Revision of the Type Mankomen Formation (Pennsylvanian and Permian), Eagle Creek Area, Eastern Alaska Range, Alaska

GEOLOGICAL SURVEY BULLETIN 1395-B

Revision of the Type Mankomen Formation (Pennsylvanian and Permian), Eagle Creek Area, Eastern Alaska Range, Alaska

By D. H. RICHTER and J. T. DUTRO, JR.

CONTRIBUTIONS TO STRATIGRAPHY

GEOLOGICAL SURVEY BULLETIN 1395-B

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1975

UNITED STATES DEPARTMENT OF THE INTERIOR

ROGERS C. B. MORTON, *Secretary*

GEOLOGICAL SURVEY

V. E. McKelvey, *Director*

Library of Congress Cataloging in Publication Data

Richter, Donald H.
Revision of the type Mankomen Formation (Pennsylvanian and Permian), Eagle Creek area, eastern Alaska Range, Alaska.
(Contributions to Stratigraphy) (Geological Survey Bulletin 1395-B)
Bibliography: p. 20-21.
Supt. of Docs. No.: I 19.3:1395-B
1. Geology, Stratigraphic–Permian. 2. Geology, Stratigraphic–Pennsylvanian. 3. Geology–Alaska–Alaska Range. I. Dutro, J. Thomas, joint author. II. Title. III. Series: United States Geological Survey. Bulletin 1395-B.
QE75.B9 No. 1395-B [QE674] 557.3'08s 74-31194
[551.7'52'097983]

For sale by the Superintendent of Documents, U. S. Government Printing Office
Washington, D. C. 20402

Stock Number 024-001-02600

CONTENTS

ILLUSTRATIONS

REVISION OF THE TYPE MANKOMEN FORMATION (PENNSYLVANIAN AND PERMIAN), EAGLE CREEK AREA, EASTERN ALASKA RANGE, ALASKA

By D. H. RICHTER and J. T. DUTRO, JR.

ABSTRACT

The Mankomen Formation is raised to group rank in its type area. Two new formations are recognized: the Slana Spur Formation, about 4,550 feet thick, consisting chiefly of volcaniclastic and calcareous volcaniclastic rocks and the overlying Eagle Creek Formation, about 2,940 feet thick, consisting of nonvolcanogenic marine argillite and limestone.

The Mankomen Group is underlain conformably by the Tetelna Volcanics, consisting of massive volcanic flows and volcaniclastic rocks of Pennsylvanian(?) age. The Nikolai Greenstone, of Middle and (or) Late Triassic age, and locally a thin sequence of chert and limestone, of probably Triassic age, rest unconformably on the Mankomen.

Fusulinids in the volcaniclastic member of the Slana Spur Formation are Middle Pennsylvanian (Atokan) in age. Fossils in the upper part of the Slana Spur Formation and the lower part of the Eagle Creek Formation are of Wolfcampian (Sakmarian) age. The upper limestone and upper argillite members of the Eagle Creek yield younger faunas of Leonardian (Artinskian) and, possibly, early Guadalupian (Ufimian?) age.

The Tetelna Volcanics reflect the development of a late Paleozoic volcanic island arc whose waning stages are represented by the volcaniclastic rocks of the Slana Spur Formation. Lithologies of the Tetelna-Mankomen strata, and the new age data, suggest that this arc had become virtually inactive by Early Permian time.

INTRODUCTION

The Mankomen Formation was named by Mendenhall (1905, p. 40–47) for the predominantly sedimentary sequence in the mountains north of Mankomen Valley between the Middle Fork of the Chistochina River and the valley of the Slana River (fig. 1). Eagle Creek valley and an adjacent mountain spur just west of the Slana River were designated the type area for the formation, and a composite section of 6,700 feet was presented. Mendenhall (1905, p. 45) assigned a Permian age to the Mankomen on the basis of fossil identifications by Charles Schuchert. Later history of study of Permian strata in the eastern Alaska Range is summarized by Moffit (1954, p. 103–118).

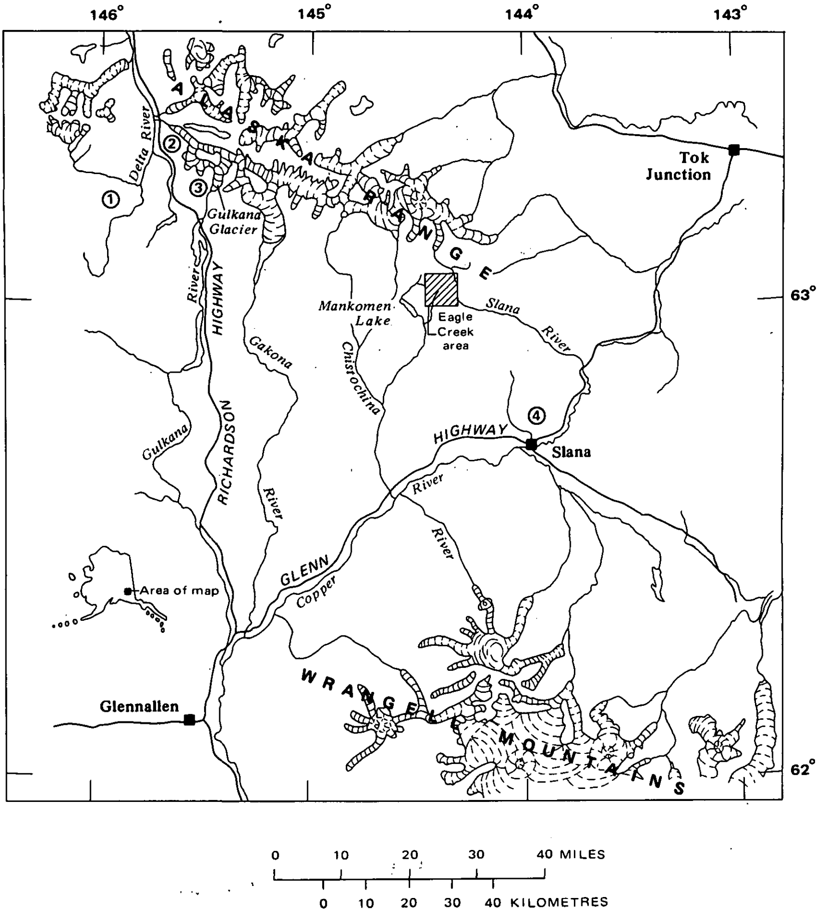


FIGURE 1.—Eagle Creek area and other localities (numbered) where Pennsylvanian and Permian rocks are exposed.

Although no other recent stratigraphic work has been done in the type area, a number of investigations have been carried out on the Permian rocks and faunas from elsewhere in the eastern and east-central Alaska Range. Corals and fusulinids from the Permian in the Delta River area (localities 1 and 2, fig. 1), 45–50 miles northwest of Mankomen Lake, were described by Rowett (1968) and Petocz (1970), respectively, and the volcanic stratigraphy and biostratigraphy in the Gulkana Glacier area (locality 3, fig. 1), 40 miles northwest of Mankomen Lake, were studied by Bond (1969) and Gilbertson (1969), respectively. Permian corals near Slana (locality 4, fig. 1), southeast of Mankomen Lake, were described by Rowett (1971), who suggested a correlation with strata in the Delta River area.

During the period July 3–9, 1972, the writers refined the 1967 reconnaissance mapping of Richter (unpub. data) north of Mankomen Lake and measured most of the stratigraphic sequence in detail. Two different lithologic suites are recognized in Mendenhall's original Mankomen Formation: a lower marine volcaniclastic sequence containing both Pennsylvanian and Permian faunal assemblages and a conformable upper nonvolcanogenic marine sequence containing only Permian fauna. We therefore raise the Mankomen Formation to group rank and, on the basis of lithologic homogeneity, propose two new formations, the Slana Spur Formation and the Eagle Creek Formation, to define the two distinct marine sequences within the group.

We wish to thank our U.S. Geological Survey colleagues R. C. Douglass and Mackenzie Gordon, Jr., for identifying the fusulinids and ammonoids, respectively. R. E. Grant and G. A. Cooper of the U.S. National Museum have provided valuable suggestions concerning the significance of the brachiopods in correlation with Permian strata in other parts of the world.

PHYSICAL STRATIGRAPHY OF THE MANKOMEN GROUP

The redefined Mankomen Group is approximately 7,500 feet thick. It includes the Slana Spur Formation, consisting predominantly of calcareous and noncalcareous volcaniclastic rocks about 4,550 feet thick, and the Eagle Creek Formation, consisting predominantly of argillite and limestone about 2,940 feet thick. The Mankomen Group overlies with apparent conformity massive volcanic rocks of the Tetelna Volcanics (Mendenhall, 1905, p. 36–38).

Both new formations of the Mankomen Group are intruded by locally abundant dikes, sills, and small stocks of gabbro, a variety of hornblende-plagioclase porphyries mostly andesite in composition, and dark fine-grained mafic rocks. Gabbro sills, as much as 85 feet thick, are especially conspicuous in the lower limestone member of the Eagle Creek Formation.

Because a large number of high-angle faults cut the Mankomen Group, the measured sections presented here are composites based on detailed mapping and correlation of units largely within the drainage of Eagle Creek. The locations of the individual sections used in compiling the composite sections are shown on the geologic map in figure 2. Only about 700 feet of the Slana Spur Formation, including the uppermost 500 feet of section, were measured in detail. Although data on the remainder of the formation are taken from less-detailed traverses (sections F and G, fig. 2), they are sufficient to describe the major lithologic features of the rocks. Most of our attention has been focused on the Eagle Creek Formation, whose two distinctive limestone members and two predominantly argillite members have yielded significant collections of marine fossils.

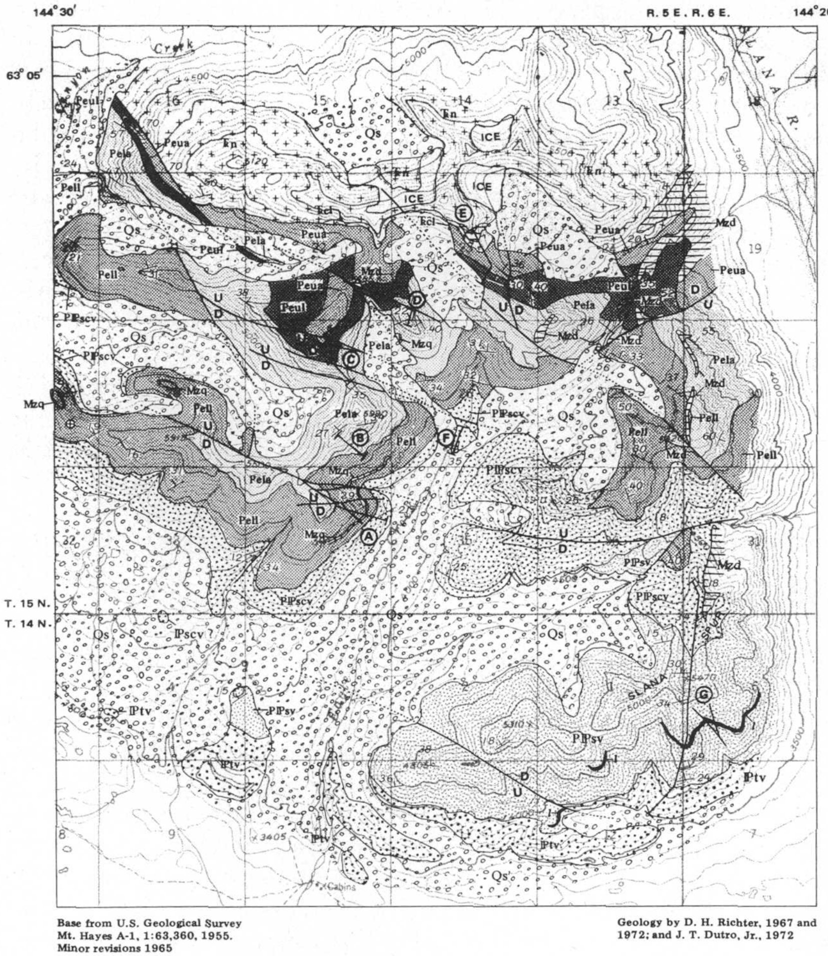


FIGURE 2.—Eagle Creek area, eastern Alaska Range.

SLANA SPUR FORMATION

The type locality for the new Slana Spur Formation is designated as Eagle Creek valley and adjacent Slana Spur, a north-trending mountain ridge separating the Eagle Creek and Slana River drainages (fig. 2). This locality is within secs. 1 and 12, T. 14 N., R. 5 E.; sec. 6, T. 14 N., R. 6 E.; secs. 26 and 34, T. 15 N., R. 5 E.; and sec. 31, T. 15 N., R. 6 E., in the Mt. Hayes A–1 quadrangle (scale 1:63,360).

The Slana Spur Formation, about 4,550 feet thick, is divided into two lithologic members: a lower or volcaniclastic member, approximately 3,100 feet thick, and an upper or calcareous volcaniclastic member, approximately 1,450 feet thick. The base of the formation, placed at the top of the first massive volcanic flow unit from the top of

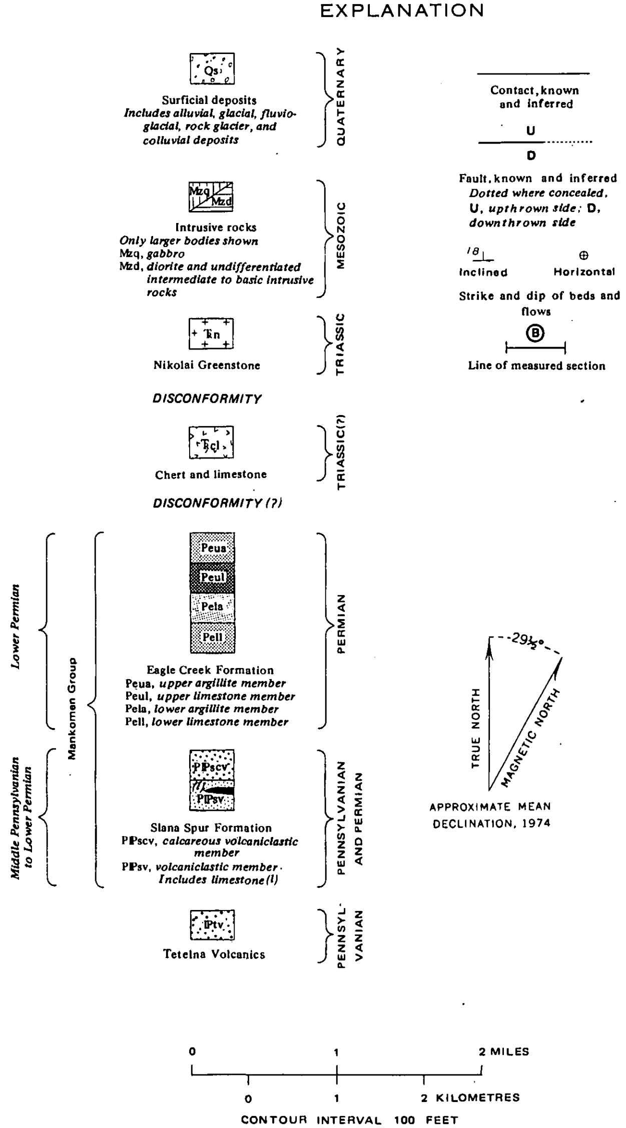


FIGURE 2.—Continued.

the section, is consistent with Mendenhall's (1905, p. 40) original designation of the base of the Mankomen Formation. This flow unit and the underlying 500 feet of section exposed on the south side of the Slana Spur (fig. 2; section G, fig. 3) are considered to belong to the Tetelna Volcanics. The Tetelna consists predominantly of dark-gray-green massive fragmental volcanic rocks, apparently submarine lahars and flow breccias, and massive dark-green porphyritic and,

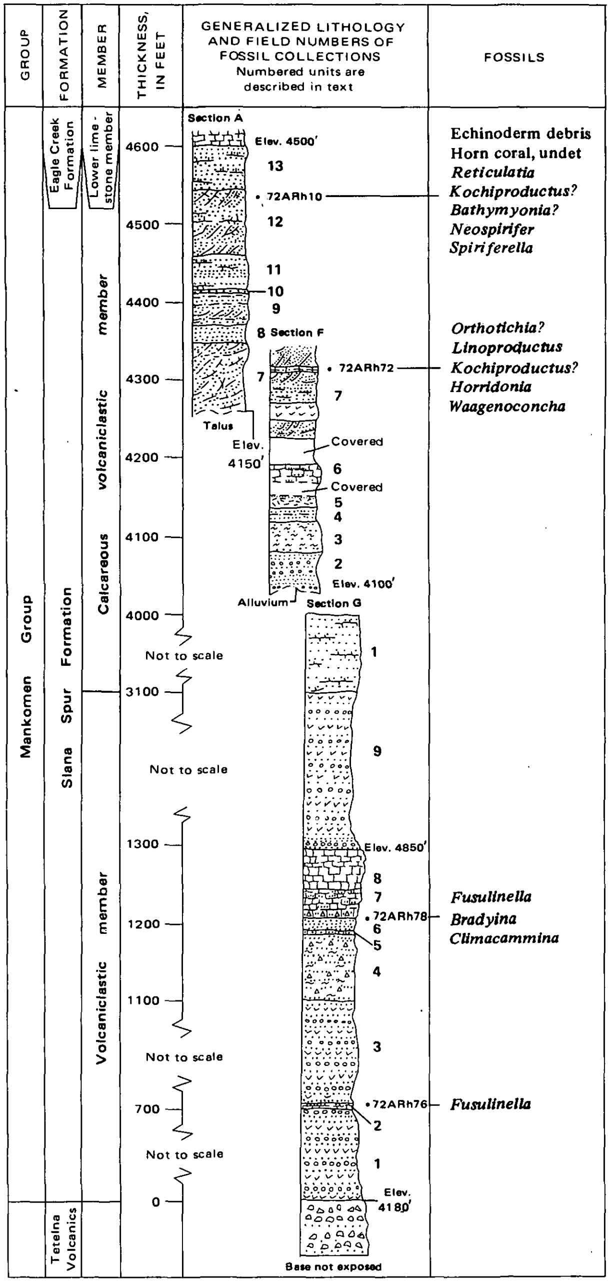


FIGURE 3.—Sections, with fossil assemblages, of the Slana Spur Formation (Mankomen Group), Eagle Creek area. Location of section shown in figure 2.

locally, amygdaloidal flows. Dark thin-bedded volcaniclastic rocks in places separate the massive volcanic units. No fossils were observed in the Tetelna.

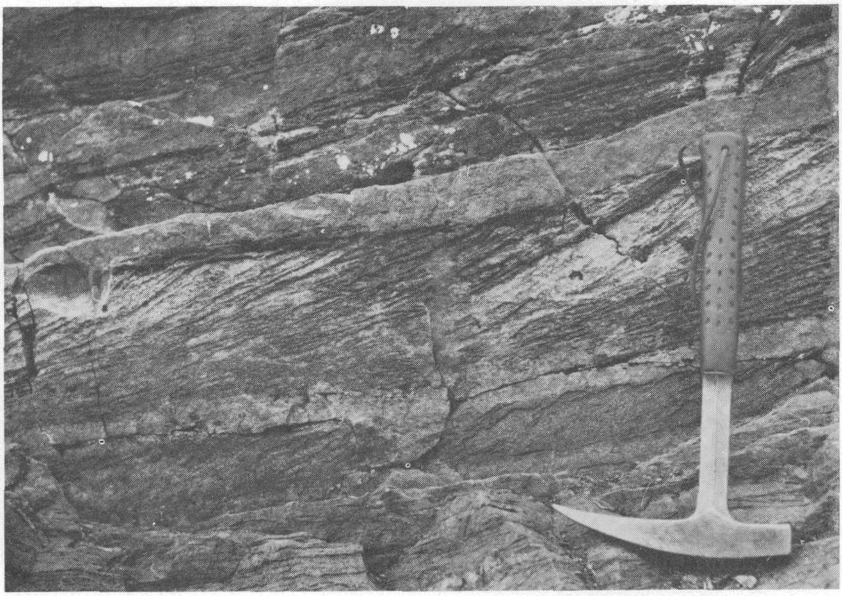
Rocks of the volcaniclastic member of the Slana Spur Formation are predominantly dark-gray, dark-green, and maroon volcaniclastics with interbedded tuff, fragmental volcanic rock, and limestone. Carbonate debris in the clastic rocks is generally negligible. The volcaniclastic rocks range from massive conglomerate and sandstone to thin-bedded sandstones, grit, and siltstone that commonly show graded bedding. Most strata contain variable amounts of dark argillaceous matrix and could be classified as volcanic graywackes and volcanilutites. One conspicuous lens of medium-bedded limestone, as much as 80 feet thick, and a much thinner lens of siliceous limestone occur in the lower half of the member. Foraminifers and nondiagnostic brachiopod shell fragments occur in these limestone lenses, but in general, the rocks are only sparsely fossiliferous.

Section of Slana Spur Formation, volcaniclastic member

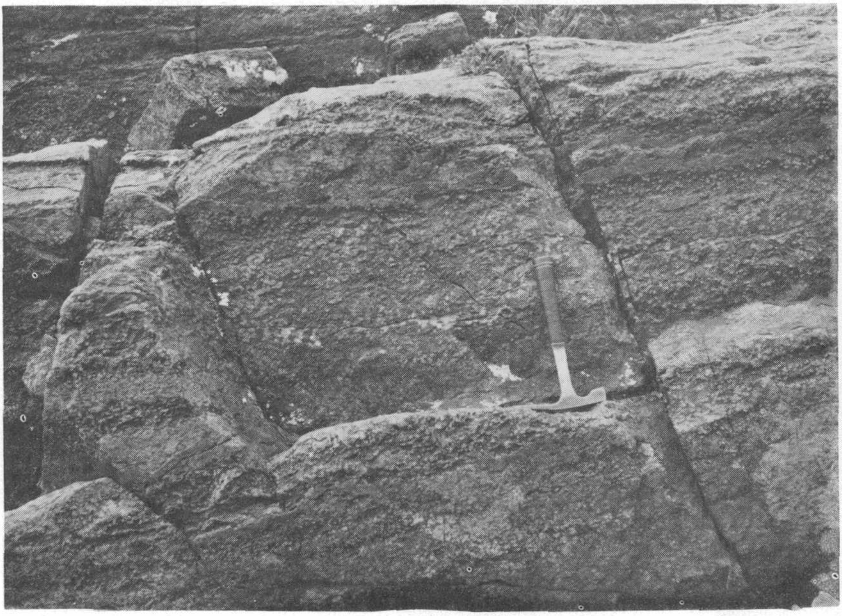
[Numbered lithologic units correspond to units shown in fig. 3]

	Thickness (ft)
Section G:	
Calcareous volcaniclastic member (overlying unit).	
9. Not measured in detail. Interbedded gray, maroon, and dark-green volcanic sandstone and grit with subordinate volcanic conglomerate, lapilli tuff, and lahar(?) deposits; beds 2 in. to more than 3 ft thick; locally graded	1,800 (approx)
8. Limestone, gray, fine- to medium-grained; beds 1–3 ft thick	45
7. Limestone, light-gray, siliceous, buff-weathering; beds ½–2 ft thick; base contains abundant volcanic debris	35
6. Sandstone, volcanic, green-buff, calcareous	20
5. Limestone, dark-gray; contains volcanic debris	3
4. Fragmental volcanic rocks, green-gray, massive; contains pumice (altered to chlorite) and angular volcanic fragments	90
3. Not measured in detail. Interbedded green and maroon volcanic conglomerate, grit, and coarse- to fine-grained sandstone. Massive in coarser beds, thin bedded and graded in finer beds. Cut by a number of dark-gray mafic sills and dikes	400 (approx)
2. Limestone, gray, siliceous, hackly fracture	7
1. Not measured in detail. Chiefly coarse-grained volcaniclastic rocks with subordinate lapilli tuff and lahar(?) deposits. Gray, green, and maroon; graded beds common	700 (approx)
Tetelna Volcanics (underlying unit).	

The calcareous volcaniclastic member is gradational with the underlying volcaniclastic member. It consists of a variety of volcanic-rich clastic limestone and both calcareous and noncalcareous volcaniclastic rocks with minor interbedded massive and bioclastic limestone, tuff, and volcanic breccia. The predominant rocks are grayish-green cross-



A



B

FIGURE 4.—Lithologic features of the calcareous volcaniclastic member of the Slana Spur Formation. *A*, Thin crossbedded volcanic-rich clastic limestone interbedded with thin calcareous sandstone. *B*, Analcite-bearing mottled calcareous sandstone.

bedded coarse clastic limestones (fig. 4*A*), ranging in thickness from a few inches to 80 feet, and grayish-green calcareous coarse-grained sandstones that locally exhibit a pronounced mottled texture (fig. 4*B*). Noncarbonate grains in these rocks consist chiefly of red and green jasper, gray chert, epidote- and chlorite-bearing volcanic rock, and feldspar. The ratio of limestone to nonlimestone detritus ranges from 1:1 to 1:4 in the clastic limestone and is generally less than 1:4 in the calcareous sandstone. The mottled texture in some of the calcareous sandstone is due to replacement and cementation of the grains by authigenic analcite. Brachiopods and echinoderm debris are scattered throughout the member; the upper part contains a few poorly preserved horn corals.

Section of Slana Spur Formation, calcareous volcaniclastic member

[Numbered lithologic units correspond to units shown in fig. 3]

	Thickness (ft)
Section A:	
Lower limestone member, Eagle Creek Formation (overlying unit).	
13. Sandstone, volcanic, dark-gray, coarse-grained, mottled; minor clastic limestone; locally graded	54
12. Limestone, gray, volcanic-rich, clastic; interlayered with green-gray volcanic sandstone; beds ½–6 in. thick. Locally crossbedded	85
11. Sandstone, volcanic, green-gray, massive to thin-bedded, locally calcareous	45
10. Sandstone, dark-green-gray, friable	5
9. Siltstone and sandstone, volcanic, green-gray, mottled, thin-bedded in graded sets 4–8 in. thick; locally crossbedded	40
8. Sandstone, volcanic, green-gray, massive to thin-bedded, calcareous	25
7. Sandstone, volcanic, and volcanic-rich clastic limestone, gray, crossbedded; sandstone locally mottled	100
Talus.	
Section F:	
7. Sandstone and limestone similar to, and assumed equivalent with, unit 7 in section A. Also contains minor thin volcanic-rich bioclastic limestone. Intruded by a number of hornblende-feldspar dikes and sills	100
Covered	35
6. Limestone, dark-gray, massive, crinoidal; contains abundant volcanic detritus	20
Covered	20
5. Argillite, dark-gray, brecciated	15
4. Sandstone and siltstone, volcanic, buff, calcareous	15
3. Lapilli tuff, light-green-gray, massive; contains chlorite clasts	40
2. Sandstone and grit, volcanic, light-green, buff, calcareous; granules of red and green chert common; some graded beds	45
Alluvium.	

Section of Slana Spur Formation, calcareous volcaniclastic member–Continued

	Thickness (ft)
Section G:	
1. Not measured in detail. Consists chiefly of gray massive cross-bedded clastic limestone and volcanic sandstone, thin-bedded volcanic-rich limestone, graded volcanic sandstone and siltstone and minor calcareous volcanic grit, green chert, and massive lapilli tuff and volcanic agglomerate	900
Volcaniclastic member (underlying unit).	

EAGLE CREEK FORMATION

The type locality for the new Eagle Creek Formation is designated as the west side of Eagle Creek valley in secs. 22, 23, 27, and 34, T. 15 N., R. 5 E., Mt. Hayes A–1 quadrangle (scale 1:63,360). Four informally named members are recognized in the Eagle Creek Formation at the type locality (fig. 5). These four members and their lithologic subunits, together with approximate thicknesses, are as follows from the top downward:

	Approximate thickness (ft)
4. Upper argillite member	410
3. Upper limestone member	266
2. Lower argillite member:	
c. Limestone and siltstone "ribbon bed" unit	340
b. Bryozoan biostrome unit	120
a. Argillite and siltstone unit	880
Total	1,340
1. Lower limestone member:	
c. Upper limestone marker	249
b. Calcareous volcanic sandstone unit	498
a. Basal limestone marker	175
Total	922
Total thickness	2,938

LOWER LIMESTONE MEMBER

The lower limestone member forms prominent outcrops and conspicuous light-gray cliffs along the west and upper east walls of Eagle Creek valley (fig. 6). Total thickness of the member is about 922 feet. Three lithologic units are recognized: a basal limestone marker, a calcareous volcanic sandstone unit, and an upper limestone marker. The base of the lower limestone member is placed at the base of the lowest distinctive sequence of limestone beds (basal limestone marker) in the marine section. These limestones conformably overlie volcanic-rich calcareous clastic rocks with interbedded tuff, volcanic breccia, and bioclastic limestone. We consider this change in lithology, which reflects a significant change in depositional conditions and in the

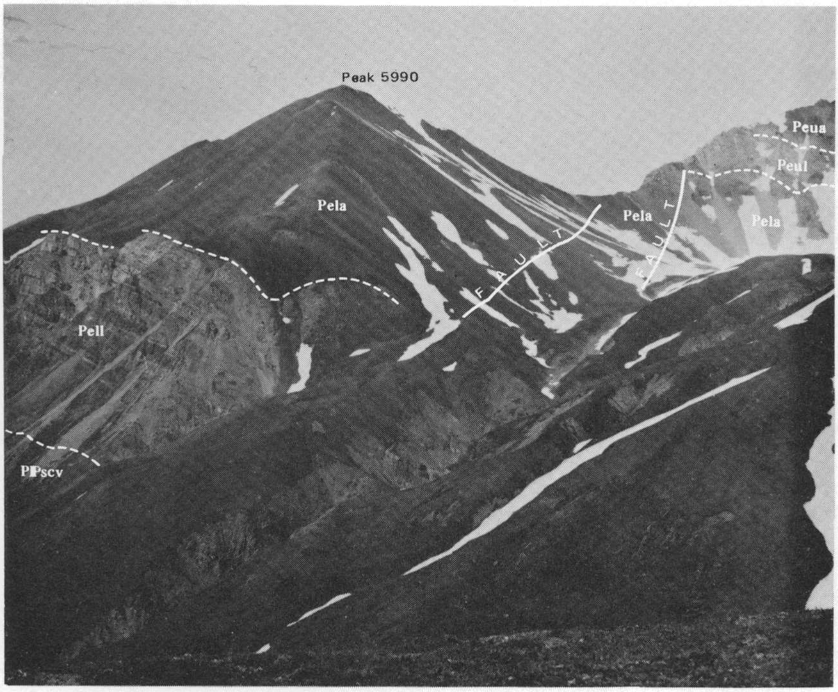


FIGURE 5.—The four members of the Eagle Creek Formation along part of west wall and upper basin of Eagle Creek. Pell, lower limestone member; Pela, lower argillite member; Peul, upper limestone member; Peua, upper argillite member; PIPscv, calcareous volcaniclastic member of the Slana Spur Formation.

nature of the source materials, to mark the contact between the Slana Spur Formation and Eagle Creek Formation.

The basal limestone marker consists of 175 feet of thin-bedded to massive gray limestone with interbeds of graded volcaniclastic rock and minor gray chert lenses. The limestones are fine grained with locally abundant coarse clastic volcanic debris.

The basal limestone marker is separated from the upper limestone marker by about 500 feet of interbedded calcareous volcanic sandstone, siltstone, and grit, volcanic-rich clastic limestone, and minor dark-gray bioclastic limestone. Graded bedding is common in the calcareous volcaniclastic rocks, and crossbedding is locally pronounced in the volcanic-rich limestones.

The upper limestone marker, about 250 feet thick, consists principally from bottom to top of medium- to thin-bedded gray limestone with abundant dark-gray buff-weathering siliceous layers, massive light-gray limestone in beds as much as 12 feet thick, and medium-bedded gray limestone. Most of the limestone is fine grained with local bioclastic zones containing abundant crinoidal debris. Nodules and

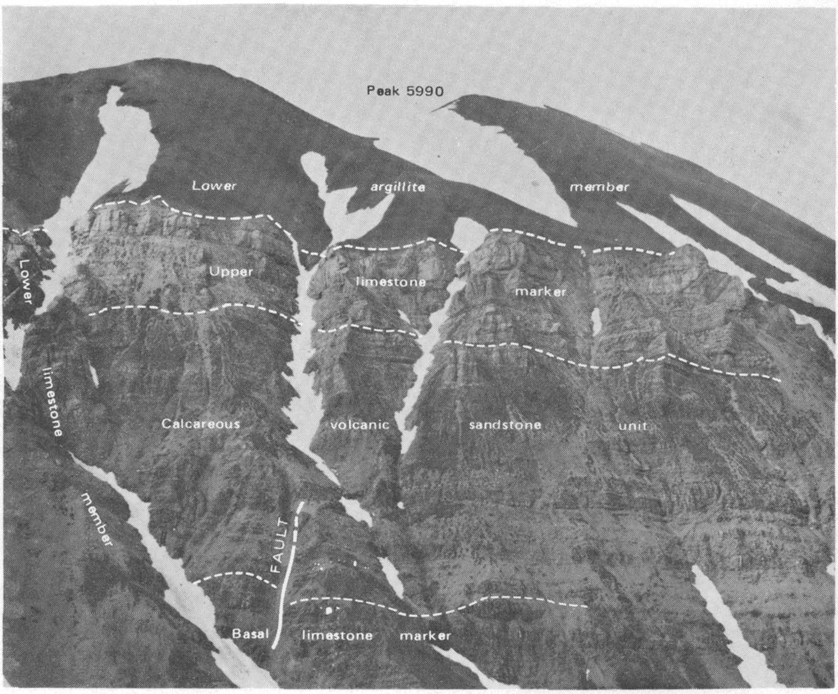


FIGURE 6.—Lower limestone member and overlying lower argillite member of the Eagle Creek Formation along the west wall of Eagle Creek valley. The approximate contacts of the three lithologic units in the lower limestone member are shown.

lenses of black to light-gray chert constitute as much as 25 percent of the strata in the upper 40 feet of the unit, and beds of gray chert as much as 2 feet thick are common near the base of the massive limestone.

Section of Eagle Creek Formation, lower limestone member

[Numbered lithologic units correspond to units in fig. 7]

	Thickness (ft)
Section A:	
Lower argillite member (overlying unit).	
Upper limestone marker:	
20. Limestone, gray, fine-grained; beds 1–2 ft thick; abundant nodules and lenses of black to light-gray chert	40
19. Limestone, light-gray, massive; beds 2–12 ft thick; gray chert lenses in lower part; locally crinoidal; several thin dark-gray fine-grained mafic sills	86
18. Sandstone, volcanic, dark-green-gray, coarse-grained	8
17. Limestone, gray to dark-gray, fine-grained; beds 1–2 ft thick; dark-gray siliceous layers; crinoidal at base	115
Gabbro sill	17
Calcareous volcanic sandstone unit:	
16. Sandstone, volcanic, dark-gray-green, coarse-grained, calcareous; gravelly clastic limestone	15

Section of Eagle Creek Formation, lower limestone member–Continued

	Thickness (ft)
Section A—Continued	
15. Limestone, bioclastic, gray, thin-bedded; siliceous mudstone and chert	39
14. Mudstone, siliceous, dark-gray to brown; minor sandstone; contains abundant bryozoans	55
13. Limestone, gray, massive	5
12. Mudstone, siliceous, brown-gray, thin-bedded; graded coarse-grained volcanic sandstone and grit	25
11. Limestone, gray, massive to thin-bedded; dark chert lenses in middle; crinoidal at base	47
10. Argillite, dark-gray, calcareous; minor calcareous sandstone containing abundant crinoidal debris. Two hornblende-feldspar porphyry sills	46
Covered	30
9. Sandstone and grit, gray-green; calcareous siltstone and gray volcanic-rich limestone; locally graded	30
Covered	20
8. Sandstone, volcanic, gray-green, calcareous, crossbedded, friable	27
7. Sandstone, volcanic, green; interbedded friable calcareous sandstone, light-gray calcareous siltstone, and minor volcanic grit, pebble conglomerate, and chert; locally graded	102
6. Limestone, clastic, brown-gray, thin-bedded	2
5. Sandstone, volcanic, calcareous, crossbedded	10
4. Limestone, thin, volcanic-rich; interbedded green-gray volcanic sandstone, thin creamy chert, and dark argillite	45
Gabbro sill	85
Basal limestone marker:	
3. Limestone, gray and dark-gray, massive to thin-bedded, fine- to medium-grained; minor sandstone, argillite, grit and chert; cut by mafic sill	68
2. Argillite, dark-gray-green; maroon volcanic sandstone and dark-green grit	21
1. Limestone, gray, massive, fine-grained; abundant laminae of siliceous argillite and minor volcanic sandstone and chert. Grades downward into thin-bedded gray limestone with subordinate interbeds of argillite and sandstone	86
Calcareous volcaniclastic member, Slana Spur Formation (underlying unit).	

LOWER ARGILLITE MEMBER

The lower argillite member, 1,340 feet thick, is divided into three lithologic units: an argillite and siltstone unit, a bryozoan biostrome unit, and a limestone and siltstone "ribbon bed" unit. In measured section B (fig. 7), the base of the lower argillite member is marked by a 1-foot-thick bed of green medium-grained calcareous sandstone. This sandy bed appears to fill small erosional(?) irregularities at the top of the lower limestone member, suggesting a local unconformity between the two members.

The argillite and siltstone unit, 880 feet thick, forms rather subdued talus-covered slopes (figs. 5, 6) and hence is relatively poorly exposed.

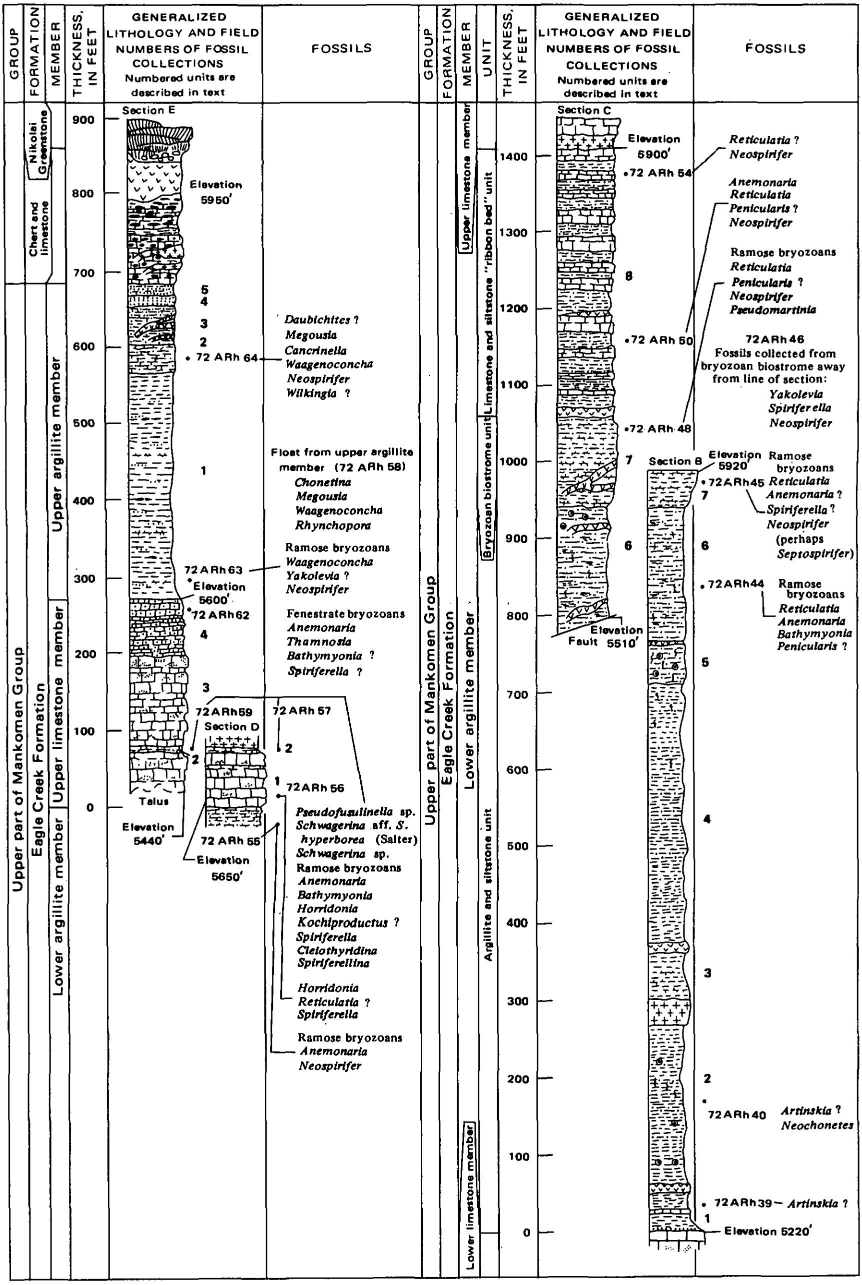


FIGURE 7.—Sections, with fossil assemblages, of the Eagle Creek Formation (Mankomen Group), Eagle Creek area. Location of sections shown in figure 2.

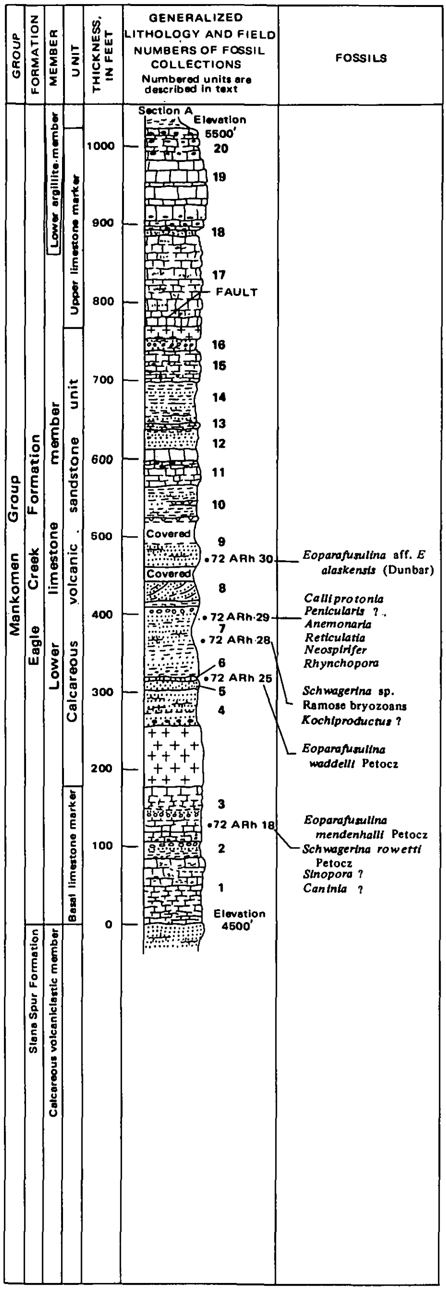


FIGURE 7.—Continued.

Predominant are thin-bedded dark-gray shaly argillite and gray-green to gray locally calcareous siltstone with minor dark-gray bioclastic limestone. Dense siliceous mudstone concretions, as much as 6 inches in diameter, generally with a nucleus of marcasite, are locally concentrated near the base and toward the top of the unit. Dark mud-filled trace fossils are scattered throughout.

The bryozoan biostrome unit consists of 120 feet of interbedded dark-gray argillite, gray calcareous siltstone, and minor dark dirty bioclastic limestone. Bedding ranges from less than 1 inch to as much as 1 foot in thickness. Bryozoans and brachiopods are common throughout the unit but are especially abundant in the siltstone beds.

The limestone and siltstone "ribbon bed" unit consists of 340 feet of gray, dirty limestone, in beds as much as 3 feet thick, alternating with dark-gray argillite and siltstone interbeds as much as 2 feet thick. Limestone increases in abundance upwards in the unit, generally resulting in a gradational contact with the overlying upper limestone member.

Section of Eagle Creek Formation, lower argillite member

[Numbered lithologic units correspond to units in fig. 7]

	Thickness (ft)
Section C:	
Upper limestone member (overlying unit).	
Gabbro.	
Limestone and siltstone "ribbon bed" unit:	
8. Limestone, gray, dirty; dark-gray argillite and siltstone imparting a ribbon effect to the unit. Beds 1 in. to 3 ft thick. Limestone increases in abundance upward in section	340
Hornblende-feldspar porphyry intrusive	11
Bryozoan biostrome unit:	
7. Argillite, dark-gray; interbedded gray calcareous siltstone and dark dirty limestone; beds 1–12 in. thick. Limestone and siltstone contain extremely abundant bryozoan and brachiopod fragments	120
Argillite and siltstone unit:	
6. Siltstone, gray, thin-bedded, shaly; locally calcareous with wispy laminae of dark-gray argillite; worm burrows common and mudstone concretions abundant in upper 30 ft. Unit intruded by several porphyritic dikes and sills. Base terminated by fault	145 (approx)
Section B:	
7. Argillite, dark-gray; interbedded calcareous siltstone and dark bioclastic limestone. Equivalent to unit 7, section C.	
6. Siltstone; equivalent to unit 6, section C	175
Feldspar porphyry	5
5. Siltstone, light-gray, thin-bedded; abundant worm burrows, common dark-gray mudstone concretions	50
4. Argillite, black, shaly; contains interbeds of calcareous gray siltstone; occasional worm burrows	335
Hornblende-feldspar porphyry	15
3. Argillite, dark-gray; minor dirty, black limestone, dense hornfels at base	60

Section of Eagle Creek Formation, lower argillite member—Continued

	Thickness (ft)
Section B—Continued	
Gabbro	30
2. Argillite, dark; siliceous green-gray siltstone and iron carbonate-bearing siltstone; dense mudstone concretions and worm burrows locally common	200
Hornblende porphyry	10
1. Argillite, dark-gray, shaly; 2-ft-thick gray bioclastic limestone and 1-ft-thick basal green calcareous sandstone	50
Lower limestone member (underlying unit).	

UPPER LIMESTONE MEMBER

The upper limestone member, 266 feet thick, consists predominantly of gray limestone containing irregular patches of ocherous silica. The lower contact is generally gradational and is arbitrarily placed within the series of alternating limestone and siltstone beds in the lower argillite member where limestone becomes the principal lithology (sec. C, fig. 7). In section D, figure 7, the lower contact is sharper with thick limestone beds containing minor interbedded siltstone and argillite overlying a thin-bedded limestone and siltstone sequence in the lower argillite member. The lower 190 feet of the member is composed of relatively massive limestone in beds as much as 3 feet thick that exhibits an increase in siliceous material upward. The remainder of the member is predominantly thin-bedded (2–12 in. thick) limestone that, owing to an abundance of ocherous silica, weathers a conspicuous yellow orange. One thin-bedded dark-gray bioclastic limestone unit approximately 6 feet thick, containing abundant bryozoans and fusulinids, occurs about 70 feet above the base of the member. The contact between the upper limestone and upper argillite members is sharp.

Section of Eagle Creek Formation, upper limestone member

[Numbered lithologic units correspond to units in fig. 7]

	Thickness (ft)
Section E:	
Upper argillite member (overlying unit).	
4. Limestone, gray, thin-bedded, siliceous; weathers conspicuous yellow orange	75
3. Limestone, gray, thick-bedded, fine- to coarse-grained; contains abundant siliceous patchworks; beds 1–3 ft thick; hackly fracture	115
2. Limestone, bioclastic, gray, thin-bedded; weathers ochre	6
Section D:	
Gabbro.	
2. Limestone; equivalent to unit 2, section E.	
1. Limestone, gray, thick-bedded; minor interbedded gray siltstone and argillite; siliceous patchworks common near top	70
Lower argillite member (underlying unit).	

UPPER ARGILLITE MEMBER

The 410-foot-thick upper argillite member consists predominantly of thin-bedded dark-gray argillite with thin lenses and laminae of gray siltstone. A dark-gray bioclastic limestone and calcareous siltstone unit about 35 feet thick occurs 300 feet above the base, and about 30 feet of coarser clastic beds, consisting of pyritic sandstone and interbedded sandstone and siltstone, occur at the top of the member.

In the vicinity of section E (fig. 2), the upper argillite member is overlain by 120 feet of interbedded light-colored chert with light-gray crystalline limestone and minor siltstone. These strata are apparently of only local extent, as both east and west of section E the upper argillite member is overlain unconformably by amygdaloidal basalt flows of the Nikolai Greenstone of Middle and (or) Late Triassic age. Although only nondiagnostic crinoid fragments were found in the chert and limestone beds, we suspect that these rocks are equivalent to *Daonella*-bearing chert, limestone, and shale beds of Middle Triassic age recently found west of Eagle Creek in the headwaters of Canyon Creek (Richter and Dutro, unpub. data). The Eagle Creek strata are also similar to *Daonella*-bearing beds that discontinuously overlie Permian argillite to the southeast in the eastern Alaska Range (Richter and Jones, 1973) and the southern Wrangell Mountains (Mac Kevett, 1970). The contact between the upper argillite member and the chert and limestone is sharp and structurally conformable, but on the basis of the assumed age difference of the two sequences, it represents an erosion interval of long duration. The Nikolai Greenstone locally includes a basal conglomerate containing clasts of chiefly argillite and chert set in a poorly sorted argillaceous to sandy matrix.

Section of Eagle Creek Formation, upper argillite member

[Numbered lithologic units correspond to units in fig. 7]

	Thickness (ft)
Section E:	
Nikolai Greenstone.	
Hornblende diorite.	
Chert and limestone of Middle Triassic(?) age (overlying unit).	
5. Siltstone, dark-gray, shaly; contains fine-grained gray sandstone interbeds	15
4. Sandstone, fine-grained, gray, thin-bedded; contains pyrite crystals	15
3. Argillite, dark-gray; gray siltstone with argillite clasts; minor dirty limestone; dikes of hornblende-feldspar porphyry	50
2. Limestone, bioclastic, dark-gray, thin-bedded; gray calcareous siltstone	35
1. Argillite, dark-gray, silty; minor bioclastic limestone and gray-green cherty argillite	295
Upper limestone member (underlying unit).	

BIOSTRATIGRAPHY OF THE MANKOMEN GROUP

Marine fossils, present throughout the Mankomen Group, are especially abundant in the Eagle Creek Formation. Vertical distribution is generally erratic, and preservation is not always adequate to permit generic identification. Nevertheless, fossils were collected from many levels in the group. The more abundant forms are brachiopods and bryozoans. Fusulinids abound in a few layers; corals and mollusks are rare. Identified fossils are listed at their respective locations in the stratigraphic columnar sections in figures 3 and 7.

Short *Fusulinella* sp. are abundant in the two limestone lenses in the volcaniclastic member of the Slana Spur Formation. In the overlying Eagle Creek Formation, larger fusulinids are found in a number of beds. Long, thin forms, including *Eoparafusulina mendenhalli* Petocz, *E. waddelli* Petocz, *E.* aff. *E. alaskensis* (Dunbar), *Schwagerina rowetti* Petocz, and *Schwagerina* sp. occur in the lower limestone member, and stouter forms, such as *Schwagerina* aff. *S. hyperborea* (Salter) and *Pseudofusulinella* sp., occur in the lower part of the upper limestone member. No fusulinids were recovered from the calcareous volcaniclastic member of the Slana Spur Formation or from either of the argillite members of the Eagle Creek Formation.

Brachiopods, the commonest marine megafossils, are widely distributed throughout most of both formations. The thicker bedded crinoidal limestones may contain many brachiopods to the exclusion of nearly all other fossils. Most brachiopod shells are scattered and isolated, although some form coquinoid layers, especially in the upper part of the lower argillite member of the Eagle Creek Formation. The small, readily recognizable brachiopod *Anemonaria* is especially abundant in the lower argillite and upper limestone members of the Eagle Creek Formation, and where stratigraphic control is lacking, its presence may serve as a field criterion for distinguishing between the two limestone members.

Both ramose and fenestrate bryozoans are common throughout the Eagle Creek Formation and the calcareous volcaniclastic member of the Slana Spur Formation. They are particularly abundant in the bryozoan biostrome unit of the lower argillite member of the Eagle Creek Formation where they occur in association with spiriferoid and productoid brachiopods.

Corals are rare except in a few strata in the lower limestone member of the Eagle Creek Formation, where they occur in profusion, and in the calcareous volcaniclastic member of the Slana Spur Formation. Those in the Slana Spur Formation are poorly preserved. In the Eagle Creek Formation the corals include *Caninia* and the syringoporoid

Sinopora and are found associated with abundant *Eoparafusulina*. These coral-fusulinid beds are probably equivalent to Assemblage Zone C of Petocz (1970, p. 19).

Mollusks are very rare and are represented by a few poorly preserved pelecypods and gastropods found only in the Eagle Creek Formation. Cephalopods were collected at two horizons in the Eagle Creek Formation and are important in corroborating other evidence as to age. One form, *Artinskia*? or *Synartinskia*?, occurs in the lower 200 feet of the lower argillite member. A second form, resembling *Daubichites*, was collected from high in the upper argillite member.

AGE AND CORRELATION

The Slana Spur Formation is Middle Pennsylvanian to Early Permian in age. Fossils collected from the two limestone lenses in the volcaniclastic member, approximately 700 and 1,200 feet above the top of the Tetelna Volcanics, include abundant *Fusulinella* sp. associated with other smaller foraminifers including *Bradyina* sp. and *Climacammina* sp. A Middle Pennsylvanian (probable Atokan) age is indicated. This age is within the limits given by Rowett (1969, p. 15, 18) for lithologically similar volcanogenic rocks exposed on Rainbow Mountain in the Delta River area (locality 2, fig. 1). Brachiopods from the calcareous volcaniclastic member are similar to the Early Permian (Sakmarian) forms from the lower part of the overlying Eagle Creek Formation.

The Eagle Creek Formation is entirely of Early Permian age. The lower limestone member contains Early Permian brachiopods, associated with fusulinids which Petocz (1970) described from his Assemblage Zone C (fig. 8). Petocz assigned a late middle to late(?) Sakmarian age to this zone. This level is also probably equivalent to fusulinids found in beds near the top of Zone E of Waterhouse (in Bamber and Waterhouse, 1971), the uppermost of his E Zone faunas. Brachiopods from the lower argillite member are not too different from those in the underlying lower limestone member. The cephalopod *Artinskia*?, or possibly *Synartinskia*, was collected from low in the lower argillite member, but the material is not well enough preserved for positive generic identification. The age of the lower argillite member is either late Sakmarian or early Artinskian. The lower two members are, in part, correlatives of the Jungle Creek Formation of the Yukon Territory (Bamber and Waterhouse, 1971).

The upper limestone member contains brachiopods like those in Waterhouse's Zone F, together with *Schwagerina* aff. *S. hyperborea* (Salter), which is also characteristic of this level in the Yukon Territory. *Schwagerina hyperborea* is found in Petocz's Assemblage Zone F, which he considered of early to middle Artinskian age. The age of the upper limestone member is, therefore, most likely middle or late Artinskian (upper Leonardian). Finally, the few brachiopods from the upper argillite, together with the occurrence of *Daubichites*?, indicate a correlation with the upper part of Waterhouse's brachiopod Zone F. This suggests a post-Artinskian, possibly Ufimian, equivalence. The upper limestone and upper argillite members of the Eagle Creek Formation are thus approximate correlatives of the type Tahkandit Limestone (Brabb and Grant, 1971).

Probable correlations of Mankomen Group strata in the eastern and east-central Alaska Range are shown in figure 8. The lithology of the Slana Spur Formation and observed fusulinid zonation suggests affinity with the upper part of Bond's (1969) informal Phelan Creek formation in the Gulkana Glacier area and with the lower sequence of Rowett's (1971) and Petocz' (1970) Mankomen Formation in the Rainbow Mountain and upper Delta River areas. The nonvolcanogenic sequences of limestone and argillite in these same areas are, without much question, correlative with the Eagle Creek Formation. Less certain is correlation to the southeast in the Slana area, where Permian limestones, overlying a thick sequence of volcaniclastic rocks, contain abundant volcanic debris. Eagle Creek affinity is indicated, however, because of the similarity in coral zonation between the Slana and Rainbow Mountain areas (Rowett, 1971).

In the upper Delta River and Rainbow Mountains areas, both Petocz (1970) and Rowett (1971) placed the Wolfcampian-Leonardian boundary near the base of the limestone and argillite sequence (fig. 8). At Eagle Creek however, fusulinids in apparently correlative rocks indicate that the boundary is higher, probably near the base of the upper limestone member of the Eagle Creek Formation. This interpretation agrees with the middle Wolfcampian age assigned to the lower units of limestone and argillite in the Gulkana Glacier area (informal Gulkana Glacier formation) by Bond (1969) and Gilbertson (1969).

The Pennsylvanian-Permian boundary at Eagle Creek lies somewhere within the Slana Spur Formation, probably near the base of the calcareous volcaniclastic member. Northwest in the east-central Alaska Range, a similar change in lithology from predominantly volcanic-noncalcareous volcaniclastic rock to calcareous volcaniclastic rock also appears to span the Pennsylvanian-Permian boundary (fig. 8). Southeast of the area shown in figure 8, the thick sequences of andesitic volcanic, and interbedded volcaniclastic rocks mapped by Moffit (1954) and Richter (1971a, b) are now considered equivalent to the Tetelna Volcanics and hence presumably are of Pennsylvanian age. These sequences were originally thought to be Permian in age chiefly because of their association with conformably overlying Per-

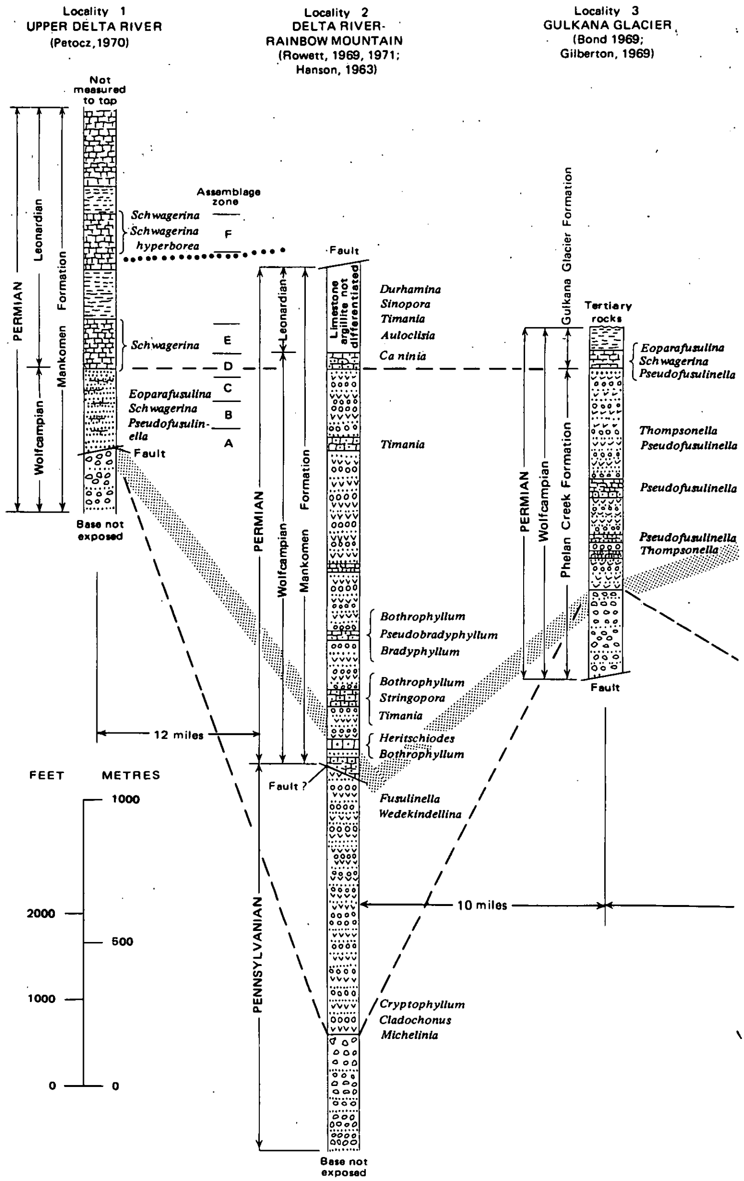


FIGURE 8.—Generalized sections of Pennsylvanian and Permian sequences in the eastern and east-central Alaska Range showing zonation of fusulinids and corals, suggested lithologic correlation of the Mankomen Group, and some inferred time boundaries. Ages at left side of each column are those assigned by author(s) cited at top of column. The time lines that extend across the diagram are based on faunal evidence from the Eagle Creek area.

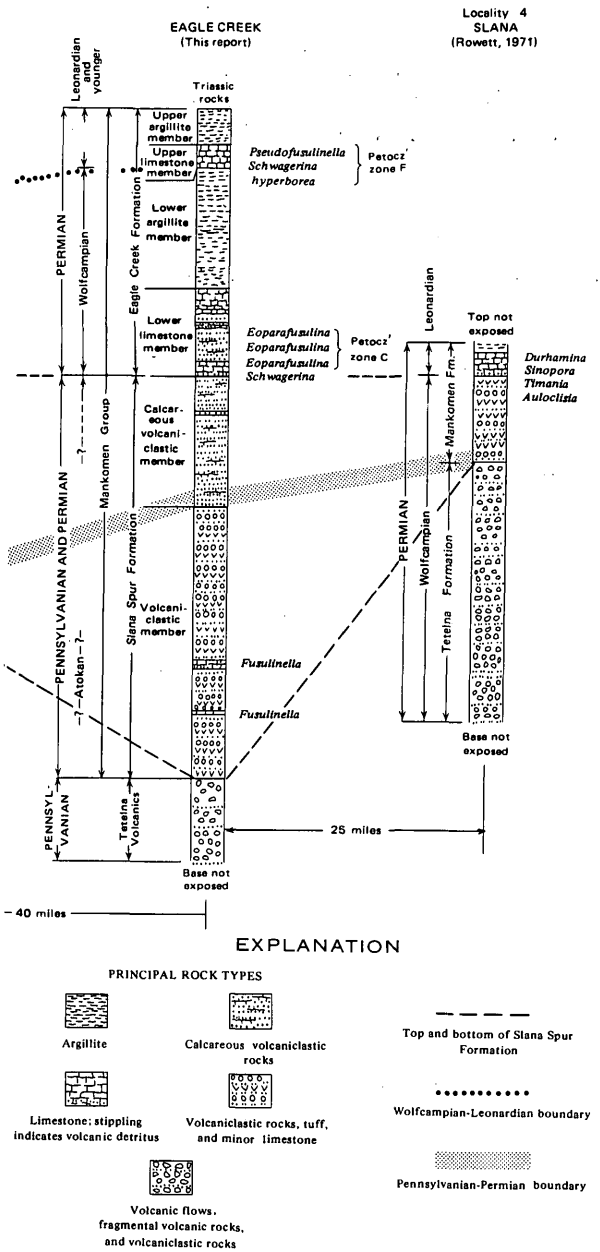


FIGURE 8.—Continued.

mian marine strata (the upper parts of our Mankomen Group). Similar volcanic and volcaniclastic rocks in the Station Creek Formation in the northern Wrangell Mountains described by Smith and MacKevett (1970), and assigned a Permian(?) age by them, also suggest affinity with the Tetelna Volcanics.

TECTONIC SIGNIFICANCE

The available lithologic and paleontologic data from Eagle Creek and elsewhere in the eastern part of the Alaska Range suggest that the beginning of marine carbonate deposition and the end of persistent volcanism occurred near the end of Pennsylvanian time. Recognition of a Pennsylvanian age for the bulk of the volcanogenic rocks, conformably underlying Permian marine deposits, shifts the timing of volcano-tectonic events in this part of Alaska. On the basis of the earlier assumed Permian age of most of the volcanic rocks in the eastern Alaska Range, Richter and Jones (1973) and Berg, Jones, and Richter (1972) postulated that a late Paleozoic volcanic island arc from which these rocks were derived was also mostly Permian in age. The new data presented in this paper suggest that the arc developed in the Pennsylvanian and may have been virtually inactive by the Early Permian.

REFERENCES

Bamber, E. W., and Waterhouse, J. B., 1971, Carboniferous and Permian stratigraphy and paleontology, northern Yukon Territory, Canada: Bull. Canadian Petroleum Geology, v. 19, no. 1, p. 29–250.

Berg, H. C., Jones, D. L., and Richter, D. H., 1972, Gravina-Nutzotin belt—tectonic significance of an upper Mesozoic sedimentary and volcanic sequence in southern and southeastern Alaska, *in* Geological Survey research 1972: U.S. Geol. Survey Prof. Paper 800–D, p. D1–D24.

Bond, G. C., 1969, Permian volcanics, volcaniclastics, and limestones in the Cordilleran eugeosyncline, east-central Alaska Range, Alaska: Ph.D. thesis, Univ. Wisconsin, Madison, 144 p.

Brabb, E. E., and Grant, R. E., 1971, Stratigraphy and paleontology of the revised type section for the Tahkandit Limestone (Permian) in east-central Alaska: U.S. Geol. Survey Prof. Paper 703, 26 p.

Gilbertson, R. L., 1969, Biostratigraphy of the upper Paleozoic rocks in the Gulkana Glacier area, Alaska: M.S. thesis, Univ. Wisconsin, Madison, 43 p.

Hanson, L. G., 1963, Bedrock geology of the Rainbow Mountain area, Alaska Range, Alaska: Alaska Div. Mines and Minerals Geol. Rept. 2, 82 p.

MacKevett, E. M., Jr., 1970, Geologic map of the McCarthy C–4 quadrangle, Alaska: U.S. Geol. Survey Geol. Quad. Map GQ–844, scale 1:63,360.

Mendenhall, W. C., 1905, Geology of the central Copper River region, Alaska: U.S. Geol. Survey Prof. Paper 41, 133 p.

Moffit, F. H., 1954, Geology of the eastern part of the Alaska Range and adjacent areas: U.S. Geol. Survey Bull. 989–D, p. 65–218.

Petocz, R. G., 1970, Biostratigraphy and Lower Permian Fusulinidae of the upper Delta River area, east-central Alaska Range: Geol. Soc. America Spec. Paper 130, 94 p.

Richter, D. H., 1971a, Reconnaissance geologic map and section of the Nabesna A–3 quadrangle, Alaska: U.S. Geol. Survey Misc. Geol. Inv. Map I–655, scale 1:63,360.
———1971b, Reconnaissance geologic map and section of the Nabesna B–4 quadrangle, Alaska: U.S. Geol. Survey Misc. Geol. Inv. Map I–656, scale 1:63,360.
Richter, D. H., and Jones, D. L., 1973, Structure and stratigraphy of eastern Alaska Range, Alaska, *in* Arctic Geology: Am. Assoc. Petroleum Geologists, Memoir 19, p. 408–420.
Rowett, C. L., 1969, Upper Paleozoic stratigraphy and corals from the east-central Alaska Range, Alaska: Arctic Inst. North America, Tech. Paper 23, 120 p.
———1971, Reconnaissance biostratigraphy of the Lower Permian in the Slana area, eastern Alaska Range, Alaska: Pacific Geology, v. 3 , p. 31–44.
Smith, J. G., and MacKevett, E. M., Jr., 1970, The Skolai Group in the McCarthy B–4, C–4, and C–5 quadrangles, Wrangell Mountains, Alaska: U.S. Geol. Survey Bull. 1274–Q, 26 p.