nautiloids and ammonoids. Gastropods: *Angyomphalus* (*Angyomphalus*) sp. Indet. gastropod with cancellate sculpture. [91JS38]	*Angyomphalus* (*Angyomphalus*) sp. indicates an age of late Middle Devonian (Givetian) to Lower Carboniferous; other megafossils do not further constrain age. Conodonts from this locality are early Early Mississippian (Kinderhookian).	Pelecypod identified by J. Pojeta, Jr., USGS; all other specimens identified by R.B. Blodgett, Oregon State University. All samples from concretions in uppermost part of Kayak Shale. Table 4 contains conodont data from this locality.

Table 4. Paleontological data (published since 1980) from the west-central part of the Howard Pass quadrangle, Alaska

[Letters in field number refer to collector: AD, J.A. Dumoulin; ADo, J.H. Dover; AHe, Carl Huie; AK, J.S. Kelley; AMH, M.L. Miller; AMM, M. Mullens; ANk, W.J. Nokleberg; ANs, S.W. Nelson; Ha, E. Harris; Mu, C.G. Mull; JS (and STA), J.M. Schmidt, and Tr, I.L. Tailleur. CAI, conodont color alteration index. *, latitude/longitude herein corrected from previously published version. No., number; loc. locality; indet., indeterminate]

Locality No., map unit	Quadrangle, latitude/ longitude	Fossils [field No.; USGS collection No.]	Age [CAI]	Reference, remarks (see "References cited" following section on biostratigraphic data)
14 Mu	**Howard Pass C-5** 68°33'43"/ 158°51'45"	Conodonts [92AD57E; 32451-PC]	early Early Mississippian; middle to early late Kinderhookian (Upper *Si. duplicata* Zone to lower part *Si. isosticha*-Upper *Si. crenulata* Zone). [2 or 3]	Dumoulin and Harris, 1997, table 1, loc. 15.
29 Mlri	**Howard Pass C-3** 68°35'55"/ 157°41'00"	Conodonts [91AD11A, G; 31745-PC, 31746-PC]	No older than late Early Mississippian (no older than middle Osagean); both samples contain redeposited conodonts of early Early Mississippian (Kinderhookian) age. [2-2.5]	Dumoulin and others, 1993, table 1, loc. 19. Sample from 80-m-thick measured section of unit Mlri; 11A, 70 m above base of section; 11G, 80 m above base of section. Table 1 contains additional conodont data from this locality.
30 IPMap	**Howard Pass C-3** 68°37'05"/ 157°36'00"	Conodonts [91Tr17; 31721-PC]	Mississippian [1.5-2]	Dumoulin and others, 1993, table 1, loc. 15. Sample from Bion barite deposit of Kelley and others (1993), from about 25 m below chert containing Late Mississippian or Early Pennsylvanian radiolarians.
32 IPMap	**Howard Pass C-3** 68°37'30"/ 157°33'14"*	Conodonts [91Tr30; 31767-PC]	late Early Mississippian (Osagean, but not earliest) [1.5]	Dumoulin and others, 1993, table 1, loc. 15.
40 IPMap	**Howard Pass C-3** 68°36'10"/ 157°29'35"	Conodonts [91Tr23; 31720-PC]	middle Mississippian (latest Osagean to Meramecian; probably middle Meramecian). [1.5-2]	Dumoulin and others, 1993, table 1, loc. 16. Sample from a layer of calcitized radiolarite in the Stack barite deposit of Kelley and others (1993).
47 Mlri	**Howard Pass C-3** 68°33'58"/ 157°35'10"	Conodonts [90AD61Z; 30939-PC]	No older than late Early Mississippian (no older than early Osagean); contains redeposited conodonts of early Early Mississippian (Kinderhookian) age. [3-3.5]	Dumoulin and others, 1993, table 1, loc. 20. A few specimens have a surficial gray patina suggesting rapid heating; sample taken 5 m above a mafic sill.
48 IPMap	**Howard Pass C-3** 68°33'43"/ 157°30'22"*	Conodonts [91Tr39; 31722-PC]	late Early Mississippian (Osagean; Upper *typicus* Zone through most of *anchoralis-latus* Zone). [1.5-2]	Dumoulin and others, 1993, table 1, loc. 18. From 70-m-thick measured section 0.8 km east of the Abby Creek barite deposit of Kelley and others (1993). Sample from a baritic limestone bed 34 m above base of section.
IPMap/JIPip		Radiolarians [91AK22C] [91AK22B]	Late Mississippian (Meramecian or Chesterian) Early or Middle Pennsylvanian (Morrowan or Atokan)	Kelley and others, 1993, fig. 5. Sample 91AK22C taken several meters below 91AK22B and about 30 m above 91Tr39; both radiolarian samples from chert that is lithologically transitional between units IPMap/JIPip.
49 Mlri	**Howard Pass C-3** 68°32'55"/ 157°30'20"	Conodonts [90AD67G; 30944-PC]	No older than late Early Mississippian (no older than middle Osagean); contains redeposited conodonts of early Early Mississippian (Kinderhookian) age. [2]	Dumoulin and others, 1993, table 1, loc. 23.

Table 4. Paleontological data (published since 1980) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[Letters in field number refer to collector: AD, J.A. Dumoulin; ADo, J.H. Dover; AHe, Carl Huie; AK, J.S. Kelley; AMH, M.L. Miller; AMM, M. Mullens; ANk, W.J. Nokleberg; ANs, S.W. Nelson; Ha, E. Harris; Mu, C.G. Mull; JS (and STA), J.M. Schmidt, and Tr, I.L. Tailleur. CAI, conodont color alteration index. *, latitude/longitude herein corrected from previously published version. No., number; loc. locality; indet., indeterminate]

Locality No., map unit	Quadrangle, latitude/ longitude	Fossils [field No.; USGS collection No.]	Age [CAI]	Reference, remarks (see "References cited" following section on biostratigraphic data)
50 Mlri	**Howard Pass C-3** 68°33'00"/ 157°29'30"	Conodonts [90AD66A; 30943-PC]	late Early Mississippian (early Osagean; *typicus* Zone) [3-4]	Dumoulin and others, 1993, table 1, loc. 22. About 25 percent of specimens have a surficial gray patina suggesting nearby hydrothermal and (or) igneous activity.
51 Mlri	**Howard Pass C-3** 68°32'58"/ 157°29'10"	Conodonts [90AD64F; 30940-PC]	No older than late Early Mississippian (no older than middle Osagean, middle *anchoralis-latus* Zone); contains redeposited conodonts of early Early Mississippian (Kinderhookian) age. [2.5-3]	Dumoulin and others, 1993, table 1, loc. 22. Sample taken 16.5 m below a mafic sill.
54 Mlri	**Howard Pass C-3** 68°32'00"/ 157°34'55"	Conodonts [91AD6F, U; 31741-PC, 31742-PC]	No older than late Early Mississippian (no older than middle Osagean); 6F contains redeposited conodonts of early Early Mississippian (Kinderhookian) age. [1.5-2]	Dumoulin and others, 1993, table 1, loc. 21. From 67-m-thick measured section within unit Mlri; 6F, 5.5 m above base of section and about 0.5 m above mafic sill; 6U, 61 m above base of section.
55 Mlri	**Howard Pass C-3** 68°32'03"/ 157°34'15"	Conodonts [91AD2B; 31740-PC]	late Early Mississippian (lower ⅔ of Osagean; *typicus* Zone-most of *anchoralis-latus* Zone). [1.5]	Dumoulin and others, 1993, table 1, loc. 21. From top of Mlri unit, about 0.25 m below contact with overlying Imnaitchiak Chert. The lowermost beds of the Imnaitchiak here consist of white- to light-gray-weathering, light-green to gray chert that produced very poorly preserved radiolarians (91JS28E; USGS DR 1528) of possible Late Paleozoic age.
97 JDbc	**Howard Pass B-5** 68°22'52"/ 158°38'35"	Brachiopods [78ANk35]	Early Permian	Nelson and Nelson, 1982, table 1, loc. 4. Fossils are probably in tectonic inclusions; locality described as melange by collector.
99 PDlc	**Howard Pass B-5** 68°24'18"/ 158°27'11"	Conodonts [79ANs25C; 10018-SD]	early Late Devonian (Frasnian) [2.5]	Nelson and Nelson, 1982, table 1, loc. 3.
100 JPip	**Howard Pass B-4** 68°24'50"/ 158°17'10"	Radiolarians [79ANs2E]	Pennsylvanian (Morrowan) to Permian (Guadalupian)	Nelson and Nelson, 1982, table 1, loc. 1.
101 Mi	**Howard Pass B-4** 68°23'/ 157°55.8'	Conodonts [84STA04; 29639-PC]	early Early Mississippian (middle to late Kinderhookian). [3.5]	Mull and others, 1997, table 1. Story Creek Zn-Pb prospect.
105 Mlri	**Howard Pass B-4** 68°21'35"/ 158°08'50"*	Conodonts [91JS35D; 31753-PC]	No older than early Late Mississippian (no older than late Meramecian); contains redeposited conodonts of Early Mississippian (late Kinderhookian and Osagean) age. [3.5]	Dumoulin and others, 1993, table 1, loc. 25. Mafic sill at least 7 m thick occurs 5 m above sample site.
106 Mi	**Howard Pass B-4** 68°22'05"/ 158°04'52"*	Brachiopods [93Mu78-1]	early Early Mississippian (late Kinderhookian; *Calvustrigis rutherfordi* Zone).	Mull and others, 1997, table 1.

Table 4. Paleontological data (published since 1980) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[Letters in field number refer to collector: AD, J.A. Dumoulin; ADo, J.H. Dover; AHe, Carl Huie; AK, J.S. Kelley; AMH, M.L. Miller; AMM, M. Mullens; ANk, W.J. Nokleberg; ANs, S.W. Nelson; Ha, E. Harris; Mu, C.G. Mull; JS (and STA), J.M. Schmidt, and Tr, I.L. Tailleur. CAI, conodont color alteration index. *, latitude/longitude herein corrected from previously published version. No., number; loc. locality; indet., indeterminate]

Locality No., map unit	Quadrangle, latitude/ longitude	Fossils [field No.; USGS collection No.]	Age [CAI]	Reference, remarks (see "References cited" following section on biostratigraphic data)
111 JDbc	**Howard Pass B-4** 68°21'/ 158°16'15"	Corals, stromatoporoids [79ANs41E]	early Late Devonian (Frasnian)	Nelson and Nelson, 1982, table 1, loc. 6. Sample 92AD25E (table 1) from approximately this locality contains conodonts of middle Frasnian age.
112 JDbc	**Howard Pass B-4** 68°20'56"/ 158°16'00"	Conodonts [79ANs41C; 10091-SD]	Late Devonian [7]	Nelson and Nelson, 1982, table 1, loc. 7. Sample 92AD25H (table 1) from approximately this locality contains conodonts of Frasnian age.
113 JDbc	**Howard Pass B-4** 68°20'42"/ 158°17'	Conodonts [78ANs205B]	Late Devonian (middle Famennian)–late Early Mississippian (middle Osagean). [3.5-4]	Nelson and Nelson, 1982, table 1, loc. 9. Collected from limestone within Copter Peak basalt unit of Siniktanneyak mafic complex.
114 JDbc	**Howard Pass B-4** 68°20'/ 158°19'23"	Corals, brachiopods [78AMM35C]	Middle-Late Devonian	Nelson and Nelson, 1982, table 1, loc. 11. Collected from limestone within Copter Peak basalt unit of Siniktanneyak mafic complex.
		Conodonts [78AMM35D]	Devonian-Triassic [3]	
116 Mk	**Howard Pass B-4** 68°19'44"/ 158°16'16"*	Brachiopods, echinoderms, sponge(?) [78AMH194A]	Middle Devonian–Early Mississippian	Nelson and Nelson, 1982, table 1, loc. 10.
		Conodonts [93Mu80; 32213-PC]	early Early Mississippian (Kinderhookian) [3 or 4]	Mull and others, 1997, table 1. Limestone and shale member of Kayak Shale (Mull and others, 1997).
117 JTRo	**Howard Pass B-4** 68°19'20"/ 158°19'05"	Pelecypods, radiolarians [79ANs31A]	Late Triassic (Norian)	Nelson and Nelson, 1982, table 1, loc. 12. Sample 86SK239A (table 2) from approximately this locality contains radiolarians of Triassic age.
		Conodonts [79ANs31B]	Middle Triassic (Anisian and (or) Ladinian)	
118 Mk	**Howard Pass B-4** 68°18'58"/ 158°18'58"	Brachiopods, corals, echinoderms [78ANs135B]	Late Devonian-Early Mississippian	Nelson and Nelson, 1982, table 1, loc. 13.
119 Mk	**Howard Pass B-4** 68°18.7'/ 158°05.8'	Conodonts [93Mu73; 32217-PC]	Devonian to Early Mississippian; probably early Early Mississippian (Kinderhookian). [3 or 4]	Mull and others, 1997, table 1. Shale member of the Kayak Shale (Mull and others, 1997).
120 Mikv	**Howard Pass B-4** 68°19'/ 158°04.5'	Conodonts [91JS36Z; 31754-PC]	early Early Mississippian (Kinderhookian) [3-3.5]	Dumoulin and Harris, 1997, table 1, loc. 3, and Mull and others, 1997, table 1. Limestone and shale member of the Kayak Shale (Mull and others, 1997); sample from limestone that stratigraphically overlies about 10 m of volcaniclastic rocks (in Kayak Shale) and underlies spiculitic chert (Kuna Formation).

Table 4. Paleontological data (published since 1980) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[Letters in field number refer to collector: AD, J.A. Dumoulin; ADo, J.H. Dover; AHe, Carl Huie; AK, J.S. Kelley; AMH, M.L. Miller; AMM, M. Mullens; ANk, W.J. Nokleberg; ANs, S.W. Nelson; Ha, E. Harris; Mu, C.G. Mull; JS (and STA), J.M. Schmidt, and Tr, I.L. Tailleur. CAI, conodont color alteration index. *, latitude/longitude herein corrected from previously published version. No., number; loc. locality; indet., indeterminate]

Locality No., map unit	Quadrangle, latitude/ longitude	Fossils [field No.; USGS collection No.]	Age [CAI]	Reference, remarks (see "References cited" following section on biostratigraphic data)
122 Mikv	**Howard Pass B-4** 68°17.7'/ 157°58.8'	Conodonts [91JS37G; 31755-PC]	early Early Mississippian (middle to late Kinderhookian). [3.5-4]	Dumoulin and Harris, 1997, table 1, loc. 4, and Mull and others, 1997, table 1. Limestone and shale member of the Kayak Shale (Mull and others, 1997).
123 Mik	**Howard Pass B-4** 68°20'10"/ 157°52'58"	Conodonts [92ADo248B; 32207-PC]	early Early Mississippian (probably Kinderhookian) [3 or 4]	Dumoulin and Harris, 1997, table 1, loc. 9, and Mull and others, 1997, table 1. Sandstone member of the Kayak Shale (Mull and others, 1997).
124 Mik	**Howard Pass B-4** 68°20'/ 157°52'30"*	Conodonts [92ADo316B; 32208-PC]	early Early Mississippian (probably Kinderhookian) [3 or 4]	Dumoulin and Harris, 1997, table 1, loc. 9, and Mull and others, 1997, table 1. Sandstone member of the Kayak Shale (Mull and others, 1997); probably stratigraphically lower than 92ADo248B (loc. 123).
125 Mik	**Howard Pass B-4** 68°19'40"/ 157°52'35"	Conodonts [91JS38A; 31756-PC]	early Early Mississippian (Kinderhookian) [3.5-4]	Dumoulin and Harris, 1997, table 1, loc. 5. Limestone and shale member of the Kayak Shale (Mull and others, 1997). See table 3 for megafossil data from this locality.
IPMk		[91JS38B; 31757-PC]	Early Mississippian [CAI indeterminate; conodonts covered with amorphous organic matter]	Dumoulin and others, 1993, table 1, loc. 8. Stratigraphically overlies 38A.
126 Mik	**Howard Pass B-4** 68°19'/ 157°51'10"*	Conodonts [92ADo239B2; 32209-PC]	early Early Mississippian (Kinderhookian) [≈3.5]	Dumoulin and Harris, 1997, table 1, loc. 8, and Mull and others, 1997, table 1. Shale member of the Kayak Shale (Mull and others, 1997).
131 Mlr	**Howard Pass B-3** 68°27'08"/ 157°31'02"	Conodonts [92AD46A; 32446-PC]	early Early Mississippian (middle to late—but not latest—Kinderhookian). [1.5]	Dumoulin and others, 1993, table 1, loc. 14. Sample 92AD46A is from strata that structurally underlie 92ADo78 and 79; 46A is 0.5 m below base of Kuna Formation.
132 Mik	**Howard Pass B-3** 68°26'50"/ 157°31'00"	Conodonts [92ADo79A; 32216-PC]	early Early Mississippian (middle to late Kinderhookian). [2]	Dumoulin and Harris, 1997, table 1, loc. 14. Sample 92ADo79A is from ≈75 m stratigraphically above 92ADo78B (loc. 133).
133 Mik	**Howard Pass B-3** 68°26'48"/ 157°30'35"*	Conodonts [92ADo78B; 33320-PC]	early Early Mississippian; early to middle Kinderhookian (*Si. sulcata* Zone into lowest part of the Lower *Si. crenulata* Zone). [2]	Dumoulin and Harris, 1997, table 1, loc. 14.
140 JDbc	**Howard Pass B-3** 68°24'00"/ 157°27'10"	Conodonts [92AD37D; 32443-PC]	early Early Mississippian (middle to late Kinderhookian). [3]	Dumoulin and Harris, 1997, table 1, loc. 16. Sample from carbonate thrust beneath (and locally intercalated with?) basalt of unit JDbc.
142 Mk	**Howard Pass B-3** 68°22'55"/ 157°40'50"	Conodonts [91ADo70E; 31747-PC)	early Early Mississippian (middle to late Kinderhookian). [≈3]	Dumoulin and Harris, 1997, table 1, loc. 6, and Mull and others, 1997, table 1. Limestone and shale member of the Kayak Shale (Mull and others, 1997). Sample 91ADo70E is from strata about 20 m structurally (and stratigraphically?) above 91ADo70C (loc. 143).

Table 4. Paleontological data (published since 1980) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[Letters in field number refer to collector: AD, J.A. Dumoulin; ADo, J.H. Dover; AHe, Carl Huie; AK, J.S. Kelley; AMH, M.L. Miller; AMM, M. Mullens; ANk, W.J. Nokleberg; ANs, S.W. Nelson; Ha, E. Harris; Mu, C.G. Mull; JS (and STA), J.M. Schmidt, and Tr, I.L. Tailleur. CAI, conodont color alteration index. *, latitude/longitude herein corrected from previously published version. No., number; loc. locality; indet., indeterminate]

Locality No., map unit	Quadrangle, latitude/ longitude	Fossils [field No.; USGS collection No.]	Age [CAI]	Reference, remarks (see "References cited" following section on biostratigraphic data)
143 Mk	**Howard Pass B-3** 68°22'52"/ 157°40'50"	Conodonts [91ADo70C; 31748-PC]	early Early Mississippian (middle to late Kinderhookian). [≈3]	Dumoulin and Harris, 1997, table 1, loc. 6, and Mull and others, 1997, table 1. Limestone and shale member of the Kayak Shale (Mull and others, 1997).
144 Mlr	**Howard Pass B-3** 68°23'30"/ 157°39'15"	Conodonts [91AD9F; 31743-PC]	early Early Mississippian (Kinderhookian) [2-2.5]	Dumoulin and Harris, 1997, table 1, loc. 1.
145 Mik	**Howard Pass B-3** 68°22'30"/ 157°37'16"*	Conodonts [92Mu22; 32210-PC]	early Early Mississippian (Kinderhookian) [3.5]	Mull and others, 1997, table 1. Limestone and shale member of the Kayak Shale (Mull and others, 1997).
148 Mlr	**Howard Pass B-3** 68°19'36"/ 157°45'15"	Conodonts [92AD55-0; 32449-PC]	early Early Mississippian (Kinderhookian) [4]	Dumoulin and Harris, 1997, table 1, loc. 2. About 1 km southwest of type section of the Kuna Formation. Sample 55-0 is from near or at top of Rough Mountain Creek unit.
Mk		[92AD55-22; 32450-PC]	early Early Mississippian (Kinderhookian) [4]	Sample 55-22 is from the limestone and shale member of the Kayak Shale, about 12 m below contact with Rough Mountain Creek unit.
149 Mlr	**Howard Pass B-3** 68°19'38"/ 157°45'05"	Conodonts [92AD73G; 32462-PC]	early Early Mississippian (Kinderhookian) [4]	Dumoulin and Harris, 1997, table 1, loc. 2. Structural repeat of section at 92AD55 located 0.2 km to northeast; sample from about 6 m below top of Rough Mountain Creek unit.
150 Mlr	**Howard Pass B-3** 68°19'30"/ 157°44'55"	Conodonts [92AD72-5; 32461-PC]	early Early Mississippian (Kinderhookian) [4]	Dumoulin and Harris, 1997, table 1, loc. 2. From chert-rich outcrop about 5 m below top of Rough Mountain Creek unit.
153 Mk	**Howard Pass B-3** 68°20.5'/ 157°13'	Conodonts [93JS03E]	Late Devonian-Mississippian [4]	Dumoulin and Harris, 1997, table 1, loc. 13, and Mull and others, 1997, table 1. These authors assign rocks at this locality to the lower part of Isikut unit, several meters above contact with underlying Kanayut Conglomerate.
154 Mk	**Howard Pass B-3** 68°20'24"/ 157°13' 23"*	Brachiopods [93Ha109]	early Early Mississippian (late Kinderhookian; *Calvustrigis rutherfordi* Zone).	Mull and others, 1997, table 1. These authors assign rocks at this locality to the Isikut unit.
155 Mlr	**Howard Pass B-3** 68°15'29"/ 157°20'17"*	Conodonts [93Mu63-1; 32202-PC]	early Early Mississippian (Kinderhookian) [3.5]	Mull and others, 1997, table 1. From an interval of Rough Mountain Creek unit too small to show on geologic map.
Mi	**Howard Pass B-3** 68°15'25"/ 157°20'20"*	Conodonts [93Mu63-2; 32200-PC]	early Early Mississippian (Kinderhookian) [3.5]	Mull and others, 1997, table 1. These authors assign rocks at this locality to the limestone and shale member of Kayak Shale.

Table 4. Paleontological data (published since 1980) from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[Letters in field number refer to collector: AD, J.A. Dumoulin; ADo, J.H. Dover; AHe, Carl Huie; AK, J.S. Kelley; AMH, M.L. Miller; AMM, M. Mullens; ANk, W.J. Nokleberg; ANs, S.W. Nelson; Ha, E. Harris; Mu, C.G. Mull; JS (and STA), J.M. Schmidt, and Tr, I.L. Tailleur. CAI, conodont color alteration index. *, latitude/longitude herein corrected from previously published version. No., number; loc. locality; indet., indeterminate]

Locality No., map unit	Quadrangle, latitude/ longitude	Fossils [field No.; USGS collection No.]	Age [CAI]	Reference, remarks (see "References cited" following section on biostratigraphic data)
155 Mi [cont.]	**Howard Pass B-3** 68°15'22"/ 157°20'17"	Conodonts, brachiopods [93Ha136; 32194-PC]	Conodonts indicate early Early Mississippian (middle to late Kinderhookian); brachiopods indicate Carboniferous. [3.5-4]	Mull and others, 1997, table 1.
156 Mi	**Howard Pass B-3** 68°15'07"/ 157°20'10"	Conodonts, brachiopods [93Mu63; 32201-PC]	Brachiopods indicate early Early Mississippian (late Kinderhookian; *Calvustrigis rutherfordi* Zone); conodonts indicate middle to late Kinderhookian. [3.5]	Mull and others, 1997, table 1. These authors assign rocks at this locality to the limestone and shale member of Kayak Shale.
158 JPPii	**Howard Pass C-3** 68°36.5'/ 157°20.0'	Radiolarians [78Tr232A; MR 5346]	Late Triassic	Murchey and others, 1988, table 32.3. Sample location approximate; based on latitude and longitude in Murchey and others (1988).
160 PMap	**Howard Pass B-4** 68°23.92'/ 158°05'	Radiolarians [77AHe56; MR 0035]	Early(?) Mississippian	Murchey and others, 1988, table 32.3. Sample location approximate; based on latitude and longitude in Murchey and others (1988).

Table 5. Early fossil collections from the west-central part of the Howard Pass quadrangle, Alaska

[Letters in field number refer to collector: (A)La, A.H. Lachenbruch; AMg, M.D. Mangus; K, AKt, B.H. Kent, Jr.; R, ARr, H.N. Reiser; T, (A)Tr, I.L. Tailleur. *Many collections in the west-central Howard Pass quadrangle published by Elder and others (1989) are mislocated; these locations have been replotted herein using the original field station maps and notes. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Fossils [field station No. (field collection. No.); USGS collection No.]	Age	Remarks (see "References cited" following section on biostratigraphic data)
161 Mlri?	**Howard Pass C-5** 68°43'19"/ 158°53'24"	Spores: Well-preserved assemblage including *Hymenozonotriletes lepidophytus* Kedo [65ATr55.1, 55.2]	late Late Devonian (upper Famennian or Strunian).	Identified by R.A. Scott, USGS, April 1970, unpublished fossil report on shipments A-65-5D, 6D. Sample from clay shale, mudstone, and siltstone associated with hematitic quartz-pebble conglomerate and sandstone (to south) and carbonaceous shale interbedded with carbonaceous chert (to north). Spore-bearing strata included here with unit Mlri but may be previously unrecognized, unnamed older unit underlying unit Mlri. Similar rocks produced an identical spore assemblage 5.6 km east of the map area (65ATr122; Howard Pass C-2 quadrangle).
162 Kop	**Howard Pass C-5** 68°45'/ 158°48'32"*	Bivalves: *Buchia sublaevis* Keyserling [51T51 (51ATr177F); 23574]	early Early Cretaceous (early Valanginian).	Elder and others, 1989, table 1, loc. 95. Fossils occur in a section of dark clay shale with 30% very fine grained, dark-gray, rippled to even-bedded sandstone.
163 Mlri	**Howard Pass C-5** 68°32'49"/ 158°49'12"	Ammonoid cephalopod: *Münsteroceras* sp. [51T106 (51ATr392); 13240-PC]	Early Mississippian (late Tournaisian).	Gordon, 1957, p. 6, 13–15, 18. Both fossils from thinly interbedded gray-black chert, limestone, and calcareous shale. Sample 51ATr392 is from 440 ft stratigraphically below base of 105-ft–thick igneous sill; 51ATr393 is from 30 ft above sill.
		Ammonoid cephalopod: *Protocanites*? sp. [51T106 (51ATr393); 13241-PC]	Probably Early Mississippian (Tournaisian?).	
164 JPe	**Howard Pass C-5** 68°34'41"/ 158°46'37"	Bivalve: *Monotis* sp. cf. *alaskana* Smith [51K133 (51AKt169); 24052]	Late Triassic (Norian)	Identified by B. Kummel, December 1952, unpublished fossil report on shipment A-52-9. Fossil from limestone bed with abundant *Monotis* sp.
165 JTro	**Howard Pass C-5** 68°36'25"/ 158°44'17"	Bivalve: *Monotis subcircularis* Gabb [51K117 (51AKt150); 24051]	Late Triassic (Norian)	Identified by B. Kummel, December 1952, unpublished fossil report on shipment A-52-9. Fossil from gray coquinoid limestone interbedded with chert.
166 JTro	**Howard Pass C-5** 68°34'01"/ 158°44'02"	Bivalve: *Halobia cordillerana* Smith [51K103 (51AKt135); 24050]	Late Triassic (Carnian)	Identified by B. Kummel, December 1952, unpublished fossil report on shipment A-52-9. Fossil from light gray limestone associated with shale.
167 KJo	**Howard Pass C-5** 68°44'24"/ 158°25'44"*	Bivalves: *Buchia sublaevis* Keyserling ?*B. keyserlingi* (Lahusen) [51T77 (51ATr266F); 23577]	early Early Cretaceous (early Valanginian).	Elder and others, 1989, table 1, loc. 99, and Jones and Grantz, 1964, p. 1464–65. Bivalves at this locality originally identified (by R. Imlay, USGS, 1952) as *B. rugosa* (Fischer) of Late Jurassic age, but reassigned to *B.* cf *sublaevis* by Imlay in 1964. Fossils occur in coquinoid limestone.
168 KJo	**Howard Pass C-5** 68°44'13"/ 158°25'48"*	Bivalve: *Buchia sublaevis* Keyserling [51T75 (51ATr257F); 23697]	early Early Cretaceous (Valanginian)	Elder and others, 1989, table 1, loc. 99. Bivalves at this locality originally identified (by R. Imlay, USGS, 1952) as *B. rugosa* (Fischer) of Late Jurassic age, but reassigned to *B.* cf *sublaevis* by Imlay in 1964. Fossils occur in 1-m-thick bed of coquinoid limestone.

Table 5. Early fossil collections from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[Letters in field number refer to collector: (A)La, A.H. Lachenbruch; AMg, M.D. Mangus; K, AKt, B.H. Kent, Jr.; R, ARr, H.N. Reiser; T, (A)Tr, I.L. Tailleur. *Many collections in the west-central Howard Pass quadrangle published by Elder and others (1989) are mislocated; these locations have been replotted herein using the original field station maps and notes. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Fossils [field station No. (field collection. No.); USGS collection No.]	Age	Remarks (see "References cited" following section on biostratigraphic data)
169 Kon	**Howard Pass C-5** 68°42'25"/ 158°27'36"*	Bivalve: *Buchia crassicollis solida* (Lahusen) [51T72 (51ATr231F); 23576]	early Early Cretaceous (middle to late Valanginian).	Elder and others, 1989, table 1, loc. 96. Fossils occur in section of well-indurated, medium-yellow sandstone, in ≈1-m-thick beds, interbedded with shale and siltstone.
170 Koi	**Howard Pass C-5** 68°41'46"/ 158°28'26"*	Bivalve: *Buchia crassicollis solida* (Lahusen) [51T69 (51ATr209F); 23575]	early Early Cretaceous (middle to late Valanginian).	Elder and others, 1989, table 1, loc. 94. Bivalves at this locality originally identified (by R. Imlay, USGS, 1952) as ?*B.subokensis* (Pavlow) and *B.* cf *B. uncitoides* (Pavlow) and assigned a Berriasian age. Fossils occur in a 5-m-thick zone of rippled sandstone, in 2- to 4-m-thick beds; shells are abundant and in parallel alignment.
		Bivalve: *Buchia* cf. *volgensis* (Lahusen) [65Tr46.2; M2944]	early Early Cretaceous (Berriasian)	Elder and others, 1989, table 1, loc. 98. *Buchia* from medium-bedded "rhythmites" (of sandstone and shale), at least several hundred meters above base of formation.
171 Koi	**Howard Pass C-5** 68°41'02"/ 158°23'56"	Bivalve: ?*B.subokensis* (Pavlow) [51K56 (51AKt57F)]	early Early Cretaceous (Berriasian?)	Near (perhaps equivalent to) M1268 in Elder and others, 1989, table 1, loc. 97. Fossil occurs in a section of greenish sandstone interbedded with shale.
172 Koi	**Howard Pass C-5** 68°40'26"/ 158°28'01"*	Bivalve: *Buchia crassicollis solida* (Lahusen) [51K67 (51AKt72F); 24041]	early Early Cretaceous (middle to late Valanginian).	Elder and others, 1989, table 1, loc. 93. Fossil occurs in a section of interbedded sandstone and shale.
173 JTRo	**Howard Pass C-5** 68°32'42"/ 158°35'42"	Bivalve: *Monotis* cf. *subcircularis* Gabb [65Tr61.2; M2982]	Late Triassic (late Norian)	Identified by N.J. Silberling, USGS, November 1965, unpublished fossil report on shipment A-65-13M. Fossil from gray, platy-bedded, *Monotis*-bearing limestone, locally silicified, near top of Otuk Formation.
174 PMk	**Howard Pass C-5** 68°31'55"/ 158°28'19"	Ammonoid cephalopod: *Bollandites kiligwae* Gordon, n. sp. [51Tr89 (51ATr319); 13204-PC]	Late Mississippian (middle Visean; Meramecian).	Gordon, 1957, p. 6, 7, 13-15, 18. Fossil from calcareous concretion in interbedded black chert and shale, about 150 ft above base of exposed section.
175 PMk	**Howard Pass C-5** 68°31'08"/ 158°32'10"	Nautiloid cephalopod: *Cycloceras* sp. Ammonoid cephalopod: *Ammonellipsites polaris* Gordon, n. sp. [50T219 (50ATr300F); 11857-PC]	Early Mississippian (early Visean; middle or late Osagean).	Gordon, 1957, p. 6, 13-15, 17. Fossils from isolated 125-ft section of black platy shale containing calcareous nodules.
		Coiled nautiloid cephalopod Form recalls the genera *Millkoninckioceras*, *Subvestinautilus*, and *Lispoceras*, but fits none of them perfectly. [77Tr12G; 28594-PC]	Early Mississippian (early Visean; middle or late Osagean).	Identified by M. Gordon, Jr., USGS, July 1982, unpublished fossil report on shipment NPRA-81-1. Fossil from black siliceous shale, impure chert, and limestone; same locality as 50T219.
176 JTRo	**Howard Pass C-5** 68°30'47"/ 158°34'08"	Bivalve: *Monotis subcircularis* Gabb [51R101 (51ARr141); 24053]	Late Triassic (Norian)	Identified by B. Kummel, December 1952, unpublished fossil report on shipment A-52-9. Fossil from thinly interbedded chert and shale.

Table 5. Early fossil collections from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[Letters in field number refer to collector: (A)La, A.H. Lachenbruch; AMg, M.D. Mangus; K, AKt, B.H. Kent, Jr.; R, ARr, H.N. Reiser; T, (A)Tr, I.L. Tailleur. *Many collections in the west-central Howard Pass quadrangle published by Elder and others (1989) are mislocated; these locations have been replotted herein using the original field station maps and notes. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Fossils [field station No. (field collection. No.); USGS collection No.]	Age	Remarks (see "References cited" following section on biostratigraphic data)
177 JTRo	**Howard Pass C-5** 68°30'32"/ 158°34'26"	Bivalve: *Monotis subcircularis* Gabb [51R101 (51ARr142); 24054]	Late Triassic (Norian)	Identified by B. Kummel, December 1952, unpublished fossil report on shipment A-52-9. Fossil from black massive chert.
178 Koi	**Howard Pass C-4** 68°40'16"/ 157°48'47"*	Bivalve: *Buchia crassicollis solida* (Lahusen) [49AMg46; 24657]	early Early Cretaceous (middle to late Valanginian).	Elder and others, 1989, table 1, loc. 101.
179 Koi	**Howard Pass C-4** 68°33'47"/ 157°55'19"*	Bivalves: *Buchia okensis* (Pavlow) *Buchia subokensis* (Pavlow) [49La38 (49ALa74F); 21821]	early Early Cretaceous (Berriasian)	Elder and others, 1989, table 1, loc. 102; Jones and Grantz, 1964. Bivalves at this locality originally identified (by R. Imlay, USGS, 1950) as *B. crassicollis* Keyserling of Valanginian age. Fossils occur in section of graywacke and shale.
180 JTPii	**Howard Pass C-4** 68°32'10"/ 157°51'22"	Bivalve: *Monotis subcircularis* Gabb [51T97(51ATr344); 24049]	Late Triassic (Norian)	Identified by B. Kummel, December 1952, unpublished fossil report on shipment A-52-9. Fossil occurs in very fine grained, dark-green to dark-brown sandstone containing abundant shell fragments.
181 Koi	**Howard Pass C-3** 68°34'23"/ 157°46'44"*	Bivalve: *Buchia crassicollis solida* (Lahusen) [50K233 (50AKt285); 22522]	early Early Cretaceous (middle to late Valanginian).	Elder and others, 1989, table 1, loc. 99. Fossil from fine-grained, dark-gray-green, micaceous graywacke.
182 KJo	**Howard Pass C-3** 68°37'30"/ 157°35'17"*	Bivalve: *Buchia crassicollis solida* (Lahusen) [50K164 (50AKt219F); 22519]	early Early Cretaceous (middle to late Valanginian). .	Elder and others, 1989, table 1, loc. 100. Fossil from medium-grained, dark-gray-green graywacke.
183 KMi	**Howard Pass C-3** 68°38'28"/ 157°28'08"*	Bivalve: *Buchi*a sp. [50K210 (50AKt257); 22521]	Jurassic or Cretaceous	Elder and others, 1989, table 1, loc. 104. Fossil from thin-bedded, fine-grained, gray-green graywacke with local iron staining.
184 Kop	**Howard Pass C-3** 68°36'58"/ 157°28'41"*	Bivalve: *Buchia crassicollis solida* (Lahusen) [50K135 (50AKt185); 22518]	early Early Cretaceous (middle to late Valanginian).	Elder and others, 1989, table 1, loc. 104. Fossil from cherty, medium-grained, dark-green graywacke.
185 KJo	**Howard Pass C-3** 68°36'/ 157°30'22"*	Bivalve: *Buchia sublaevis* Keyserling [50T115 (50ATr166F); 22507]	early Early Cretaceous (early Valanginian).	Elder and others, 1989, table 1, loc. 103; Jones and Grantz, 1964. Bivalves at this locality originally identified (by R. Imlay, USGS, 1952) as *B. aff. B. bronni* (Rouiller) of Late Jurassic age, but reassigned to *B.* cf. *sublaevis* by Imlay in 1964. Fossils occur in float of coquinoid limestone.
186 JDbc	**Howard Pass B-4** 68°24'11"/ 158°14'42"	Brachiopods: *Aulacella*? sp. rhynchonelloid, indet. *Cyrtospirifer* sp. spiriferoid, indet. "*Athyris*" (*Angelica*-type) [77Tr15.2; 10353-SD]	Late Devonian (probably Famennian)	Identified by J.T. Dutro, Jr., USGS, February 1981, report on shipment NPRA-81-1. Fossils from rubble of calcareous arenite associated with mafic igneous rocks.

Table 5. Early fossil collections from the west-central part of the Howard Pass quadrangle, Alaska—Continued.

[Letters in field number refer to collector: (A)La, A.H. Lachenbruch; AMg, M.D. Mangus; K, AKt, B.H. Kent, Jr.; R, ARr, H.N. Reiser; T, (A)Tr, I.L. Tailleur. *Many collections in the west-central Howard Pass quadrangle published by Elder and others (1989) are mislocated; these locations have been replotted herein using the original field station maps and notes. No., number; indet., indeterminate; loc., locality]

Locality No., map unit	Quadrangle, latitude/ longitude	Fossils [field station No. (field collection. No.); USGS collection No.]	Age	Remarks (see "References cited" following section on biostratigraphic data)
187 JTRo	**Howard Pass B-3** 68°28'08"/ 157°45'47"	Bivalve: *Monotis subcircularis* Gabb [51T102 (51ATr367); 24036]	Late Triassic (Norian)	Identified by B. Kummel, December 1952, unpublished fossil report on shipment A-52-10. Fossil from section of shale and sandstone containing a few interbeds and concretions of calcareous shale. Exact location of sample along line of traverse is uncertain.
188 KDe (KJo?)	**Howard Pass B-3** 68°24'50"/ 157°12'04"*	Bivalve: *Buchia rugosa* (Fischer) [51T010 (51ATr19F); 23598]	Late Jurassic (Kimmeridgian)	Elder and others, 1989, table 1, loc. 109. Bivalves at this locality were originally identified (by R. Imlay, USGS, 1952) as *B. bronni* (Rouiller) and *B.* cf. *mosquenensis* (von Buch) of Late Jurassic age; "probable" but "poorly preserved" *B.* cf. *mosquensis* was confirmed by by Imlay in 1964. *B. mosquensis* and *B. concentrica* reported from this locality in Imlay and Detterman (1973, p. 26, loc. 4). Fossils from lenses of poorly developed pelecypod coquina within pebbly siltstone.