The Paleozoic Section in the Shainin Lake Area, Central Brooks Range, Alaska

A New Upper Paleozoic Formation, Central Brooks Range, Alaska

EXPLORATION OF NAVAL PETROLEUM RESERVE NO. 4 AND ADJACENT AREAS, NORTHERN ALASKA, 1944–53

PART 3, AREAL GEOLOGY

GEOLOGICAL SURVEY PROFESSIONAL PAPER 303–A, B

Prepared and published at the request of and in cooperation with the U. S. Department of the Navy, Office of Naval Petroleum and Oil Shale Reserves

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By ARTHUR L. BOWSHER *and* J. THOMAS DUTRO, JR.

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[Letters in parentheses preceding the titles are those used to designate the separate chapters]

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THE PALEOZOIC SECTION IN THE SHAININ LAKE AREA, CENTRAL BROOKS RANGE, ALASKA

By Arthur L. Bowsher and J. Thomas Dutro, Jr.

ABSTRACT

The 7,500–8,000-foot-thick Paleozoic section exposed in the Shainin Lake area, central Brooks Range, northern Alaska, is divided into 5 formations, 4 of which have not been described before. The 3,300-foot-thick, probably nonmarine, Kanayut conglomerate (new name), of Late Devonian age, overlies an unnamed shale and sandstone, also of Late Devonian age. Massive lower and middle members of the Kanayut conglomerate are 1,400 and 1,030 feet thick, respectively. The upper, 860-foot-thick, Stuver member (revised name), consists of alternating beds of shale, orthoquartzitic sandstone, and orthoquartzitic conglomerate.

The overlying Kayak shale (new name), 960 feet thick, consists of black shale with a quartzose sandstone member at the base and argillaceous-limestone beds, which contain early Mississippian fossils, in the upper part.

The Lisburne group (revised name), about 2,200 feet of fossiliferous bioclastic limestone and dolomite, is composed of 2 formations. The Wachsmuth limestone (new name), the lower 1,230 feet of the Lisburne, is predominantly cherty limestone and dolomite with some shale. Early Mississippian corals, echinoderms, bryozoans, and brachiopods occur sporadically throughout. The Alapah limestone (new name), the upper 970 feet of the Lisburne, is limestone with some chert and is characterized by late Mississippian lithostrotionoid corals and *Gigantoproductus*.

Topmost beds of the Lisburne group are covered by high-level gravel deposits; the contact with overlying Permian or Triassic rocks is not exposed. Structurally the area is characterized by imbricate thrust faulting and high-angle reverse faulting. Mississippian rocks apparently represent platform-type deposition in an east-trending late Paleozoic seaway.

INTRODUCTION AND ACKNOWLEDGMENTS

During a part of the summer of 1949 the authors measured stratigraphic sections of Paleozoic rocks exposed in the Shainin Lake area, Brooks Range, northern Alaska (pl. 1 and fig. 1). The main objective of the field work, a part of the exploration program of Naval Petroleum Reserve No. 4 in northern Alaska by the U. S. Geological Survey, was to obtain detailed stratigraphic and paleontologic information about the Mississippian rocks.

Rock descriptions and graphic stratigraphic sections of upper Paleozoic formations that have not been described before (fig. 2) are presented. Locations of measured sections are plotted on the geologic sketch map (pl. 2); lines of traverse for sections A, D, F, H, I, J, and K are shown on plate 1, and graphic sections of all the formations are shown on plates 3, 4, 5, and 6. Type sections, except for the Kayak shale, are composites of two or more measured sections as indicated on the plates.

Although few paleontologic data are presented, the authors wish to acknowledge the help of Helen Duncan and Mackenzie Gordon, Jr., who are studying the late Paleozoic corals and cephalopods collected in the Brooks Range province. Certain of their preliminary identifications are used as faunal-zone guides, and their discussions concerning general correlations have been very helpful.

Some of the information relating to the Kanayut conglomerate and the Kayak shale, obtained by us in 1949, was incorporated in a dissertation submitted by Dutro in partial fulfillment of requirements for an advanced degree.[1]

GEOLOGIC SETTING

The Shainin Lake area is located in a belt of imbricate thrust faulting at the north front of the central Brooks Range (pl. 2). Sections A, D, F, G, H, I, J, and K were measured in the same fault plate. Sections B, C, and E are in other fault plates to the south.

The Mississippian rocks apparently represent platform-type deposition in an east-trending late Paleozoic seaway. Probable nonmarine deposition in latest Devonian time was succeeded in early Mississippian time by deposition of marine sand, clay, and argillaceous limestone. Predominantly carbonate sediments accumulated during the remainder of Mississippian time. (See fig. 2.) Differences in texture, composition, and structure of these carbonate rocks reflect minor changes in depositional conditions and minor fluctuations in source areas. Significant interruptions of sedimentation are indicated by disconformities at the base and top of the Wachsmuth limestone.

[1] 1952, Stratigraphy and paleontology of the Noatak and associated formations, Brooks Range, Alaska: Yale Univ., unpublished doctoral thesis, 209 p., 18 pls., 13 figs.

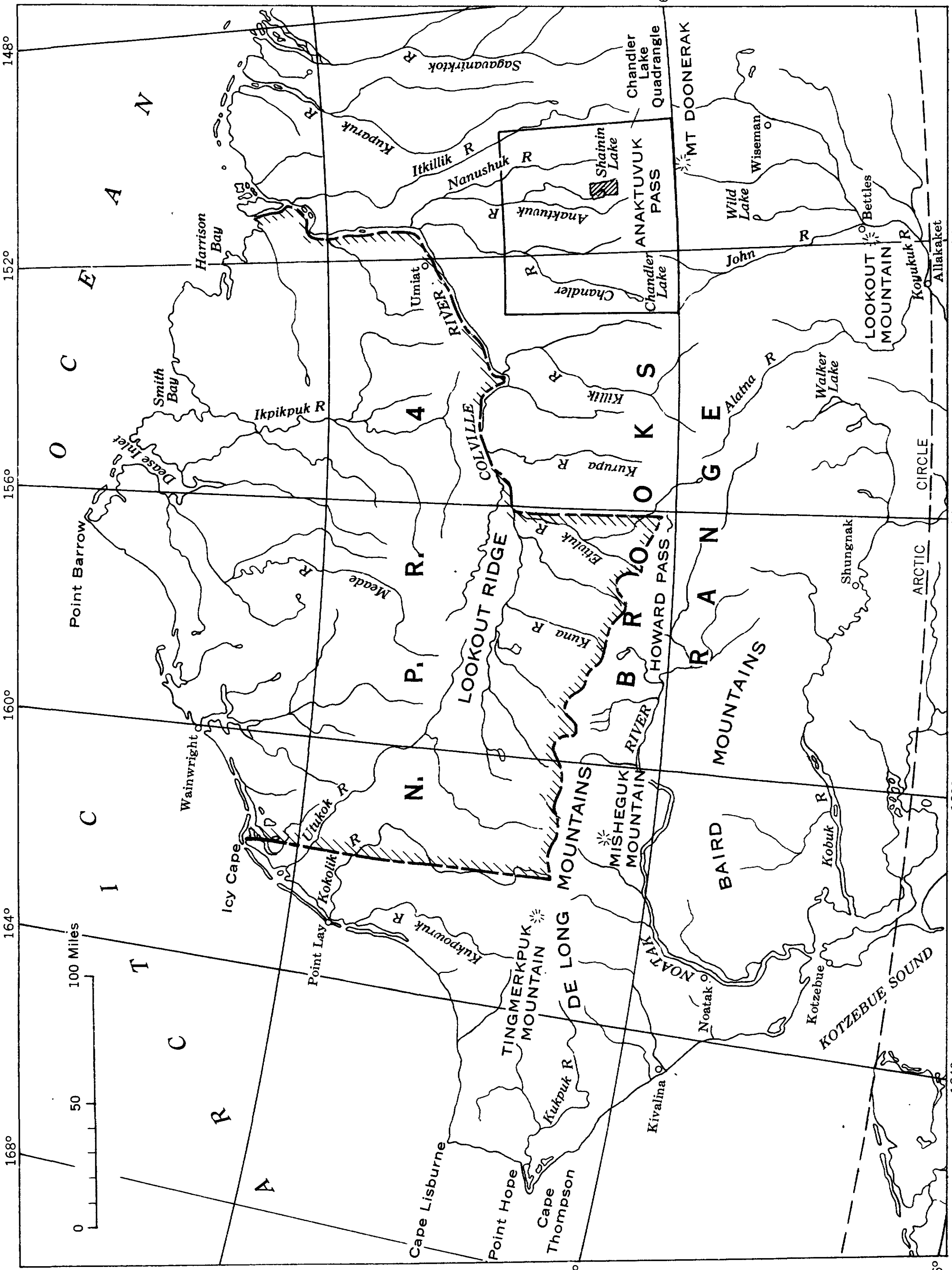

FIGURE 1.—Index map showing location of area of this report, Chandler Lake quadrangle, and Naval Petroleum Reserve No. 4.

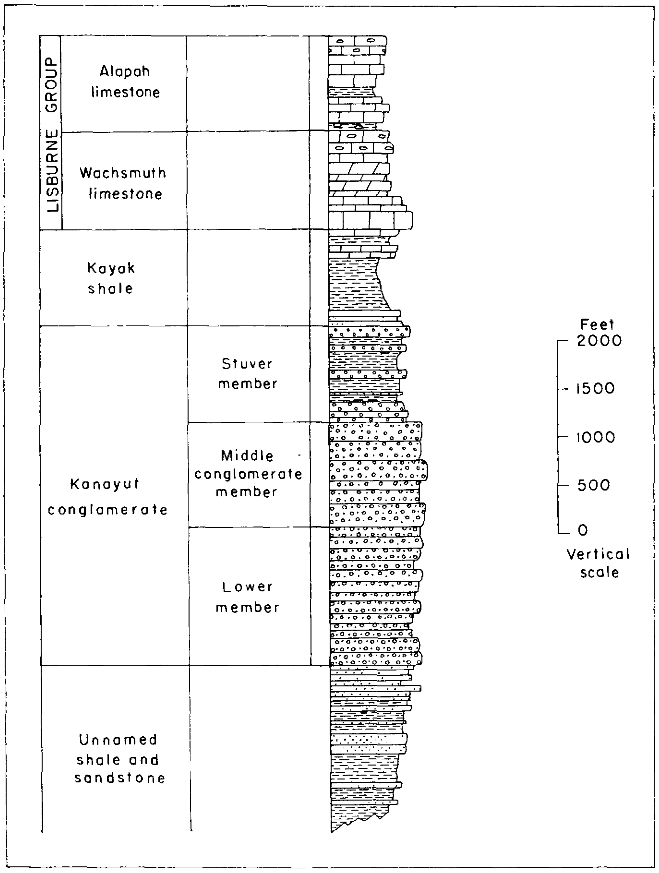

FIGURE 2.—Generalized columnar section.

STRATIGRAPHY

HISTORY OF STRATIGRAPHIC NOMENCLATURE

Paleozoic rocks in this area were first described in 1902 by Frank C. Schrader (fig. 3). Although the first name applied to the Carboniferous rocks was Fickett series, this term later was found to be inapplicable and was abandoned (Smith and Mertie, 1930, p. 149). Schrader (1902, p. 241–243) used the name Lisburne formation for a limestone unit exposed in the upper Anaktuvuk River valley. He noted here and later (1904, p. 62–66) that the Lisburne formation might be correlated with a similar limestone and shale section at Cape Lisburne, the geographic feature from which the name was taken. Although the limestone was first thought to be Devonian in age, critical evaluation by G. H. Girty of new fossil collections resulted in the assignment of a Mississippian age (Collier, 1906, p. 22–26). For more than 40 years the name Lisburne formation (later modified to Lisburne limestone) was applied, for all practical purposes, to any limestone of Mississippian age.

Schrader (1902, p. 240) gave the name Stuver series to a conglomeratic sequence beneath his Lisburne formation in the central Brooks Range. Although the name Stuver later fell into disuse (Smith and Mertie, 1930, p. 155), it is here reestablished and applied to the top member of the Kanayut conglomerate.

Philip S. Smith (1913, p. 69–75) proposed the name Noatak sandstone for dominantly clastic strata which underlie the Lisburne limestone in the central Noatak River valley. Smith and Mertie (1930, p. 151–168) redefined the Noatak formation to include all clastic rocks of early Mississippian age in northern Alaska. In practice, this included rocks here designated as the Kanayut conglomerate (including the Stuver member) and the Kayak shale, as well as the Noatak sandstone of the type area.

The names Noatak formation and Lisburne limestone were in use when the Geological Survey, as part of the investigations in northern Alaska, began a series of detailed studies of Paleozoic rocks in 1949 (Payne and others, 1952). By that time both names had taken on a time-stratigraphic meaning which, while useful for broad reconnaissance mapping, was inappropriate for detailed mapping in any limited area.

NEW AND REVISED STRATIGRAPHIC NAMES

The Lisburne limestone is herein raised in rank to Lisburne group, the name Stuver is reestablished and redefined, and four new names of formational rank are proposed. The Kanayut conglomerate (new name) and the Kayak shale (new name) comprise rocks previously referred to as the Noatak formation (Smith and Mertie, 1930; and Payne and others, 1952). Dutro suggests, on the basis of his field work in the type area of the Noatak formation in 1950, that the name for this nonmarine sandstone is not appropriate for use in the Shainin Lake area.

A new name, Kanayut conglomerate, is proposed for conglomerate, sandstone, and shale of Late Devonian age whose type locality is on the ridge south of Mount Wachsmuth (pl. 1). Three members are recognized in this formation in its type locality. The two members in the lower part are informally named the lower member and the middle conglomerate member. The name Stuver member, originally Stuver series, is in this revised description restricted to the upper part of the Kanayut conglomerate as these beds most closely resemble those exposed on Mount Stuver (approximate lat 68°12′ N., long 151°91′ W.) from which Schrader took the name. The type locality of the Stuver member is on the ridge just south of Mount Wachsmuth (pl. 1). The thicknesses of these members are shown in figure 4. The name Kanayut is taken from the Kanayut River, which originates at the north end of Shainin Lake.

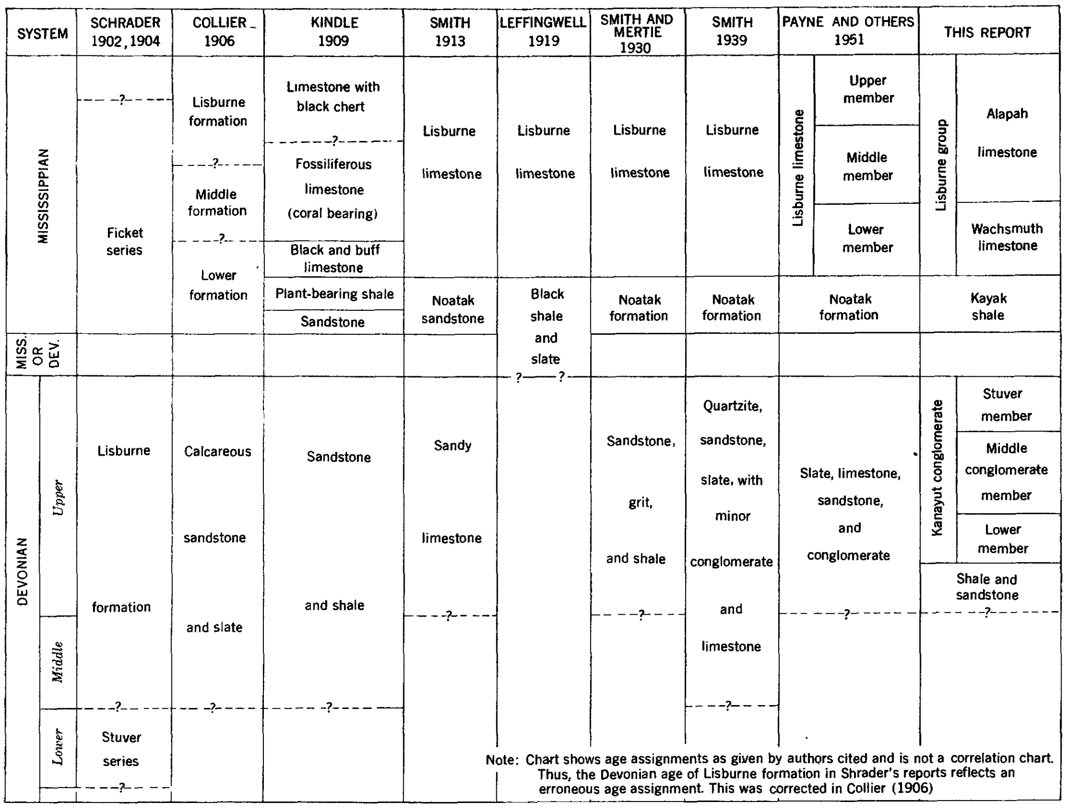

FIGURE 3.—Development of stratigraphic nomenclature of Mississippian and Devonian rocks in northern Alaska.

A new name, Kayak shale, is proposed for sandstone, shale, and limestone of early Mississippian age [2] with type locality on the south slope of Mount Wachsmuth. The name is taken from Kayak Creek, which joins Alapah Creek south of Shainin Lake (pl. 2). Five members with informal names are recognized in the Kayak shale at its type locality. The thicknesses of these members are shown in figure 4.

The formations described below are present[3] in the type area of the Lisburne formation of Schrader (1902), which is here raised to the rank of group.

A new name, Wachsmuth limestone, is proposed for early Mississippian limestone and dolomite, overlying the Kayak shale, in the lower part of the Lisburne group. The name is taken from Mount Wachsmuth, the type locality of this formation (pls. 1, 2). Four members with informal names are recognized in the Wachsmuth limestone at its type locality on Mount Wachsmuth. The thicknesses of the members are shown in figure 4.

A new name, Alapah limestone, is proposed for the late Mississippian limestone, shale, and dolomite which disconformably overlie the Wachsmuth limestone and form the upper part of the Lisburne group. The name is taken from Alapah Creek, which flows into the south end of Shainin Lake (pl. 2). Nine members with informal names are recognized in the Alapah limestone at its type locality on Mount Wachsmuth. The thicknesses of the members are shown in figure 4.

DEVONIAN SYSTEM

UNNAMED SHALE AND SANDSTONE

An incomplete section of shale and sandstone more than 1,600 feet thick lies at the base of the Shainin Lake thrust plate, 4.8 miles east of the camp on Shainin Lake (pl. 2). The lower 400 feet, in which Upper Devonian marine fossils are present, is correlated in part with the Upper Devonian rocks, described by Smith and Mertie (1930, p. 140–146), along the Killik and John Rivers. Schrader apparently included these rocks in his Fickett series (1904, p. 67–72). These shales and sandstones, overlain by conglomerate beds of the lower member of the Kanayut conglomerate, weather to smoother textured physiographic features than does the conglomerate. The nature of the contact between the two formations is unknown.

Only the upper part of this formation is present in the Shainin Lake area. Other Survey geologists have studied the formation where it is best developed along

[2] The terms "early" and "late" Mississippian are used here in the broadest sense, encompassing together the entire span of the Mississippian.

[3] Personal communication, W. P. Brosgé, U. S. Geological Survey, Washington, D. C., 1955.

SYSTEM OR SERIES	GROUP	FORMATION	THICKNESS (FT.)			MEMBER	FAUNAL ZONE
MISSISSIPPIAN	Lisburne (Ml)	Alapah limestone (Ma)	2200+	970+	70	Upper limestone (Mau)	
					80	Chert nodule (Man)	*Gigantoproductus striato-sulcatus* (Schwetzoff)
					80	Fine-grained limestone (Maf)	
					46	Light-gray limestone (Mal)	*Lithostrotionella?* sp. (small corallites)
					38	Black chert-shale (Mac)	*Goniatites crenistria* (Phillips)
					210	Banded limestone (Mab)	*Sciophyllum lambarti* (Harker and McLaren)
					187	Platy limestone (Map)	*Eumetria costata* (Hall)
					175	Dark limestone (Mad)	*Lithostrotion* aff. *L. asiaticum* (Yabe and Hayasaka)
					85	Shaly limestone (Mas)	*Naticopsis howi* (Dawson)
						DISCONFORMITY	
		Wachsmuth limestone (Mw)		1230	429	Banded chert and limestone (Mwb)	*Brachythyris suborbicularis* (Hall)
					564	Dolomite (Mwd)	*Spirifer tenuicostatus* (Hall)
					219	Crinoidal limestone (Mwc)	"*Zaphrentis*" *konincki* s.l. (Milne Edwards and Haime)
					18	Shaly limestone (Mws)	
						DISCONFORMITY	
		Kayak shale (Mk)		960±	10-15	Red limestone (Mkr)	*Cryptoblastus* aff. *C. pisum* (Meek and Worthen)
					140	Upper black shale (Mku)	*Leptaena analoga* (Phillips)
					80	Argillaceous limestone (Mka)	
					595	Lower black shale (Mkl)	
					131	Basal sandstone (Mks)	*Scalarituba* sp.
UPPER DEVONIAN		Kanayut conglomerate (Dk)		3300±	860	Stuver (Dks)	
					1026±	Middle conglomerate (Dkm)	
					1400±	Lower (Dkl)	
		Unnamed shale and sandstone (Ds)		1600±			*Cyrtospirifer* sp.

FIGURE 4.—Generalized stratigraphic section of Paleozoic rocks in the Shainin Lake area.

the tributaries of the John River. No formal name is presented for the formation in this report. Although not measured in detail, a generalized description of these strata is given in section A and in figure 2.

KANAYUT CONGLOMERATE

The Kanayut conglomerate, 3,300 feet of probable nonmarine conglomerate, sandstone, and shale, is typically exposed along the east side of Alapah Creek upstream from Shainin Lake (pl. 2). Lower parts of this formation make up the ridges on either side of Alapah Creek south of Block Mountain. This formation is considered to be of Late Devonian age because of the presence of lycopsid fragments and *Archeopteris* [4] in the Stuver member at the top of the formation.

Three members are recognized: the lower member, about 1,400 feet thick and apparently unfossiliferous; the 1,030-foot-thick middle conglomerate member, composed of unfossiliferous massive chert-pebble conglomerate; and the Stuver member, at the top, about 860 feet of orthoquartzite, gray, red, and green shale, and conglomerate. The composite type section of the Kanayut conglomerate is described by sections B, C, and D.

[4] Identifications by J. M. Schopf, U. S. Geological Survey, Columbus, Ohio, 1952.

CARBONIFEROUS ROCKS

MISSISSIPPIAN SYSTEM

KAYAK SHALE

The Kayak shale, approximately 960 feet of marine black shale, argillaceous limestone, and sandstone, lies disconformably above the Kanayut conglomerate and is disconformably overlain by the Wachsmuth limestone. Coral-echinoderm-bryozoan-brachiopod faunas of early Mississippian age are present in the upper part. This formation at the type locality is composed of 5 members. In ascending order they are the basal sandstone member, 130 feet thick; lower black shale member, 595 feet thick; argillaceous limestone member, 80 feet thick; upper black shale member, 140 feet thick; and red limestone member, 10–15 feet thick. Three faunal zones are recognized in this formation: the *Scalarituba* zone (see Shimer and Shrock, 1944, p. 234), restricted to the basal sandstone member; the *Leptaena analoga* (Phillips) zone (see Cooper, 1944, p. 341, 343), in the argillaceous limestone and upper black shale members; and the *Cryptoblastus* aff. *C. pisum* (Meek and Worthen) zone (see Cline, 1944, p. 137), in the red limestone member. Section F is the type section for the formation.

LISBURNE GROUP

The Lisburne group consists of two formations in the Shainin Lake area: the Wachsmuth and the Alapah limestones, in ascending order.

WACHSMUTH LIMESTONE

Limestone, dolomite, and chert are the principal rock types in the 1,230-foot-thick Wachsmuth limestone of early Mississippian age. The formation is divided into four lithologic members, as shown on plate 5. These informally named members are, in ascending order, the shaly limestone member, 18 feet thick; crinoidal limestone member, 179 feet thick; dolomite member, 564 feet thick; and banded chert-limestone member, 429 feet thick. Three distinctive faunal zones are present: the "*Zaphrentis*" *konincki* (sensu lato) Milne Edwards and Haime zone (see Milne Edwards and Haime, 1851, p. 331), in the lower part; the *Spirifer tenuicostatus* Hall zone (see Weller, 1914, p. 328–330), in the dolomite member; and the *Brachythyris suborbicularis* (Hall) zone (see Weller, 1914, p. 374–376), in the banded chert-limestone member. Disconformities separate this formation from the Kayak shale below and the Alapah limestone above. The composite type section is described by sections H and I.

ALAPAH LIMESTONE

The Alapah limestone is a 970-foot-thick carbonate-rock sequence which overlies the Wachsmuth limestone. It contains zones of shale, chert, clastic limestone, silicified limestone, and oolitic limestone. Nine lithologic members and seven faunal zones are recognized. These informally named members are, in ascending order, the shaly limestone member, 85 feet thick; dark limestone member, 175 feet thick; platy limestone member, 187 feet thick; banded limestone member, 210 feet thick; black chert-shale member, 38 feet thick; light-gray limestone member, 46 feet thick; fine-grained limestone member, 80 feet thick; chert-nodule member, 80 feet thick; and upper limestone member, 70 feet thick. Lithostrotionoid corals, characteristic of the lower two-thirds of the unit, and productid brachiopods (*Gigantoproductus*), in the upper part, indicate a probable late Mississippian age. Faunal zones, from the base of the formation upward, are *Naticopsis howi* Dawson zone (see Bell, 1929, p. 178–179), *Lithostrotion* aff. *L. asiaticum* (Yabe and Hayasaka) zone (see Yü, 1933, p. 95–96), *Eumetria costata* (Hall) zone (see Weller, 1914, p. 445–447), *Sciophyllum lambarti* Harker and McLaren zone (see Harker and McLaren, 1950, p. 29–34), *Goniatites crenistria* Phillips zone (see Gordon, Jr., 1957, p. 42–45), *Lithostrotionella* sp. (small corallites) zone (see McLaren and Sutherland, 1949, p. 625–634), and *Gigantoproductus striato-sulcatus* (Schwetzoff) zone (see Sarycheva and Sokolskaya, 1952, p. 126). The type section of this formation is described by sections J and K.

STRATIGRAPHIC SECTIONS

Each formation was considered separately and an attempt was made to find outcrops where a complete section was exposed. However, talus and structural complexities in the area necessitated the description of composite sections for most formations. An uninterrupted succession of strata from the middle member of the Kanayut conglomerate to almost the top of the Alapah limestone is present along the ridge south of Mount Wachsmuth and on Mount Wachsmuth itself (see pl. 2). Sections D, F, H, I, J, and K are all from this succession of strata.

Most of the sections were measured with a 6-foot tape graduated in feet and tenths of feet. The authors realize that the precise thicknesses recorded are not characteristic over a great distance; these measurements are the most accurate that could be made in the line of traverse. Where significant, variations in thickness of beds in the vicinity of the traverse are discussed in the descriptions, and an average thickness is plotted in the graphic sections.

The Wentworth scale was used for textural terminology of the noncarbonate clastic rocks. In descriptions of clastic carbonate rocks, fine grained applies to rocks with an average grain size of 0.1 millimeter or less, medium grained applies to an average grain size of 0.1–1 millimeter, and coarse grained applies to rocks with most grains more than a millimeter in diameter; the same scale was used in describing the crystalline carbonate rocks.

Color names conform with the National Research Council rock-color chart (Goddard and others, 1948).

The exact positions at which all samples were collected are indicated in the reference list of fossil-collection and rock-sample numbers and on the graphic stratigraphic sections, although little detailed paleontologic information regarding them is given in this report. Fossil names in the written sections refer to field identifications by the authors.

The stratigraphic sections are described from the top downward, and the units are numbered from the bottom upward.

An asterisk (*) before a unit number in the written sections indicates that a fossil collection was made from the unit, and a double asterisk (**) indicates that a rock sample was taken.

UNNAMED SHALE AND SANDSTONE—SECTION A

Section A, in the unnamed shale and sandstone (Upper Devonian), was measured along a single line of traverse on the east slope of a ridge 4.8 miles east of the Shainin Lake camp. The base of unit 1 of this formation is the base of a thrust plate (see pl. 2). The Alapah limestone, of which approximately 800 feet is exposed, lies directly beneath the thrust fault. It is not known how much of the lower part of the unnamed shale and sandstone has been eliminated by faulting. Also, the traverse was not completed to the base of the overlying Kanayut conglomerate.

Section on ridge 4.8 miles east of Shainin Lake at lat 68°18'30'' N., long 150°47' W. (approximate)

[Examined by A. L. Bowsher, V. E. Shainin, and J. H. Downs in 1950. Generalized section compiled by Bowsher from field notes and aerial photographs, all measurements approximate; location, pl. 2]

	Cumulative thickness above base of section (feet)
Kanayut conglomerate: Lower member: Conglomerate. Estimated thickness (from aerial photographs) 1,400± feet.	
Unnamed shale and sandstone (incomplete):	
14. Sandstone and shale, reddish-brown, thin-bedded; sandstone appears to predominate. Observed beyond end of traverse but not examined in detail. Thickness estimated	1,600±
**13. Sandstone, light-brownish-gray to medium-brownish-gray, fine- to medium-grained; subangular to subround clear and milky-white quartz grains, with minor amount of black chert and limonite grains; most beds weather medium gray; beds with much ferruginous cement weather dusky red; some orthoquartzite beds; sorting poor; argillaceous; some beds appear glauconitic; beds 0.2–3 ft thick	1,400
Unnamed shale and sandstone (incomplete)—Con.	
12. Shale, medium-gray, with thin beds of fine-grained quartzose sandstone. Mostly covered	1,220
11. Sandstone, thin-bedded, similar to unit 13	1,190
10. Shale, similar to unit 12	1,140
** 9. Sandstone, light-olive-gray to light-brownish-gray; angular to subround grains; weathers light brown; most beds with predominantly clear quartz grains but some with abundant milky-white quartz grains; minor amount of black chert grains throughout, white chert grains in some beds; most beds thin and tabular, 2–8 mm in thickness, but range from 2 mm to 2 ft in thickness; argillaceous; poor sorting	1,030
8. Shale, similar to unit 12. Mostly covered	1,000
7. Sandstone, similar to unit 13, thin-bedded, shaly, but with shale bed 10–15 ft thick in middle of unit	900
6. Shale, similar to unit 12, but with lenticular sandstone beds and some thin, platy sandstone beds	720
** 5. Sandstone, medium- and light-brownish-gray, fine- to medium-grained; clear and milky-white quartz grains; most beds with some black chert grains; some beds calcareous(?), ferruginous, glauconitic(?) and weather dark reddish brown; *Cyrtospirifer*(?) common in some beds	400
4. Shale, with thin lenticular sandstone beds. Mostly covered	350
** 3. Sandstone and limestone; the sandstone is light brownish gray, medium grained, poorly sorted, weathers light brown, and is composed of angular to subround clear and milky-white quartz grains and a few yellowish-brown and black chert grains; the interbedded limestone occurs as light-brownish-gray very arenaceous ferruginous limestone, with clear and milky-white quartz grains and a few black chert grains; limestone weathers dusky red; *Cyrtospirifer*(?), *Productella*(?), *Rhynchonella*(?), pelecypods, and orthoceratid cephalopods common in limestone beds	210
2. Shale, medium-gray; silt-size particles; quartzose, micaceous, kaolinitic, fissile; thin sandstone beds as in unit 3	180
* ** 1. Shale, similar to unit 2, but highly folded and contorted; cut by many shear zones; interbedded sandstone with *Cyrtospirifer*(?)	80
Thickness of unnamed shale and sandstone	1,600+
Thrust fault.	
Alapah limestone: Banded limestone member (incomplete): Limestone, broken and contorted at top. 800 ft or more exposed.	

KANAYUT CONGLOMERATE

The authors were unable to measure the entire Kanayut conglomerate along a single line of traverse. Also, no suitable exposure was located for measurement of a detailed section in the lower member, which is 1,400+ feet thick; consequently no section is presented for this member. The middle conglomerate member (section B) was measured along a single line of traverse where it is typically exposed 7 miles south of the Shainin Lake camp on Alapah Creek, and the lower part of the Stuver member (section C) was measured nearby. The type section of the Stuver member (section D) was measured at the type locality of the Kanayut conglomerate just south of Mount Wachsmuth; it directly overlies the middle conglomerate member of the Kanayut and underlies the basal sandstone member of the Kayak shale. Relations among these sections are shown on plate 3.

MIDDLE CONGLOMERATE MEMBER, KANAYUT CONGLOMERATE—SECTION B

Measurement of section B was begun in the lowest conglomerate beds of the middle conglomerate member. Conglomerate beds of the lower member, lying stratigraphically below this section, are incompletely exposed in the west wall of Alapah Creek and are covered by talus and gravel along the floor of the valley. Gravel and talus partly cover the upper beds of the middle conglomerate member and much of the overlying Stuver member.

Section along east side of Alapah Creek, about 7.1 miles S. 30° E. of camp on Shainin Lake, at lat 68°14′ N., long 150°47′20″ W. (approximate)

[Measured with hand level and tape by the authors and C. J. Gudim in 1949. Graphic section, pl. 3; location, pl. 2]

	Cumulative thickness above base of section (feet)
Kanayut conglomerate:	
Stuver member: See stratigraphic section C.	
Middle conglomerate member:	
59. Covered; talus of blocks of conglomerate similar to top beds of this member at base of stratigraphic section C	1,026±
58. Conglomerate, light- to medium-gray, with cobbles of gray and black chert in matrix of light-gray coarse-grained sandstone; massive beds as much as 2 ft thick	826.0
57. Conglomerate, light-gray, with cobbles of gray chert in coarse-grained medium-gray sandstone; less resistant than units above or below	816.0
56. Conglomerate, similar to unit 58, except that beds are 0.6–1.5 ft thick	813.0
55. Conglomerate, light- to medium-gray; 15–20 percent small, medium-size, and large pebbles of white, light-gray, grayish-black, and olive-gray chert scattered in a very coarse grained sandstone matrix; layers of small pebbles every 4 to 8 ft give banded appearance; pebbles form nearly 50 percent of a 2-foot-thick layer from 777 to 779 feet; massive beds 4–8 ft thick	803.0
54. Conglomerate, light-gray and reddish-brown, ferruginous; 50 percent white, light-gray, grayish-black, and olive-gray chert pebbles	769.0
Kanayut conglomerate—Continued	
Middle conglomerate member—Continued	
53. Conglomerate, light- to medium-gray; 15–20 percent white, light-gray, grayish-black, and olive-gray chert pebbles; becomes coarser toward top	767.0
52. Conglomerate, similar to unit 54, in massive beds; about 10 percent of coarse constituents are small cobbles	759.0
51. Conglomerate, similar to unit 54, with small to medium-size pebbles grading upward to 50 percent small cobbles near top; cobbles and pebbles apparently derived from conglomerate below unit 42 are present in this unit and downward through unit 42	719.0
50. Conglomerate, light- to medium-gray; 30 percent pebbles and small cobbles of milky-white, medium-gray, dark-gray, mottled light- and dark-gray, yellowish-gray, and black chert; nonresistant	708.0
49. Covered; conglomerate talus	698.0
48. Conglomerate, light- to medium-gray; 10–40 percent pebbles, similar to those in unit 50, concentrated in resistant bands; less resistant sandy zones interspersed between pebble bands	688.0
47. Conglomerate, medium-gray; 50 percent large cobbles and small pebbles of milky-white, medium-dark-gray, and black chert in coarse sandstone matrix	677.5
46. Sandstone, medium-light-gray to light-olive-gray, medium-grained	670.5
45. Conglomerate, similar to unit 47	670.1
44. Sandstone, similar to unit 46	669.6
43. Conglomerate, medium-gray; 25 percent medium-size to large pebbles and small cobbles of white, medium-dark-gray, and black chert in coarse sandstone matrix. Single massive bed forms rounded scarp face	669.3
42. Conglomerate, medium-gray; 15 percent medium-size pebbles of gray and black chert and some pebbles of sandstone; lithologically similar to units 39–41; cobbles and pebbles from units below this unit are present upward through unit 51	658.3
41. Sandstone, medium-light-gray to light-olive-gray, medium- to coarse-grained; thin, platy beds	654.3
40. Sandstone, brownish-gray to light-olive-gray, medium- to coarse-grained; contains 10 percent ferruginous grains; single massive bed	654.0
39. Sandstone, similar to unit 40, but thin beds	652.5
38. Conglomerate, medium- to yellowish-gray; 70 percent small to medium-size pebbles of white, light-olive-gray, medium-gray, and grayish-black chert and white quartzite; some pebbles of silicified argillite and siltstone; matrix is coarse-grained sandstone; slightly crossbedded	652.0

Kanayut conglomerate—Continued

Middle conglomerate member—Continued

	Cumulative thickness above base of section (feet)
37. Conglomerate, similar to unit 38, but with some small and medium-size cobbles scattered throughout	639.0
36. Conglomerate, similar to unit 38, except that about 50 percent of the pebbles are of medium and large size; thin lenticular bed of coarse-grained olive-gray to medium-gray sandstone from 623 to 627.1 feet	633.0
35. Covered	619.0
34. Conglomerate, lithologically similar to unit 38, with a very few cobbles scattered throughout	610.0
33. Conglomerate, similar to unit 34; about 15 percent small cobbles	606.0
32. Conglomerate, medium- to yellowish-gray; 70 percent medium-size to large pebbles of white, light-olive-gray, medium-gray, and grayish-black chert, quartzite, and silicified argillite; matrix is coarse sandstone; massive beds 2–8 ft thick	603.0
31. Covered	570.0
30. Conglomerate, 10 percent small to medium-size pebbles of light-gray, medium-gray, white, and yellowish-green chert in matrix of coarse-grained light-gray to light-yellowish-gray sandstone; percentage of pebbles increases upward to about 40 at top of unit	557.0
29. Conglomerate, 30 percent medium-size to large pebbles and 10 percent small cobbles of white, gray, black, light-yellowish-green, pale-brown, and dark-reddish-brown chert, and gray and greenish-gray quartzite in matrix of coarse to very coarse light-gray to light-yellowish-gray sandstone. This is typical of the lithologic character of the lower part of the middle conglomerate member of the Kanayut conglomerate	549.0
28. Conglomerate, similar to unit 29; 40 percent medium-size to large pebbles	545.0
27. Conglomerate, similar to unit 29; 60 percent small to medium-size pebbles; thin bedded	523.0
26. Conglomerate, similar to unit 29; 15 percent small to medium-size pebbles; about 10 percent light-brown ferruginous grains in matrix	516.0
25. Conglomerate, similar to unit 29; 30 percent medium-size to large pebbles in matrix ranging from very coarse sand to granule size	515.0
24. Conglomerate, similar to unit 29; 40 percent large cobbles	480.0
23. Conglomerate, similar to unit 29; 50 percent medium-size to large pebbles	477.0
22. Conglomerate, similar to unit 29; 90 percent medium-size to large pebbles	468.0
21. Conglomerate, similar to unit 29; 50 percent small and large cobbles of chert and appreciable percentages of vein quartz and greenish-gray quartzite cobbles	465.0

Kanayut conglomerate—Continued

Middle conglomerate member—Continued

	Cumulative thickness above base of section (feet)
20. Conglomerate, similar to unit 29; 80 percent small to medium-size pebbles and a few small cobbles; beds 1–4 ft thick in lower 12 ft, upper part massive	456.0
19. Conglomerate, similar to unit 29; 20 percent small to medium-size pebbles in an orthoquartzite matrix	424.5
18. Conglomerate, similar to unit 29; 70 percent medium-size pebbles and scattered subangular cobbles alined parallel to bedding	417.5
17. Conglomerate, similar to unit 29; 60 percent small cobbles near base; grades upward from large to small pebbles; poorly developed crossbedding in lower 10 ft	401.5
16. Conglomerate, similar to unit 29; 60 percent pebbles; grades upward from small to large cobbles; some dark-green and jet-black chert; cobbles are oblate spheroids with long axes parallel to bedding	382.5
15. Conglomerate, similar to unit 29; 50–60 percent small to large pebbles in matrix of very small pebbles and granules; crossbedded	376.5
14. Covered; beds probably conglomerate	368.0
13. Conglomerate, similar to unit 29; 30–40 percent medium-size to large pebbles; 4 massive beds	338.0
12. Conglomerate, similar to unit 29; 30 percent small to medium-size pebbles; 2-ft zone of 60 percent medium-size to large pebbles at top	313.0
11. Conglomerate, similar to unit 29; 30 percent large pebbles; 3 massive beds	296.0
10. Conglomerate, similar to unit 29; 15 percent medium-size to large pebbles in matrix containing 50 percent ferruginous grains; weathers light brown to yellowish gray; thin beds 0.3–0.4 ft thick	285.0
9. Conglomerate, similar to unit 29; 30–50 percent small to large pebbles in medium-grained to coarse sandstone matrix containing 20 percent ferruginous grains; tabular, massive beds 6–16 ft thick	281.0
8. Covered; beds probably conglomerate	213.0
7. Conglomerate, similar to unit 29; 50–75 percent medium-size to large pebbles; 3 massive beds	197.0
6. Covered; beds probably conglomerate	181.0
5. Conglomerate, similar to unit 29; single massive bed	174.0
4. Conglomerate, similar to unit 29; 25 percent small pebbles in friable thin-bedded sandstone matrix	156.0
3. Conglomerate, similar to unit 29; 60 percent medium-size to large pebbles, becomes more sandy in upper 9 ft; massive beds 3–14 ft thick	145.5
2. Covered; beds probably conglomerate	75.0
1. Conglomerate, 60 percent medium-size to very large pebbles, becomes 25 percent small to medium-size pebbles in upper part; light-gray, medium-gray, dark-gray,	

Kanayut conglomerate—Continued Middle conglomerate member—Continued	*Cumulative thickness above base of section (feet)*
olive-gray, dark-reddish-brown (10*R* 3/4), grayish-purple (5*P* 4/2), and moderate-red (5*R* 5/4) chert, quartzite, and silicified limestone pebbles as coarse components; matrix of coarse-grained light-olive-gray (5*Y* 5/2) sandstone; massive, tabular beds 8–10 ft thick; pebbles in upper beds oriented with long axes parallel to bedding. Unit is 55 ft thick	55.0
Thickness of middle conglomerate member (section starts at or near the base of the middle conglomerate member)	1,026±

STUVER MEMBER, KANAYUT CONGLOMERATE—SECTION C

Although most of the Stuver member is covered by talus where section B of the middle conglomerate member was measured, the lower part of it is exposed approximately 1 mile northwest above a cliff formed by the middle member. Here shale at the base of the Stuver member rests with apparent conformity upon a massive conglomerate bed of the middle conglomerate member. The upper part of the shale is cut by many shear zones and is highly contorted. A precipitous cliff of the lower member of the Kanayut is a thrust plate on shale of the Stuver member. Stratigraphic section C is of the strata in the lower part of this shale.

Section on south side of Block Mountain, about 800 feet above the valley floor of Alapah Creek, 6.6 miles south-southeast of camp on Shainin Lake, at lat 68°14′ N., long 150°50′ W. (approximate)

[Measured with hand level and tape by the authors and C. J. Gudim in 1949. Graphic section, pl. 3; location, pl. 2]

	Cumulative thickness above base of section (feet)
Kanayut conglomerate:	
Lower member: More than 500 feet of yellowish-orange-weathering conglomerate of the lower member has been thrust onto the Stuver member of this section and forms a precipitous cliff.	
Thrust fault.	
Kanayut conglomerate:	
Stuver member (incomplete):	
18. Shale, olive-gray (5*YR* 3/1), kaolinitic; clay-size particles; relatively hard, with bands of ferruginous nodules in middle part; some nodules contain small rounded ferruginous grayish-black phosphatic pebbles which weather dark reddish brown (10*R* 3/4) or very dusky reddish purple (5*RP* 2/2); a much contorted zone with chevron folds, slickensides along bedding; shear zones more resistant and, when seen from a distance, appear to be beds in the shale; true thickness of unit not known but exposed thickness is 390 ft+; unit not plotted on pl. 3	550±
17. Shale, grayish-black, kaolinitic; clay-size particles; weathers grayish purple (5*RP* 3/2); zones of very fine grained lenticular dark-greenish-gray kaolinitic quartzose sandstone which weather light brown (5*YR* 5/6); sandstone lenses as much as 0.3 ft thick at 154 and 160 ft; only a part of this unit is plotted on pl. 3	160.0
16. Shale, grayish-black, micaceous, somewhat kaolinitic; silt-size particles; weathers dark yellowish brown (10*YR* 4/2)	132.0
15. Siltstone, medium- to dark-gray; weathers dark yellowish brown (10*YR* 4/2); lenticular	112.4
14. Shale, olive-gray (5*Y* 4/1), micaceous; silt-size particles; weathers dark yellowish orange	111.6
**13. Siltstone, medium- to dark-gray, laminated, lenticular; thickness ranges from a feather edge to 1.4 ft; weathers dark yellowish orange and moderate reddish brown	108.8
**12. Shale, olive-gray, kaolinitic; clay-size particles; weathers dark yellowish orange	108.3
11. Shale, grayish-black, hard, massive; clay-size particles; weathers orange red, with metallic luster; unit appears to be a shear zone	104.0
10. Shale, olive-gray; clay-size particles; weathers dark reddish gray	101.0
9. Sandstone, very fine grained, hard, dense, lenticular, fucoidal	96.2
8. Shale, grayish-black; clay-size particles; weathers light brown and dark yellowish orange	95.8
* ** 7. Shale, grayish-black, fissile; clay-size particles; weathers reddish gray; 2-ft-thick zone of dark-gray lenticular ironstone nodules that weather dusky red (5*R* 3/4) and are as much as 0.5 ft thick between 78 and 80 ft	87.0
6. Claystone, grayish-black; weathers light brown (5*YR* 5/6) or dark yellowish orange (10*YR* 6/6); badly crumpled, may be a shear zone	66.0
* ** 5. Siltstone, medium-gray, shaly, micaceous; weathers reddish purple or purplish black with metallic luster; basal 4 ft forms massive ledge; upper 3 ft is more shaly, with bed of limonite nodules that weather dusky red (5*R* 3/4) and are as much as 0.3 ft thick in top foot	51.0
* ** 4. Siltstone, medium-dark-gray, very shaly, with thin stringers of very fine grained sandstone and small ferruginous concretions; weathers reddish gray; folded and crenulated, may be a shear zone	44.0
3. Sandstone, medium- to dark-gray and grayish-purple, laminated, slightly micaceous; weathers moderate reddish brown (10*R* 4/6), with some surfaces showing a very dusky purple (5*P* 2/2) metallic sheen	25.0

Kanayut conglomerate—Continued *Cumulative thickness above base of section (feet)*
Stuver member (incomplete)—Continued

2. Claystone, black, kaolinitic, arenaceous, hard, with a vitreous luster; lower part blocky, upper part shaly ---------- 18.0

* 1. Claystone, black, kaolinitic, arenaceous, hard, with a vitreous luster; rounded polished small to medium-size chert pebbles 6–12 mm in diameter similar to those in the top beds of the underlying middle conglomerate member ---------- 1.0

Exposed thickness of Stuver member -- 550±

Middle conglomerate member: Conglomerate, grayish-red (10*R* 4/2), with well-rounded polished pebbles and small cobbles of dark-gray chert; from a distance the beds appear moderate grayish blue (5*PB* 4/2); forms vertical cliff more than 700 ft high on west side of Alapah Creek; beds 3–10 ft thick at top, 30–40 ft thick in main part of cliff. See correlated section B.

STUVER MEMBER, KANAYUT CONGLOMERATE, TYPE SECTION—SECTION D

The Stuver member at its type locality, 0.7 mile south of Mount Wachsmuth, overlies the middle conglomerate member of the Kanayut, which is only partly exposed. The lower 140 feet of the Stuver member is covered by talus but appears to be largely shale (pl. 3). Ledges formed by the upper part of this member form a conspicuous hogback cutting across the ridge at this locality. The northern or dip slope of the hogback is partly overlain by the basal sandstone member of the Kayak shale shown in section F, a continuation of this section.

Section on ridge about 1.8 miles east of camp on Shainin Lake at lat 68°19′ N., long 150°33′ W. (approximate)

[Measured with hand level and tape by the authors and C. J. Gudim in 1949. Graphic section, pl. 3; location, pl. 2]

Cumulative thickness above base of section (feet)

Kayak shale: Basal sandstone member: See stratigraphic section F, a continuation of this section.
Disconformity.
Kanayut conglomerate:
Stuver member:

*66. Sandstone, medium-dark-gray, fine-grained, quartzose, orthoquartzitic; beds 0.5 ft thick, with very thin interbedded shale -- 860.0

65. Sandstone, medium-bluish-black, very fine grained, shaly; thickness of unit ranges from feather edge to 0.5 ft ---------- 857.3

**64. Conglomerate, light-gray, with large pebbles and small cobbles of black, gray, and white chert in orthoquartzitic coarse quartzose sandstone matrix ---------- 856.8

* **63. Sandstone, light- to bluish-gray, very fine grained; in beds 0.05–0.5 ft thick; scattered chert granules in basal 0.5 ft ---------- 855.5

Kanayut conglomerate—Continued *Cumulative thickness above base of section (feet)*
Stuver member—Continued

62. Conglomerate, light-gray, with small chert pebbles in coarse sandstone matrix; platy beds 0.2–0.5 ft thick ---------- 850.5

* **61. Conglomerate, light- to dark-gray, with pebbles and small cobbles of white, gray, and black chert in matrix of coarse quartzose sandstone; shaly stringers near base, with plant fragments ---------- 846.5

* **60. Shale, medium-light-gray; clay-size particles; thin lenses of conglomerate ---------- 842.5

*59. Sandstone, dark-gray, fine-grained, orthoquartzitic ---------- 841.0

*58. Sandstone, dark-gray, fine- to medium-grained, shaly ---------- 840.5

*57. Sandstone, dark-gray, fine- to medium-grained, quartzose, ferruginous, with scattered small pebbles of white and black chert ---------- 840.0

**56. Conglomerate, dark-gray; about 20 percent small cobbles and pebbles of gray and black chert and white quartzite in orthoquartzitic coarse quartz sandstone matrix; cobbles show internal primary bedding --- 835.0

55. Covered; beds probably shale ---------- 826.0

54. Sandstone, medium-gray, medium-grained, orthoquartzitic ---------- 769.0

* **53. Sandstone, dark-gray, fine-grained, bituminous; a few stringers of coarse sandstone and conglomerate; plant fragments throughout unit ---------- 766.0

**52. Sandstone, medium-gray, fine-grained, orthoquartzitic, kaolinitic (?); in blocky beds -- 759.0

**51. Conglomerate, white to light-gray, with medium-size to large pebbles of white, gray, and black chert; irregular beds; lenses of light-gray coarse sandstone as much as 0.5 ft thick ---------- 755.0

*50. Sandstone, dark-gray, fine-grained, orthoquartzitic; thin lenses of pebble conglomerate near top ---------- 752.0

49. Sandstone, light-brownish-gray, medium-grained, orthoquartzitic, crossbedded ---- 750.0

**48. Conglomerate, white to light-gray, massive; pebbles and cobbles of white, red, and gray chert and silicified limestone, shale, and sandstone; 90 percent pebbles at base decreasing to 20 percent at top ---------- 749.5

47. Sandstone, dark-gray, medium-grained, orthoquartzitic ---------- 739.5

46. Conglomerate, similar to unit 48; in addition, contains pebbles of sandstone from lower units ---------- 738.8

45. Covered; shaly-sandstone talus ---------- 731.8

44. Sandstone, dark-gray to greenish, medium-grained, orthoquartzitic; crossbedded in part ---------- 731.3

43. Sandstone, dark-gray, fine- to medium-grained, shaly ---------- 729.0

42. Sandstone, medium-gray, medium- to coarse-grained, orthoquartzitic; 0.3-ft-thick lens of pebble conglomerate at top - 727.9

Kanayut conglomerate—Continued Stuver member—Continued	*Cumulative thickness above base of section (feet)*
41. Conglomerate, with large black and white chert pebbles; grades laterally into gray shale of silt-size particles	726.0
40. Sandstone, medium-gray, fine- to coarse-grained, orthoquartzitic; basal part white, gray, and black chert-pebble conglomerate, with pebbles 6–20 mm in diameter	725.5
39. Sandstone, medium-gray, fine-grained, ferruginous, orthoquartzitic	723.7
38. Conglomerate, light-gray, with large rounded pebbles of white, gray, and black chert	721.6
37. Sandstone, similar to unit 39	721.1
36. Conglomerate, with granules of gray and black chert and white quartz in very fine grained medium-gray sandstone matrix	719.9
**35. Sandstone, medium-gray, fine-grained, kaolinitic(?), with rounded frosted quartz grains; blocky beds	719.6
34. Sandstone, light-grayish-purple, coarse-grained, with lenses of white, gray, and black chert-pebble conglomerate	702.6
33. Shale, medium-gray to light-brownish-gray, kaolinitic(?); clay-size particles	700.6
**32. Sandstone, light-purple, fine- to medium-grained; single massive bed	700.3
**31. Sandstone, similar to unit 34, but with lenses of white, gray, and purple chert-pebble and chert-cobble conglomerate; very ferruginous in lower 0.7–0.8 ft	697.3
30. Shale, brownish-gray to greenish-gray; clay-size particles	694.3
29. Claystone and shale, dark-gray, with metallic sheen, kaolinitic(?); clay-size particles; brownish-gray shale in upper part	609.5
28. Covered; talus of material similar to unit 27	432.5
**27. Conglomerate, dark-gray, with pebbles and cobbles of white and black chert in coarse orthoquartzitic sandstone matrix; scattered ferruginous mudstone nodules	379.5
26. Sandstone, light-yellow-green, very fine grained, carbonaceous, micaceous, argillaceous, shaly; weathers dark yellowish orange; mostly covered	366.0
25. Sandstone, light-gray to dark-gray, fine- to medium-grained, orthoquartzitic	355.0
**24. Sandstone, dark-gray, coarse-grained, poorly sorted, with conglomerate lenses; in flaggy 0.2- to 0.5-ft-thick beds; weathers to white or light-yellowish-brown powder	345.0
23. Covered; beds apparently lithologically similar to unit 22	307.0
**22. Shale and sandstone; light-bluish-gray to brownish-gray platy shale of clay-size particles; thin beds of fine-grained dark-gray micaceous platy sandstone	282.0
**21. Sandstone, light-gray, medium-grained; weathers reddish brown; beds 0.5 ft thick at base, thinning to 0.1 ft at top	272.0
**20. Sandstone, similar to unit 21, but more massive, crossbedded	262.0
**19. Sandstone, similar to unit 21, but strongly crossbedded	257.0
18. Conglomerate, with white, green, and black chert pebbles to large cobbles in a sandstone matrix that is similar to unit 21; unit is 0.5–1.5 ft thick	254.0
17. Sandstone, similar to unit 21, but with very irregular bedding	253.0
**16. Conglomerate, white to light-gray, with white, gray, green, and black chert pebbles scattered in matrix of coarse sandstone with frosted quartz grains	250.0
15. Covered; rubble of shale and sandstone similar to unit 14	245.0
14. Shale and sandstone; reddish- to greenish-gray micaceous fissile shale of clay-size particles, and thin beds of reddish-gray fine- to medium-grained quartzose sandstone	230.0
13. Shale, black, micaceous, bituminous, hard, platy; clay-size particles	205.0
12. Covered; rubble of sandstone similar to unit 11	168.0
11. Sandstone, medium-gray, fine- to medium-grained, orthoquartzitic; weathers reddish brown	162.8
10. Sandstone, medium-gray, medium-grained, orthoquartzitic, with a few small pebbles scattered throughout	158.8
** 9. Sandstone, medium-gray, medium-grained, orthoquartzitic; weathers greenish gray; ferruginous grains weather reddish brown; in tabular beds 0.6–1 ft thick	156.8
** 8. Conglomerate, medium-gray, with gray and black chert pebbles in medium-grained quartzose sandstone matrix	152.7
** 7. Shale and sandstone; greenish-gray hard arenaceous shale with very fine quartz grains; beds of dark-gray fine-grained orthoquartzitic thin-bedded sandstone	152.4
6. Sandstone, dark-gray, fine- to medium-grained, quartzose, orthoquartzitic, with scattered black chert grains; weathers reddish brown; crossbedded	151.3
5. Sandstone, greenish-gray, very fine grained, shaly	144.3
4. Sandstone, medium-gray, medium-grained, dense, orthoquartzitic	144.1
3. Sandstone, medium-gray, very fine to fine-grained, orthoquartzitic	143.6
* 2. Conglomerate, light- to medium-gray; 40 percent white, gray, and black pebbles in matrix of fine-grained reddish-brown-weathering quartzose and orthoquartzitic sandstone	143.1
1. Covered; beds probably shale, sandstone, and conglomerate	140.0
Thickness of Stuver member	860.0

Kanayut conglomerate—Continued

Middle conglomerate member (incomplete): Conglomerate, light-gray; weathers light brown; 20–90 percent pebbles to small cobbles of white, light-gray, dark-gray, and black chert; matrix coarse-grained light- to medium-gray sandstone; massive beds 2–10 ft thick.

KAYAK SHALE

Talus covers parts of the Kayak shale at its type locality in the saddle near the foot of the south slope of Mount Wachsmuth (pl. 2). Section F, measured at the type locality along a single line of traverse, indicates the true thickness of the members and their position in the formation. The basal sandstone member of the Kayak shale (section E) is typically exposed 3.7 miles south-southeast of the Shainin Lake camp (pl. 2). The argillaceous limestone, upper black shale, and red limestone members (section G) are typically exposed 1 mile south of the Shainin Lake camp (pl. 2). The relations among these three sections are shown on plate 4.

BASAL SANDSTONE MEMBER, KAYAK SHALE—SECTION E

The basal sandstone member is well exposed 3.7 miles south-southeast of the Shainin Lake camp. Here the disconformable contact between the Stuver member of the Kanayut conglomerate and this member is well exposed. All parts of the member were examined. Small folds and faults present in the overlying lower black shale member do not involve the basal sandstone member, except locally in the upper part. The details of the member at this locality are presented on plate 4, and the section is correlated with the basal sandstone member at the type locality of the Kayak shale (section F).

Section 1.2 miles west of junction of Kayak Creek with Alapah Creek, 3.7 miles south-southeast of the Shainin Lake camp, lat 68°16′ N., long 150°55′ W. (approximate)

[Measured with hand level and tape by the authors and R. L. Miller in 1949. Graphic section, pl. 4; location, pl. 2]

	Cumulative thickness above base of section (feet)
Kayak shale:	
Lower black shale member: This member is only 410 ft thick here because of faulting. See section F for true thickness of the member.	
Basal sandstone member:	
12. Sandstone, medium-gray, very fine to fine-grained, ferruginous, thin-bedded; has "hackly" surfaces when weathered; composed of subangular to subround clear and milky-white quartz grains; ferruginous beds weather grayish red (5*R* 4/2); numerous thin, lenticular beds of medium-gray or dark-gray arenaceous silty shale; beds 2 mm–13 mm in thickness	126+
11. Shale, dark-gray, fissile, kaolinitic; clay-size particles; light-olive-gray (5*Y* 5/2) ferruginous septate claystone concretions which weather dark yellowish orange and very dusky reddish purple	107.4
10. Shale, dark-gray, relatively hard, fissile, kaolinitic; clay-size particles	103.3
9. Sandstone, medium-gray to medium-light-gray; very fine grained at base, becomes fine to medium grained toward top; wavy bedded, lenticular, with thin shaly-sandstone lenses; macerated plant fragments common throughout; *Scalarituba* abundant from 91.5 to 92 ft	96.3
8. Covered; beds probably sandy shale with thin sandstone beds	90.0
** 7. Sandstone, very-dusky-red (10*R* 2/2), coarse-grained to very coarse grained, ferruginous; 60 percent angular to subround clear and milky-white quartz grains; 40 percent fine- to medium-sized angular to subround clear and milky-white quartz grains; uniform tabular beds 0.1–0.2 ft thick	82.0
** 6. Sandstone, very-light-gray to medium-light-gray, coarse-grained, hard; predominantly clear subangular quartz grains, with ferruginous and siliceous cement; tabular beds 0.1–1.9 ft thick, with most beds 0.2–0.7 ft thick; conspicuous crosslamination throughout, crosslaminae dip predominantly north; weathered surface of cliff irregularly banded with blackish red to dusky red (5*R* 3/4) and pale yellowish orange (10*YR* 8/6) to grayish yellow (5*Y* 8/4); bedding surfaces of crosslaminae are dusky red (5*R* 3/4); unit forms cliff	71.4
* 5. Sandstone, medium- to dark-gray, fine-grained, hard, graphitic, ferruginous, with thin stringers of shaly very fine grained medium- to dark-gray sandstone; hard beds 0.4–0.5 ft thick and shaly beds 0.1–0.3 ft thick; 0.2-ft-thick bed from 28.6 to 28.8 ft is medium grayish red and laminated	32.8
4. Shale and sandstone; interbedded medium-dark-gray to medium-gray shale of silt-size particles, and medium-dark-gray to medium-gray very fine grained sandstone, with subround to subangular clear and frosted quartz grains; slightly ferruginous	25.1
3. Shale, medium-dark-gray, ferruginous; clay- and silt-size particles; weathers light brown with purplish-blue sheen on some bedding planes; somewhat crumpled and folded	21.3
2. Sandstone, medium-gray, fine-grained, hard, siliceous; beds 0.05–0.4 ft thick	2.8
1. Shale, medium-gray, splintery, slightly kaolinitic, with very thin lens of quartzose sandstone	.05
Thickness of basal sandstone member	126+

Disconformity.
Kanayut conglomerate: Stuver member (incomplete: Conglomerate, light- to medium-gray, with rounded pebbles of medium-dark-gray, dark-gray, and white chert in orthoquartzitic matrix; faintly banded; approximately 5 percent pebbles in top bed, 30 percent pebbles in next to top bed; beds, in ascending order, are 0.3, 0.6, 0.2, and 0.1 ft thick. Overlies massive thick beds of conglomerate.

KAYAK SHALE, TYPE SECTION—SECTION F

The Kayak shale at the type locality disconformably overlies the Stuver member of the Kanayut conglomerate and disconformably underlies the Wachsmuth limestone. This section is a continuation of section D of the Stuver member. Section H of the Wachsmuth limestone is a continuation of this section (pl. 2).

Descriptions of the covered parts of the basal sandstone member in this section are supplemented by data from section E. The lower black shale member, this section and section G, was examined at several exposures because no locality furnished a completely exposed and undeformed section. The argillaceous limestone and the upper black shale members are not completely exposed at the type locality, and details of these members are presented in section G, which is typical. The red limestone member, at the top of the formation, is typically exposed at the type locality south of Mount Wachsmuth and also across Alapah Creek, 1 mile south of the Shainin Lake camp (section G).

The Kayak shale at this locality is undeformed; this section gives a close approximation of the true thickness of the formation and its members.

Section in saddle on south side of Mount Wachsmuth, about 1.8 miles east of Shainin Lake camp at lat 68°19′19″ N., long 150° 54′29″ W. (approximate)

[Measured with tape and hand level by the authors and C. J. Gudim in 1949. Graphic section, pl. 4; location pl. 2]

	Cumulative thickness above base of section (feet)
Wachsmuth limestone: Shaly limestone member: See stratigraphic section H, a continuation of this section.	
Disconformity.	
Kayak shale:	
Red limestone member:	
*24. Limestone, medium-gray, medium- to coarse-grained, argillaceous; detrital fossil fragments, fish teeth, and phosphatic pebbles common	960±
* **23. Limestone, dark-gray, coarse-grained, bioclastic; weathers reddish brown; brachiopod fragments scattered throughout, fish teeth and phosphatic pebbles on many bedding surfaces; beds 0.8–2 ft thick	959. 9
22. Limestone, dark-gray, medium-grained, bituminous (?), hard; thin irregular beds, crosslaminated; abundant brachiopod, crinoid, and gastropod fragments; fish teeth and phosphatic pebbles common	948. 3
Thickness of red limestone member	13. 2
Upper black shale member:	
21. Shale, dark-gray to grayish-black, fissile, soft, very slightly micaceous; clay-size particles. Mostly covered, but exposed in small areas along mountainside	946. 8
Thickness of upper black shale member	140. 0
Argillaceous limestone member:	
*20. Limestone, dark-gray, fine-grained, very argillaceous, shaly, nodular; fossils rare. Poorly exposed along mountainside	806. 8
*19. Limestone, similar to unit 20. Forms ledge along mountainside	796. 8
*18. Covered; beds thought to be mostly limestone. See plate 4, sections F and G	791. 8
Thickness of argillaceous limestone member	80. 8
Lower black shale member:	
17. Shale, dark-gray to grayish-black, fissile, slightly calcareous(?), relatively soft, slightly micaceous, with scattered ferruginous limestone or clay-ironstone nodules; clay-size particles. Mostly covered, but there are scattered exposures on mountainside	726. 0
16. Shale. Mostly covered; scattered exposures of shale similar to unit 17 on south slope of Mt. Wachsmuth and in the saddle to south	550. 0
Thickness of lower black shale member	595. 0
Basal sandstone member:	
15. Sandstone, reddish-brown, fine-grained, argillaceous, fucoidal, thick-bedded	131. 0
14. Sandstone, reddish-brown, fine-grained, argillaceous, fucoidal; hard, platy, irregular, shaly beds	129. 7
**13. Sandstone, white to light-gray, fine-grained, orthoquartzitic, quartzose, with grains well rounded but not frosted; beds 0.2–0.3 ft thick	117. 7
12. Shale, light-greenish-gray, soft, fissile; clay-size particles	107. 7
11. Sandstone, dark-gray, fine-grained, micaceous, carbonaceous, argillaceous, shaly	95. 7
10. Sandstone, dark-gray, fine-grained, carbonaceous, micaceous, argillaceous; uniform beds 0.05–0.1 ft thick; vertical worm borings, *Scalarituba*, common	93. 7
* 9. Shale and sandstone; dark-gray micaceous shale of clay- and silt-size particles, with thin beds of brown fine-grained sandstone that become less numerous in upper 1.7 ft	92. 7

Kayak shale—Continued

Basal sandstone member—Continued

	Cumulative thickness above base of section (feet)
8. Shale, dark-gray, micaceous, very soft; clay- and silt-size particles	89.0
7. Sandstone, light-brownish-gray, very fine grained, in lenticular beds ranging from feather edge to 0.2 ft in thickness	86.0
6. Shale, dark-gray, kaolinitic, brittle, fissile; silt-size particles	85.0
5. Covered; beds probably shale similar to unit 6	83.0
4. Sandstone, reddish-brown, fine-grained, quartzose, with well-rounded unfrosted grains; thin tabular beds	70.0
3. Covered by talus; conceals sandstone similar to unit 4	66.0
2. Sandstone, similar to unit 4. Forms low cliff	56.0
1. Covered by talus; conceals sandstone similar to unit 2, but may be shale in part	45.0
Thickness of basal sandstone member	131.0
Total thickness of Kayak shale	960±

Kanayut conglomerate: Stuver member: See stratigraphic section D, a continuation of this section.

UPPER PART, KAYAK SHALE—SECTION G

The upper part of the Kayak shale, including the upper part of the lower black shale member, the argillaceous limestone member, the upper black shale member, and the red limestone member, is typically exposed in a gully about 1 mile south of the Shainin Lake camp on the west wall of the Alapah Creek valley. The lower part of the formation is covered by talus and alluvium. The Wachsmuth limestone disconformably overlies the red limestone member at the top of the Kayak shale. The strata in this section are correlated with those in the Kayak shale at the type locality.

Section on west wall of Alapah Creek valley, about 1 mile south of the Shainin Lake camp, lat 68°18'09'' N., long 150°57'40'' W. (approximate)

[Measured with tape and hand level by the authors, C. J. Gudim, and A. Feder in 1949. Graphic section, pl. 4; location, pl. 2. Datum is base of Kayak shale as established in section F]

Wachsmuth limestone:

Crinoidal limestone member (incomplete):

Limestone, crinoidal. Thickness 118+ feet.

Shaly limestone member:

Covered; thought to be shaly limestone similar to unit 1 of section H. Thickness 18± feet.

Disconformity.

Kayak shale:

Red limestone member:

	Cumulative thickness above datum (feet)
*41. Limestone, dark-gray, coarse-grained, reddish-brown-weathering, bioclastic, with fragments of brachiopods, fish teeth, and phosphatic pebbles throughout; top surface of unit is pavement of fish teeth, phosphatic pebbles, and weathered limestone pebbles; beds 0.3–1 ft thick	960.0
Thickness of red limestone member	11.5

Upper black shale member:

40. Covered; beds thought to be grayish-black shale similar to unit 39	948.5
39. Shale, grayish-black, calcareous, fissile; clay-size particles	938.5
38. Limestone, grayish-black, fine-grained, nodular; beds range from feather edge to 0.5 ft in thickness	899.6
*37. Shale, similar to unit 39, with many fenestrate bryozoans; as much as 0.6 ft thick	899.1
*36. Limestone, grayish-black, fine-grained, dense, very ferruginous; lenticular unit from feather edge to 0.3 ft thick	898.8
35. Shale, similar to unit 39, with band of grayish-black limestone nodules at 879 ft	898.5
34. Shale, similar to unit 39, with many nodules of dark-gray very fine grained dense sideritic(?) limestone which weather dark reddish brown (10*R* 3/4) or very dark red (5*R* 2/6)	872.8
*33. Shale, similar to unit 39	870.8
**32. Limestone, medium-dark-gray, medium-grained, slightly argillaceous, bioclastic, fossiliferous; weathers dusky red (5*R* 3/4), moderate brown (5*YR* 4/4), and moderate reddish brown (10*R* 4/6); beds, in ascending order, are 0.3, 1.0, 2.2, 0.5, and 0.3 ft thick; lower beds distinctly laminated, but laminae become fainter upward and disappear at 846.8 ft	847.6
31. Limestone and shale; dark-gray fine-grained unfossiliferous limestone as tabular beds 2 mm thick that increase uniformly in thickness to 7 mm at top, interbedded with grayish-black calcareous shale of clay-size particles; shale partings range from 0.3 mm in thickness at base to 0.6 mm at top; unit ranges from 0.7 to 2 ft in thickness	843.3
30. Shale, grayish-black, fissile; clay-size particles	841.8
29. Limestone, dark-gray, fine- to medium-grained, with many crinoidal fragments	835.9
*28. Shale, similar to unit 30	835.1
27. Limestone, grayish-black, fine-grained, argillaceous, unfossiliferous	810.9
26. Shale, similar to unit 30; weathers bluish gray	810.0
Thickness of upper black shale member	140.8

Argillaceous limestone member:

* **25. Limestone, medium-dark-gray, fine-grained, extremely argillaceous, shaly, with scattered crinoidal debris; irregularly bedded; lenticular zones of calcareous shale of clay-size particles and lenses of crinoidal bioclastic limestone; more shaly from 804.5 to top of unit	807.7

Kayak shale—Continued
Argillaceous limestone member—Continued

	Cumulative thickness above datum (feet)
24. Limestone, medium-dark-gray, fine-grained, very argillaceous, slightly bioclastic	795.3
23. Shale and limestone; dark-gray to medium-gray very calcareous fossiliferous shale with splintery fracture, and medium-dark-gray fine-grained very argillaceous limestone with crinoid fragments	794.9
22. Limestone, medium-dark-gray, coarse-grained, bioclastic, with crinoid columnals as much as 5.0 mm in diameter	794.1
21. Limestone, similar to unit 22, with numerous crinoid fragments as much as 0.2 mm in diameter	792.2
20. Shale, medium- to bluish-gray, kaolinitic, very calcareous, with splintery fracture, very few fossils	789.5
19. Limestone, dark-gray, fine-grained, very argillaceous, with small amount of comminuted fossil fragments	787.0
18. Shale, similar to unit 20	783.9
*17. Limestone and shale; dark-gray fine-grained very argillaceous limestone with minor amount of comminuted fossil fragments, nodular in top part and unevenly bedded in lower part; interbedded medium- to bluish-gray kaolinitic shale of clay-size particles, with splintery fracture and few fossils	783.3
*16. Shale, similar to unit 20	775.5
15. Limestone, grayish-black, fine-grained, very argillaceous, with few fossil fragments; very few small crinoid columnals	774.8
*14. Shale, similar to unit 20	774.4
* **13. Limestone and shale; grayish-black fine-grained very argillaceous limestone with minor amount of comminuted fossil fragments, interbedded from 765.5 to 768.3 ft with dark-gray splintery-fracturing very calcareous shale of clay-size particles that forms 30 percent of the strata; shaly zones 0.1–0.2 ft thick; limestone beds 0.2 ft thick at base, 0.8–0.9 ft thick in middle part, and 0.2–0.6 ft thick at top	770.7
12. Shale and limestone; dark-gray kaolinitic very calcareous shale of clay-size particles, with splintery fracture, that constitutes 70 percent of unit; interbedded dark-gray to grayish-black fine-grained limestone more common in upper part of unit; few fossils	765.5
11. Limestone and shale; grayish-black fine-grained nodular limestone, with sparse small crinoid columnals; interbedded medium-gray to light-bluish-gray very soft calcareous shale of clay-size particles which constitutes 15 percent of the unit. Unit forms ledge	759.6
**10. Limestone and shale; dark-gray fine- to medium-grained argillaceous bioclastic limestone, interbedded with medium-gray to light-bluish-gray soft calcareous kaolinitic shale of clay-size particles that constitutes 50 percent of the unit	755.2
** 9. Limestone, dark-gray, fine- to medium-grained, fossiliferous; weathers light brown (5*YR* 5/6); 0.1-ft-thick bed of medium-gray to grayish-black chert at base	751.7
* 8. Limestone and shale; limestone, similar to unit 9, in beds 0.2–0.4 ft thick, that are separated by medium-dark-gray calcareous shale of clay-size particles, in beds 0.1–0.5 ft thick	750.2
* 7. Limestone, similar to unit 9, in beds 0.2–0.4 ft thick	747.5
* 6. Limestone and shale; dark-gray fine-grained argillaceous limestone, in beds 0.1–0.3 ft thick; interspersed thin zones of medium-dark-gray calcareous shale of clay-size particles	745.9
* 5. Limestone, dark-gray, medium-grained, argillaceous, unfossiliferous; weathers pale yellowish orange (10*YR* 8/6) to light brown (5*YR* 5/6). Base of unit forms base of upper limestone cliff	744.4
* 4. Limestone and shale, similar to unit 6. Forms receding slope	742.9
* ** 3. Limestone, medium-dark-gray to brownish-black, coarse-grained to very coarse grained, argillaceous, with many crinoid plates and columnals; weathers yellowish gray (5*Y* 7/2); beds 0.4–1.9 ft thick, separated by thin partings of medium- to dark-gray calcareous soft shale of clay-size particles that are 0.1–0.3 ft thick; 4 rhythmic phases represented by beds from 726.7 to 729.6 ft; 729.6 to 734 ft; 734 to 737.7 ft; and 737.7 to 740.9 ft. Forms lower cliff in member	740.9
Thickness of argillaceous limestone member	81.8

Lower black shale member (incomplete; see correlated section F, pl. 4):

2. Covered; beds may be limestone and shale similar to unit 3 or grayish-black shale similar to underlying unit 1	725.9
** 1. Shale, grayish-black, micaceous, carbonaceous, fissile; weathers moderate yellow brown (10*YR* 5/4); predominately of clay-size particles but shale of silt-size particles predominates in several parts of the unit; zones of calcareous ferruginous mudstone concretions at 790.5, 683.4, and 657.1 ft. The shale in this unit is exposed between 594 and 723.9 ft above the base of the Kayak shale. Below 594 ft the formation is covered by talus and soil. See correlated section F for the lower part of the Kayak shale	723.9
Thickness of lower black shale member measured	130±
Total thickness of lower black shale member (see pl. 5)	595±

LISBURNE GROUP

WACHSMUTH LIMESTONE

The Wachsmuth limestone crops out on the south slope of Mount Wachsmuth, the type locality for this formation. The lowest beds of the Wachsmuth are well exposed just above the saddle on the south side of the mountain but are covered by slide-rock on the lower slopes of the mountain on both sides of this saddle (pl. 2). The upper part of the Wachsmuth is largely covered by slide-rock on the south face of the mountain but is well exposed on the west slopes and on the south face of Sugarloaf Hill (pl. 2). It was necessary to measure sections along two separate lines of traverse one-half mile apart to obtain detailed description of all parts of the Wachsmuth limestone. The relations between the two sections, H and I, are shown on plate 5.

LOWER PART, WACHSMUTH LIMESTONE—SECTION H

This section, comprising the shaly limestone member, the crinoidal limestone member, and part of the dolomite member, was measured just above the saddle on the south side of Mount Wachsmuth. The shaly limestone at the base of the section lies disconformably on the red limestone member of the Kayak shale. This section is a continuation of section F of the Kayak shale. The upper part of this section, in the dolomite member, is correlated with beds in section I, a continuation of this section, but was measured one-half mile west on the lower slopes of Mount Wachsmuth.

Although units 17 through 31 of this section were identified in the field as limestone, samples from correlative strata in section I were identified in the laboratory as dolomite. The strata in units 17 through 31 are probably dolomite or dolomitic limestone.

Section on south face of Mount Wachsmuth at lat 68°19′20″ N., long 150°54′30″ W. (approximate)

[Measured with tape and hand level by the authors and C. J. Gudim in 1949. Graphic section, pl. 5; location, pl. 2]

	Cumulative thickness above base of section (feet)
Wachsmuth limestone:	
Dolomite member (incomplete; see pl. 5):	
31. Limestone, light-gray, fine-grained, bioclastic in part. Slope above this unit is largely covered by slide-rock. See correlated stratigraphic section I for a description of the Wachsmuth limestone stratigraphically above this unit	312+
30. Limestone, medium-dark-gray, hard, fine-grained, bioclastic	296. 6
29. Limestone, light-gray, medium-grained, bioclastic, with few crinoid columnals; beds 1.5–5.4 ft thick	293. 6
28. Limestone, medium-gray; thin beds 0.2–0.4 ft thick; massive unit	258. 7
Wachsmuth limestone—Continued	
Dolomite member (incomplete; see pl. 5)—Continued	
27. Limestone, medium-dark-gray, medium-grained, bioclastic; band of medium-dark-gray nodular chert along bedding plane at 254 ft	254. 7
26. Limestone and chert; medium-dark-gray fine-grained argillaceous limestone and interbedded medium-dark-gray nodular chert	250. 7
25. Limestone, medium-dark-gray, medium-grained, bioclastic; beds 0.4–4 ft thick; beds of units 25 through 28 weather to distinctive light-brown band along outcrop; zones of medium-dark-gray nodular chert at 237.6, 238.5, 245.8, and 247 ft; thin shaly zones, 0.4 ft thick, from 236.2 to 236.6 and 237.7 to 238.1 ft	247. 7
24. Limestone and chert; medium-dark-gray medium-grained bioclastic crinoidal limestone and interbedded medium-dark-gray nodular chert	229. 7
23. Limestone, medium-dark-gray, medium-grained, bioclastic, crinoidal, with single layer of medium-dark-gray chert nodules in middle	225. 1
22. Limestone and chert; medium-dark-gray, fine- to medium-grained bioclastic crinoidal limestone, interbedded medium-dark-gray nodular chert	223. 7
21. Limestone, medium-dark-gray, medium-grained, bioclastic, slightly argillaceous, with a few crinoid columnals; band of medium-dark-gray chert nodules near top of bed	222. 2
20. Shale, medium-dark-gray, very calcareous, platy	218. 2
19. Chert, medium-dark-gray, dense, nodular	217. 7
18. Limestone, light-gray to white, medium-grained, bioclastic; 15 percent crinoid ossicles; massive 6 ft-thick-basal bed, with layer of thin irregular dark-gray chert nodules 0.4 ft above base, makes a prominent bench which is overlain by 3-ft ledge of similar limestone from 206.2 to 209.2 ft that is composed of 3 indistinct beds; beds between 209.2 and 217.2 ft range from 2 to 3 ft in thickness	217. 2
17. Limestone, medium-dark-gray, fine-grained, bioclastic; dark-gray chert at two levels; top and bottom contacts flat and even	200. 2
Thickness of dolomite member measured	115+
Total thickness of dolomite member (see pl. 5)	564. 0
Crinoidal limestone member:	
*16. Limestone and shale; medium-dark-gray very fine-grained to fine-grained argillaceous shaly platy limestone; interbedded gray calcareous slightly nodular platy shale with thin flat nodular beds of dark-	

Wachsmuth limestone—Continued
Crinoidal limestone member—Continued

	Cumulative thickness above base of section (feet)
gray chert which is concentrated in top 5 ft; crinoids, bryozoans, and brachiopods present; unit makes conspicuous dark band and distinct reentrant on slopes along exposures; bottom contact transitional(?), top contact flat and even	197.0
15. Limestone, medium-dark-gray, coarse-grained; appears slightly argillaceous; about 50 percent crinoid columnals 2–12 mm in diameter	183.0
14. Limestone, light-gray to white, medium-grained; 20–30 percent crinoid ossicles	174.2
13. Limestone and chert; medium-dark-gray irregularly bedded platy shaly seminodular limestone, with slightly irregular bands of dark-gray chert about every 0.5 ft	172.3
12. Limestone, light-gray to white, medium- to coarse-grained; 20–30 percent crinoid ossicles; beds flat, tabular and 0.5–2 ft thick	169.3
*11. Limestone and chert; medium-dark-gray, irregularly bedded platy shaly seminodular limestone, with interbedded dark-gray chert nodules	139.3
10. Limestone, light-gray, fine- to medium-grained, with a few medium-dark-gray chert nodules; tabular beds 0.5–1 ft thick	135.3
* 9. Limestone and chert; light-gray, nodular, and slightly shaly limestone, fine grained at base and becomes medium grained at top; interbedded with elongate irregular nodules of medium-dark-gray chert; *Syringopora*, fenestrate bryozoans, and *Syringothyris*	126.3
* ** 8. Limestone, medium-dark-gray, fine- to medium-grained, bituminous(?), similar to unit 6; beds 1–3 ft thick except from 59.5 to 65.3 ft where beds are 0.4–1 ft thick	122.3
7. Limestone, dark-olive-gray, fine-grained, very nodular and argillaceous; nodules of limestone enclosed by very shaly limestone stringers as in unit 1; limestone that is thin, slabby, light gray, shaly, crinoidal, 0.6–0.7 ft thick, and whose beds are 0.1–0.2 ft thick, occurs from 55.5 to 56.1 ft; bottom and top contacts undulatory	59.5
** 6. Limestone, medium-dark-gray, fine-grained, with solitary corals, crinoids, bryozoans, brachiopods, and trilobites; beds 0.5–2.5 ft thick, with thinner beds in upper part; appears slightly bituminous(?); bottom and top contacts flat	55.5
5. Limestone, medium-dark-gray, fine-grained; beds 0.5–0.8 ft thick	38.0
4. Limestone, medium-dark-gray, fine-grained; ranges in thickness along strike from 2.8 to 4 ft; bottom contact uneven and top contact flat	35.0
3. Limestone, medium-dark-gray, medium-grained, crinoidal; undulatory bedding; ranges from 1.8 to 3 ft in thickness along strike	32.2
* 2. Limestone, medium-dark-gray, medium- to coarse-grained, bioclastic, with about 20 percent comminuted fossil fragments; 2–6 percent crinoid ossicles 3–6 mm in diameter, lens of crinoidal debris ranging laterally from feather edge to 0.3 ft in thickness at 20.3 ft, other crinoidal lenses at 21.6 and 22.6 ft; beds 0.3–2 ft thick; thin beds, 0.2 ft thick, of relatively soft crinoidal debris occur from 23.6 to 25 ft; solitary corals, crinoids, bryozoans, brachiopods, and trilobites; bottom contact undulatory and top contact slightly undulatory	29.2
Thickness of crinoidal limestone member	179.4
Shaly limestone member:	
* ** 1. Limestone, dark-olive-gray, fine-grained, shaly, argillaceous, nodular; nodules as much as 0.4 ft in diameter enclosed by thin limestone beds as much as 0.2 ft thick; caninoid corals and fenestrate bryozoans occur sparingly throughout; upper and lower contacts undulatory and sharp	17.6
Thickness of shaly limestone member	17.6
Thickness of Wachsmuth limestone measured	312+
Total thickness of Wachsmuth limestone (see pl. 5)	1,230±

Disconformity; distinct lithologic and paleontologic break occurs at the base of the shaly limestone member of the Wachsmuth limestone.

Kayak shale: Red limestone member: See stratigraphic section F, a continuation of this section.

UPPER PART, WACHSMUTH LIMESTONE—SECTION I

Part of the crinoidal limestone member, and the dolomite and banded chert-limestone members were measured along a line of traverse across the west slope of Mount Wachsmuth and up the south face of Sugarloaf Hill. The lower part of the crinoidal member is covered by slide-rock. This section together with section H represents the strata in the Wachsmuth limestone at its type locality on Mount Wachsmuth. The relations of these two sections are shown on plate 5. The Alapah limestone disconformably overlies the Wachsmuth limestone near the crest of Sugarloaf Hill.

When this section was originally measured, snow covered the beds on a dip slope between 230 and 348 feet above the base of the Wachsmuth limestone, and these rocks were not examined. In 1950, rock samples were taken from these beds, but the section was not described in detail. Therefore, descriptions of unit 13 in this section are prepared from these samples.

Section along the west slope of Mount Wachsmuth and up the south face of Sugarloaf Hill at lat 68°19'20'' N., long 150°55'15'' W. (approximate)

[Measured with tape and hand level by the authors and O. J. Gudim in 1949. Graphic section, pl. 5; location, pl. 2. Datum is base of Wachsmuth limestone as established in section H]

Cumulative thickness above datum (feet)

Alapah limestone: Shaly limestone member: See stratigraphic section J, a continuation of this section.
Disconformity.
Wachsmuth limestone:
Banded chert-limestone member:

* **149. Limestone, light- to medium-gray, medium- to coarse-grained, bioclastic; beds 1.1–4 ft thick	1, 230. 0
**148. Limestone and chert; brownish-gray very fine grained argillaceous platy limestone, with many irregular, ragged masses of black chert scattered throughout. Forms conspicuous ledge	1, 217. 6
147. Limestone, medium-gray, medium-grained, bioclastic	1, 211. 6
146. Limestone and chert; medium-dark-gray, fine- to medium-grained bioclastic limestone, with a few crinoid columnals, and thin-bedded light-gray to medium-dark-gray laminated chert in lower part, grading upward to interbedded irregular, ragged black chert nodules in upper part. Forms conspicuous ledge	1, 209. 1
145. Limestone and chert; medium-dark-gray fine-grained argillaceous irregularly bedded limestone in rather massive beds 0.5–1 ft thick; nodular beds and nodules of black chert as much as 0.5 ft thick	1, 204. 1
144. Limestone, medium-light-gray, coarse-grained, bioclastic	1, 181. 2
143. Limestone, medium-dark-gray, fine-grained	1, 180. 2
142. Limestone and chert; medium-dark-gray very fine grained dense bioclastic irregularly bedded limestone, in beds ranging from 0.5 to 0.8 ft in thickness, with interbedded nodules and nodular beds of grayish-black to black chert 0.5–0.8 ft thick	1, 178. 2
141. Limestone, medium-dark-gray, very fine grained, dense, bioclastic, with abundant comminuted fossil fragments	1, 174. 5
140. Limestone and chert; medium-dark-gray fine- to medium-grained argillaceous bioclastic irregularly bedded limestone, interbedded with medium-gray to dark-gray nodular porous chert beds or chert nodules that constitute 80 percent of unit	1, 172. 6
139. Limestone, dark-gray, fine-grained, slightly argillaceous, bioclastic; beds 0.5–2 ft thick	1, 161. 6
138. Limestone, medium-light-gray, fine-grained, bioclastic, with light-gray nodules and nodular chert beds 0.1–0.3 ft thick	1, 141. 6

Wachsmuth limestone—Continued
Banded chert-limestone member—Continued

Cumulative thickness above datum (feet)

137. Limestone, medium-light-gray, fine- to medium-grained, bioclastic; weathers brownish gray; beds 1–3 ft thick, with alternating thick and thin beds. Forms top of third main cliff on south face of Sugarloaf Hill	1, 139. 6
**136. Limestone and chert; dark-gray fine-grained limestone similar to unit 135, with interbedded irregular, ragged grayish-black chert nodules that differ from the nodular chert beds in the unit immediately below; chert in this unit weathers mottled light olive gray and dark gray	1, 106. 6
135. Limestone and chert; dark-gray to grayish-black fine-grained limestone, with abundant interbedded laminated light-gray to grayish-black chert nodules and nodular chert beds. Forms base of third main cliff at top of south face of Sugarloaf Hill	1, 060. 9
*134. Limestone, medium-light-brownish-gray, medium-grained, thin-bedded, argillaceous, relatively unfossilferous; beds 0.1–1 ft thick. Forms receding slope beneath third main cliff at top of south face of Sugarloaf Hill	1, 052. 9
133. Limestone, medium-light-gray, medium-grained, bioclastic	1, 013. 9
132. Limestone and chert; medium-gray fine-grained bioclastic limestone in thin, platy beds 0.1–0.3 ft thick, interbedded with dark-gray to black nodular chert beds which compose over 50 percent of unit	1, 010. 9
131. Limestone and chert; medium-gray medium-grained bioclastic limestone beds 1–1.5 ft thick, with beds of laminated white and medium-gray chert, 0.3–0.6 ft thick; chert beds thicken and thin along outcrop and weather to brownish and chalky-white bands; limestone beds thinner and chert beds more abundant toward top	997. 9
*130. Limestone, medium-gray, medium-grained to very coarse grained, bioclastic; weathers medium dark gray; irregular beds 0.1–1.2 ft thick	979. 4
129. Limestone, medium-gray, medium-grained, bioclastic, with interbedded nodules and nodular beds of laminated light-gray and dark-gray chert	962. 4
128. Limestone, medium-light-gray, coarse-grained, massive	960. 3
127. Chert, laminated, light- to dark-gray	959. 2
*126. Limestone, medium-light-gray, coarse-grained, massive	958. 4
*125. Limestone, medium-light-gray, medium-grained; thin, irregular beds 0.1–0.3 ft thick	956. 4

Wachsmuth limestone—Continued
Banded chert-limestone member—Continued

Cumulative thickness above datum (feet)

124. Limestone and chert; medium-gray medium-grained bioclastic limestone that weathers to a light-gray pitted surface, in beds 0.1–0.8 ft thick, and laminated light-gray and dark-gray chert in fairly well-developed nodular beds 0.1–0.3 ft thick; conspicuous laminated chert nodules; some very nodular beds pinch out laterally. Top of unit forms top of second main cliff on south face of Sugarloaf Hill 951. 4

123. Limestone and chert; nodular laminated dark-gray and light-gray chert almost completely replacing bed of medium-light-gray medium-grained limestone 927. 4

122. Limestone, medium-light-gray, medium-grained, light-gray-weathering, with nodules of laminated light-gray and dark-gray finely crystalline dolomite 926. 6

* **121. Limestone, medium-light-gray, medium-grained; weathers light gray; 2 tabular beds, 3.9 and 1.7 ft thick 921. 6

120. Limestone, medium-light-gray, medium-grained, light-gray-weathering, with thin, lenticular beds and nodules of brown to dark-gray laminated chert; chert beds range from less than 0.1 to 0.4 ft in thickness 916. 0

119. Limestone, medium-light-gray, medium-grained, weathers light gray; tabular beds 0.7–3 ft thick; medium- to coarse-grained beds from 909.7 to 912.7 ft 914. 9

118. Limestone, brownish-gray, medium-grained, bioclastic; beds 0.8–1.7 ft thick; interbedded with undulatory nodular beds of dark-gray to black semilithographic limestone, more abundant from 883.7 to 896 ft than in upper part; semilithographic limestone beds weather reddish brown and dark gray, look like weathered chert, and are 0.3–0.8 ft thick; bedding inconspicuous. Unit forms massive conspicuous cliff 905. 7

**117. Limestone, medium-gray, fine-grained, bioclastic, with interbedded undulatory more resistant nodular beds of dark-gray very fine grained limestone; fine-grained limestone beds weather more readily than the very fine grained ones, which stand out conspicuously on outcrop face and look like chert; it is difficult to distinguish between the two types on freshly broken surfaces, but chert is found mainly in very fine grained beds which range from less than 0.1 to 0.5 ft in thickness; fine-grained beds range from 0.7 to 1 ft in thickness; this is lowest occurrence of this type of rock, although chert in unit 107 from 776.7 to 789.6 ft is replacement of very fine grained nodules and nodular limestone beds; some of the very fine grained beds are composed largely of comminuted fossil material 883. 7

Wachsmuth limestone—Continued
Banded chert-limestone member—Continued

Cumulative thickness above datum (feet)

* **116. Limestone, medium-light-gray, with dolomitic light-brown chert beds 0.1–0.4 ft thick at 867.4, 868.8, 871.4, 875.3, and 875.7 ft; fine grained at base, becoming coarse grained at top; chert bands less nodular than in underlying units; light-brown chert weathers medium dark gray to light brown in upper part 877. 2

115. Limestone and chert; medium-light-gray fine- to medium-grained limestone, with chert, as in upper part of unit 114, but beds more massive and 0.6–1.4 ft thick; beds more massive in upper part 867. 4

114. Limestone and chert; medium-light-gray fine- to medium-grained limestone in tabular beds 0.5–1 ft thick, with abundant nodular chert beds 0.1–0.4 ft thick; medium-dark-gray chert nodules in lower part; some chert beds show light-gray and medium-dark-gray laminations; light-brownish-gray to dark-gray laminated fossilocastic chert nodules near top 860. 0

113. Limestone and chert; medium-light-gray fine- to medium-grained massive limestone, with abundant dark-gray nodular chert beds 0.1–0.3 ft thick. Massive unit forms prominent ledge at base of second main cliff on south end of Sugarloaf Hill 855. 4

* **112. Dolomite, dark-gray, medium-grained; massive beds 1–3 ft thick. Unit forms receding slope below second main cliff on south side of Sugarloaf Hill 851. 7

**111. Limestone and chert; medium-dark-gray fine-grained argillaceous thin-bedded limestone; irregular beds 0.1–0.5 ft thick; heavily silicified limestone or chert nodules irregularly distributed throughout; nodules range from light gray to black, some with light-gray to black laminations; thin lenticular zones of dark-gray shaly limestone at a few levels 826. 7

110. Limestone, medium-gray, medium- to coarse-grained, thin-bedded, platy, bioclastic 804. 7

Thickness of banded chert-limestone member 428. 9

Dolomite member:

*109. Limestone, light-gray, coarse-grained, bioclastic 801. 1

* **108. Limestone, medium-gray, fine-grained, slightly argillaceous, bioclastic; weathers light gray; thin, slightly irregular beds 0.1–0.3 ft thick 798. 6

**107. Limestone and chert; medium-gray medium-grained bioclastic limestone in tabular thin beds 0.1–0.3 ft thick near base and 0.2–0.4 ft thick in upper part, with ragged chert nodules roughly arranged in bands as in units 98 and 99; finely lami-

Wachsmuth limestone—Continued
Dolomite member—Continued

Cumulative thickness above datum (feet)

nated dark- and light-gray chert bands in lower part, with chert more abundant and not so conspicuously laminated above 783 ft; chert predominates from 786.6 to 789.6 ft and zone superficially appears to be chert breccia ---- 794. 6

**106. Limestone, medium-gray, medium- to coarse-grained, platy, bioclastic; thin undulatory beds 0.2–0.5 ft thick from 746.2 to 753.9 ft, and 0.6–1.2 ft thick from 753.9 to 760.1 ft; beds in upper part more massive ---- 760. 1

**105. Limestone and chert; medium-dark-gray fine-grained thin-bedded limestone of specularitic appearance, with abundant prominent black chert nodules concentrated in upper part of unit; nodules more rounded than in unit 98. Unit forms prominent ledge at top of cliff ---- 746. 2

**104. Dolomite, medium-gray, coarse-grained, bioclastic; massive beds with a black chert bed 0.1–0.3 ft thick along bedding plane at 731 ft ---- 736. 1

103. Limestone and chert; medium-gray fine-grained bioclastic limestone, with black chert nodules arranged roughly in bands. Forms massive ledge ---- 730. 3

* **102. Limestone, light-gray, coarse-grained, massive, bioclastic; top bed, from 724.6 to 726 ft, is very coarse grained, with abundant crinoid columnals throughout; *Echinoconchus* at base; beds 1.4–1.6 ft thick ---- 726. 0

*101. Limestone, medium-light-gray to brownish-gray, medium-grained, slightly argillaceous, bioclastic; 2 beds, 0.5 and 0.9 ft thick ---- 721. 5

* **100. Limestone and chert; medium-dark thin-bedded platy fine-grained argillaceous bioclastic limestone of specularitic appearance, with abundant very ragged chert nodules arranged roughly in bands; similar to unit 98, but with more massive beds and less chert ---- 720. 1

99. Limestone and chert; medium-dark-gray fine-grained argillaceous bioclastic limestone; single bed, more massive than those in unit 98 and with less chert, quite distinct from underlying limestones; *Syringopora* common ---- 711. 5

* ** 98. Limestone and chert; medium-dark-gray fine-grained thin-bedded platy argillaceous bioclastic limestone of specularitic appearance, interbedded with abundant very ragged black chert nodules arranged roughly in bands; chert nodules seem to be secondary and contain molds of crinoid columnals. Unit forms well-defined cliff ---- 710. 0

** 97. Limestone, medium-gray, coarse-grained, bioclastic; weathers to pitted surface and is recessed beneath massive overhanging cliff made by unit 98; 3 massive dolomitic limestone beds from 687.3 to 689.4 ft, 690.2 to 693.8 ft, and 694.8 to 697 ft; thin limestone beds, 0.1–0.3 ft thick, from 689.4 to 690.2 ft and from 693.8 to 694.8 ft ---- 697. 0

96. Limestone and chert; medium-dark-gray medium-grained limestone similar to unit 95 but with fewer light- and dark-gray chert nodules ---- 687. 3

** 95. Limestone and chert; medium-dark-gray fine- to medium-grained irregularly bedded dolomitic(?) platy limestone; specularitic appearance; fine-grained beds at base grade upward to medium grained at top; beds appear to be crosslaminated and are 0.3–0.7 ft thick; medium-light-gray elliptical chert nodules throughout that bear no relation to bedding; medium-gray fine-grained basal bed from 677 ft to 677.7 ft. Unit forms massive ledge ---- 683. 3

94. Dolomite, light- to medium-gray, fine- to medium-grained, bioclastic ---- 677. 0

** 93. Limestone, light- to medium-gray, coarse-grained, bioclastic, dolomitic; 10 percent crinoid columnals, fragments of brachiopods, and large solitary corals; 2 beds, 0.8 and 0.9 ft thick ---- 673. 0

** 92. Dolomite, light- to medium-gray, medium-grained; beds 0.9–2 ft thick; grain size slightly greater than that of dolomite in unit 89; numerous coarsely crystalline calcite veins ---- 671. 3

* ** 91. Limestone, medium-dark- to dark-gray, fine-grained, argillaceous, irregular, thin-bedded; appears to be crosslaminated; basal beds have specularitic appearance caused by many small calcite crystal faces; elliptical white chert nodules contain fenestrate bryozoans; beds 0.2–0.6 ft thick; relatively soft where weathered ---- 664. 7

** 90. Dolomite, light- to medium-gray, medium-grained; beds 0.9–2.7 ft thick ---- 658. 8

** 89. Dolomite, light- to medium-gray, medium-grained, massive; beds 0.8–2.7 ft thick. Unit forms conspicuous ledge ---- 653. 4

88. Limestone, medium-gray (*N* 5) to brownish-gray (5*YR* 4/1), medium- to coarse-grained, bioclastic, soft; weathers readily ---- 646. 5

** 87. Dolomite, medium-gray (*N* 5) to brownish-gray (5*YR* 4/1), fine-grained, argillaceous, porous; vugs partly filled with secondary calcite ---- 645. 2

86. Limestone, light-gray (*N* 7 to *N* 8), medium-grained, bioclastic(?) ---- 641. 2

** 85. Dolomite, light-gray (*N* 7 to *N* 8), medium-crystalline ---- 640. 5

** 84. Dolomite, light-gray, medium-crystalline, massive; bed forms ledge ---- 635. 4

83. Limestone, light-gray (*N* 7 to *N* 8), fine-grained; thin, irregular beds ---- 629. 5

** 82. Limestone, light-gray (*N* 7 to *N* 8), medium-grained, bioclastic; thin, slightly irregular beds ---- 629. 1

Wachsmuth limestone—Continued
Dolomite member—Continued

Cumulative thickness above datum (feet)

** 81. Dolomite, light-gray (*N* 7 to *N* 8), weathers light gray; medium crystalline. One massive, conspicuous bed from 596.1 to 598 ft ---- 628. 5

80. Dolomite or dolomitic limestone, light-gray (*N* 7 to *N* 8), medium-crystalline, thin-bedded; weathers medium light gray ---- 620. 5

** 79. Dolomite, light-gray (*N* 7 to *N* 8), medium-crystalline; weathers medium light gray. Bed weathers to rounded and knobby surface ---- 619. 4

** 78. Dolomite or dolomitic limestone, light-gray (*N* 7 to *N* 8), medium-grained, bioclastic; weathers medium light gray; thin nodular beds 0.4–0.7 ft thick ---- 614. 6

77. Dolomite or dolomitic limestone, light-gray (*N* 7 to *N* 8), medium-grained, bioclastic; weathers medium light gray. Softer and less resistant to weathering than units 47 to 76 ---- 611. 6

** 76. Dolomite or dolomitic limestone, light-gray (*N* 7 to *N* 8), medium-grained, bioclastic; weathers medium light gray; irregular or wavy bedded, almost laminated; beds 0.1–2.3 ft thick ---- 609. 3

** 75. Dolomite, light-gray (*N* 7 to *N* 8), medium-crystalline; weathers medium light gray, with pitted, honeycombed surface; some fossil fragments; indistinct bedding planes at 598.3, 601.5, 602.4, and 603.2 ft. Unit forms massive ledge ---- 603. 6

** 74. Dolomite, similar to unit 75; massive bed from 592.3 to 595.8 ft which is thin bedded in top 0.7 ft; poorly developed beds from 595.8 to 596.7 are 0.1–0.2 ft thick ---- 596. 7

** 73. Dolomite, similar to unit 75; more finely crystalline than dolomite in unit 71; beds 1.0–3.3 ft thick; forms distinct ledge; *Syringopora* in talus at 589.8 ft ---- 589. 8

** 72. Dolomite, similar to unit 75, with faint irregular laminae; more finely crystalline in upper part; vuggy, very porous; beds 0.8–1.9 ft thick ---- 580. 3

** 71. Dolomite, similar to unit 75, with faint irregular laminae throughout; beds 0.6–2.1 ft thick. Forms ledge ---- 573. 7

70. Chert, laminated white and light-gray, dolomitic ---- 566. 3

69. Limestone, medium-gray, fine- to medium-grained; irregular thin beds ---- 566. 1

68. Chert, laminated white and light-gray, dolomitic ---- 565. 2

67. Limestone, medium-gray, medium-grained, bioclastic, dolomitic(?) ---- 564. 9

** 66. Chert, laminated white and dark gray in lower part, laminated white and light gray in upper part; bed 0.7–0.9 ft thick ---- 564. 5

65. Limestone, light-gray, medium-grained, bioclastic, dolomitic(?) ---- 563. 7

64. Chert and limestone; two nodular beds of grayish-black chert separated by thin irregular bed of mottled medium-light-gray to medium-gray, medium- to coarse-grained, argillaceous granular limestone ---- 563. 3

63. Limestone, mottled medium-light-gray to medium-gray, medium- to coarse-grained, argillaceous to clean bioclastic ---- 562. 8

** 62. Chert and limestone; laminated light-gray to medium-dark-gray microcrystalline chert, with thin interbedded layers of light-gray fine-grained dolomitic(?) limestone; chert predominates ---- 561. 3

61. Limestone, light-gray, fine- to medium-grained, bioclastic; irregular thin beds ---- 559. 8

60. Limestone and chert; olive-gray (5*Y* 4/1) medium-grained nodular limestone, with nodular beds of dark-gray chert ---- 556. 0

59. Limestone, olive-gray (5*Y* 4/1), medium-grained, bioclastic ---- 553. 6

** 58. Chert and limestone; laminated grayish-black (*N* 2) and light-gray (*N* 7) fine-grained dolomitic(?) chert, with thin lenses of light-olive-gray (5*Y* 6/2) fine-grained bioclastic limestone ---- 552. 1

** 57. Limestone, olive-gray (5*Y* 4/1), fine-grained, bioclastic ---- 550. 8

56. Chert, black, dense, vitreous, nodular ---- 550. 2

55. Limestone, light-gray, medium- to coarse-grained, bioclastic ---- 549. 9

** 54. Limestone, light-gray, medium-grained, nodular, with black chert nodules ---- 549. 4

53. Dolomite, thin white and black laminations, fine-grained, hard, silicified, with thin lenticular bands of black chert; thin lentil of medium-grained bioclastic limestone in middle of bed ---- 548. 4

52. Limestone, dark-gray, fine- to medium-grained, granular, bioclastic ---- 547. 5

51. Dolomite, thin white and black laminations, fine-grained, hard, silicified ---- 547. 1

50. Limestone, dark-gray, fine- to medium-grained, granular, bioclastic ---- 546. 7

* ** 49. Limestone, very-light-gray, medium- to coarse-grained, bioclastic ---- 546. 4

48. Covered; limestone or dolomite beds ---- 531. 8

47. Limestone, dark-brownish-gray, fine-grained, shaly, argillaceous ---- 508. 7

** 46. Limestone, dark-brownish-gray, fine-grained, platy, argillaceous, interbedded with thin layers of dark-gray porcelaneous chert ---- 505. 7

** 45. Shale, dark-gray, clay-size particles, fissile, with interbedded dark-gray porcelaneous silicified claystone or chert ---- 498. 4

44. Shale, dark-gray, clay-size particles, fissile; very siliceous from 494.2 to 494.8 ft. Forms resistant bed ---- 495. 1

43. Limestone, dark-gray, fine-grained, hard, siliceous, argillaceous(?) ---- 494. 2

42. Shale, dark-gray, clay-size particles, fissile. Very siliceous basal 0.2 ft forms resistant ledge ---- 493. 9

Wachsmuth limestone—Continued
Dolomite member—Continued

Cumulative thickness above datum (feet)

** 41. Limestone, dark-gray, medium- to coarse-grained, bioclastic — 493.0

** 40. Limestone, dark-gray, fine-grained, dolomitic, with large concentrically banded round chert concretions 0.6–1.4 ft in diameter; becomes shaly in top 0.8 ft; concretions, probably secondary, composed of porous chert and dark-gray dolomitic limestone in alternating layers 5–20 mm thick. Top surface of bed may represent intraformational unconformity or disconformity — 492.8

** 39. Limestone, light-gray, medium- to coarse-grained, dolomitic, bioclastic, with dark-gray chert nodules — 489.8

38. Dolomite, dark-gray, fine-grained, siliceous; irregular laminae; dark-gray chert nodules — 482.8

** 37. Shale, dark-gray, clay-size particles, highly calcareous, hard, flaky, with interbedded dark-gray fine-grained very argillaceous slightly laminated dolomite — 476.5

36. Dolomite, dark-gray, fine-grained, massive; very thin laminae, very argillaceous — 475.4

** 35. Shale, dark-gray, clay-size particles, highly calcareous, hard, flaky, with interbedded lenticular dark-gray fine-grained siliceous(?) dolomite beds 0.1–0.7 ft thick — 474.3

34. Limestone and chert; dark-gray limestone almost completely replaced by dark-gray chert; unit is composed of irregular chert nodules and may represent residual-chert zone at an intraformational break — 463.3

33. Limestone, dark-brown, fine- to medium-grained, bioclastic, with irregular bedding — 461.3

** 32. Limestone, medium-dark-brownish-gray, medium- to coarse-grained, petroliferous(?) — 458.3

** 31. Dolomite, dark-gray, fine-grained; very thin, irregular shaly beds 0.2–0.4 ft thick; dark- and light-gray laminae; very siliceous; a few interbedded stringers of dark-gray fine-grained argillaceous limestone 11–40 mm thick — 452.1

** 30. Limestone, medium-dark-gray, medium-grained, crinoidal, bioclastic, with biohermal bedding — 446.1

** 29. Limestone, medium-dark-gray, medium-grained, slightly crinoidal, bioclastic; irregular beds 0.7–3 ft thick; freshly broken pieces give strong odor of petroleum(?) — 444.7

** 28. Limestone, medium-brownish-gray, medium- to coarse-grained, crinoidal, bioclastic; freshly broken pieces give very strong odor of petroleum(?); basal nodular dark-gray chert bed 0.3–0.7 ft thick at 426.6 ft, a second chert bed 0.9–1 ft thick at 428.7 ft — 430.1

** 27. Limestone, light-brownish-gray, medium-grained, bioclastic; freshly broken pieces give strong odor of petroleum(?) — 426.6

Wachsmuth limestone—Continued
Dolomite member—Continued

Cumulative thickness above datum (feet)

* ** 26. Limestone, medium-dark-gray, fine-grained, petroliferous(?); massive but with distinctly irregular bedding; much dark-gray nodular chert along bedding and within beds — 422.1

25. Limestone, medium-dark-gray, fine-grained, very nodular — 413.1

* ** 24. Limestone, similar to unit 26; chert nodules sparse from 407.3 to 408 ft — 411.1

** 23. Limestone, medium-dark-gray, fine-grained, massive; uneven basal contact, flat upper contact — 405.1

** 22. Limestone, medium-dark-gray, fine-grained, nodular, thin-bedded, shaly, petroliferous(?), argillaceous, with many dark-gray chert nodules — 402.1

21. Limestone, medium-dark-gray, fine-grained, shaly — 396.1

** 20. Limestone, medium-dark-gray, fine-grained, petroliferous(?), bioclastic; overlain by 0.2-ft-thick bed of dark-gray slightly nodular chert — 395.6

** 19. Limestone, light-gray to medium-dark-gray, medium- to coarse-grained, bioclastic; 30–50 percent crinoid columnals — 394.5

** 18. Limestone, dark-gray, fine-grained, shaly, argillaceous(?), petroliferous(?); beds 7–20 mm thick — 383.0

** 17. Limestone, light-gray, medium-grained, bioclastic; irregular bedding in basal part — 382.0

** 16. Limestone, dark-gray, fine-grained, very argillaceous, with interbedded dark-gray to black nodular fossilocastic vuggy chert; bedding irregular; weathers to dark band along outcrop — 377.7

15. Covered; limestone or dolomite beds — 367.7

** 14. Limestone and dolomite, light-gray, medium-grained, bioclastic; nodular black chert band at 345.5 ft; bed of shaly limestone from 348.5 to 349 ft — 350.7

13. Limestone and dolomite; descriptions are of samples taken from this unit in 1950 (see page 18) — 333.5

**Limestone, slightly dolomitic, light-gray, medium- to coarse-grained, bioclastic, with coarse grains of crinoidal fragments — at 326.0

**Limestone, slightly dolomitic, very-light-gray, medium- to coarse-grained, bioclastic, crinoidal, soft and crumbly — at 321.0

**Limestone, light-gray, somewhat dolomitic, coarse-grained, poorly sorted, bioclastic, crinoidal, with many large vugs — at 315.0

**Limestone, similar to that at 315 ft — at 310.0

**Limestone, similar to that at 315 ft — at 305.0

**Limestone, dolomitic, light-gray, medium- to coarse-grained, well-sorted, bioclastic, with a few large

Wachsmuth limestone—Continued
Dolomite member—Continued

	Cumulative thickness above datum (feet)
crinoid fragments and large veins of calcite	at 301.0
**Dolomite, light-gray, medium-grained, similar to that at 265 ft	at 300.0
**Limestone, dolomitic, light-gray, coarse-grained, bioclastic; grades in hand specimen to medium-gray fine grained saccaroidal dolomite	at 295.0
**Dolomite, light-gray, medium-grained, bioclastic, with thin lenses and zones of large crinoid fragments; crinoidal lenses are predominantly limestone	at 290.0
**Limestone, very dolomitic, light-gray, medium-grained, poorly sorted; bioclastic, crinoidal; with *Platycrinites*	at 285.0
**Limestone, similar to that at 285 ft, but coarse grained	at 280.0
**Limestone, similar to that at 280 ft	at 275.0
**Dolomite, very-light-gray, coarse-grained, poorly sorted, with medium-grained saccaroidal matrix enclosing coarse grains and large fragments of fossils; many small vugs	at 270.0
**Dolomite, light-gray, medium-grained, with irregular dark patches of bituminous(?) organic material; saccaroidal, even-grained	at 265.0
**Dolomite, very-light-gray, medium- to coarse-grained, compact, saccaroidal, even-grained; a few fossil fragments	at 260.0
**Dolomite, yellowish-gray, medium-grained, with numerous large vugs	at 255.0
**Dolomite, light-brownish-gray, medium-grained, with few fossil fragments; saccaroidal, even grained	at 250.0
**Dolomite, light-gray, fine-grained, compact, with few fossil fragments	at 245.0
** 12. Dolomite, dark-gray, medium-grained, massive, bioclastic	240.5
Thickness of dolomite member	564.6

Crinoidal limestone member (incomplete):

	Cumulative thickness above datum (feet)
* 11. Limestone, dark-gray, fine-grained, argillaceous, dolomitic, thin-bedded, platy, with interbedded nodular black chert beds	236.5
10. Limestone, medium-dark-gray, medium-grained, bioclastic, dolomitic	232.8

Wachsmuth limestone—Continued
Crinoidal limestone member—Continued

	Cumulative thickness above datum (feet)
* ** 9. Limestone, dark-gray, fine-grained, argillaceous, thin-bedded, platy, with interbedded nodular black chert beds	231.2
** 8. Limestone, light-gray, medium- to coarse-grained, bioclastic	222.5
** 7. Limestone, medium-dark-gray, medium-grained, with dark-gray chert nodules; thin and irregular beds	209.5
* ** 6. Limestone, medium-dark-gray, medium-grained, thin-bedded, slightly shaly, bioclastic	203.5
* 5. Limestone, dark-gray, medium-grained, bituminous(?), bioclastic; massive, but with indistinct beds averaging 1.5 ft in thickness	188.5
* 4. Limestone, light-gray, medium-grained, bioclastic, with thin irregular lenses of coarse-grained crinoidal limestone between more massive beds	172.5
* ** 3. Limestone, medium-dark-gray, seminodular, shaly; no chert in lower 3 feet of unit; dark-gray chert nodules abundant from 144.5 to 148 ft; irregular beds of medium-dark-gray medium-grained bioclastic limestone at 143.8 and 148.4 ft; upper bioclastic bed 0.5–0.8 ft thick; elongate *Pentremites, Platycrinites, Dichocrinus,* fenestrate bryozoans and *Spirifer* common	149.5
** 2. Limestone, light-gray, fine- to medium-grained, with minor amount of medium-dark-gray chert nodules; tabular beds 1–2.5 ft thick	141.3
* ** 1. Limestone, light-gray, fine-grained, nodular, shaly, interbedded with elongate, irregular nodules of medium-dark-gray chert; similar to unit 9 of stratigraphic section H, which was measured one-half mile east on the south face of Mount Wachsmuth; the strata below unit 9 of section H are similar to those below unit 1 of this section. Strata shown in section H and this section overlap and correlation of the two is shown on pl. 5. This unit is 4 ft thick	126.3
Thickness of crinoidal limestone member measured	114.2
Total thickness of crinoidal limestone member (see pl. 5)	218.9
Thickness of Wachsmuth limestone measured	994±
Total thickness of Wachsmuth limestone (see pl. 5)	1,230±

ALAPAH LIMESTONE

The northern part of Mount Wachsmuth, the type locality of the Alapah limestone, is composed entirely of this formation. The slope of the north side of Sugarloaf Hill is steeper than the dip of the strata; for this reason there is an interruption of the section by the creek valley north of Sugarloaf Hill, although a continuous section of Alapah limestone is present. A section along a single line of traverse across the top of Sugarloaf Hill was carried to the uppermost beds in the section on the hill (section J). Another section (section K), along a line of traverse starting at creek level north of Sugarloaf Hill, contains beds that are stratigraphically below the top of section J. This traverse was carried up and over the North Ridge and down the dip slope to the uppermost exposed beds of the Alapah limestone (pl. 1). The limestone near the top of the formation is covered by glacial gravel and alluvium.

The relations between sections K and J are shown on plate 6. These two sections together are a detailed description of the Alapah limestone at its type locality.

LOWER PART, ALAPAH LIMESTONE—SECTION J

The lower part of the Alapah limestone includes the shaly limestone member, the dark limestone member, the platy limestone member, and part of the banded limestone member. The shaly limestone member disconformably overlies the Wachsmuth limestone at the type locality on Sugarloaf Hill and Mount Wachsmuth. The disconformity is not conspicuous. The basal shaly and cherty limestone beds of the formation lie over slight irregularities on the top of the Wachsmuth limestone. As much as 6 feet of strata in the top of the Wachsmuth limestone is truncated beneath the disconformity within a few hundred feet along the strike. Fossils in the upper foot of the Wachsmuth limestone are silicified. Elliptical chert nodules, as large as 1 foot long and 0.4 foot in diameter, lie at the contact and may be residual cobbles or boulders. Lithostrotionoid corals occur as cobbles; some are preserved in a position of growth in the base of the Alapah at the contact. In places the top 0.4 foot of the underlying limestone contains a heavy concentration of comminuted fossil fragments. In other places the top surface of the Wachsmuth limestone is covered with a shingle pavement of broken shells, fish teeth, and phosphate pebbles.

This section, a continuation of section I, starts at the south crest of Sugarloaf Hill and ends with the youngest bed exposed at the north end of Sugarloaf Hill.

Section on ridge top of Sugarloaf Hill, west slope of Mount Wachsmuth, at lat 68°19'40''N., long 150°55'15''W. (approximate)

[Measured with tape and hand level by the authors and C. J. Gudim in 1949. Graphic section, pl. 6; location, pl. 2]

	Cumulative thickness above base of section (feet)
Alapah limestone:	
Banded limestone member (incomplete; see correlated stratigraphic section K):	
117. Limestone, medium-gray to medium-dark-gray, fine-grained; nodular beds 0.1–0.6 ft thick. This unit includes the highest beds exposed on Sugarloaf Hill	503. 5
116. Limestone, brownish-gray, medium-grained, bioclastic, with somewhat nodular beds of medium-gray fine-grained limestone from 493.2 to 493.7 ft, 494.2 to 494.4 ft, and 495.1 to 495.9 ft	495. 9
115. Limestone, brownish-gray, medium-grained, nodular, bioclastic, interbedded with medium-gray fine-grained nodular dense limestone; beds 0.4–0.6 ft thick	493. 2
**114. Limestone, light-brownish-gray, coarse-grained, irregularly bedded; beds 0.4–0.7 ft thick; similar to bed 36 of section K	490. 1
113. Limestone, light-brownish-gray, medium-grained; tabular beds 1.2–1.8 ft thick, interbedded with light-brownish-gray very fine grained dense nodular limestone beds 0.4–1 ft thick; this is an alternating sequence of medium-grained and more resistant fine-grained limestone beds, which stand out on weathered surfaces. Unit forms conspicuous ledge	487. 7
112. Limestone, brownish-gray, medium-grained, bioclastic, with crinoid columnals; 1 bed of medium-gray very fine grained nodular limestone from 468.3 to 468.7 ft which ranges from a feather edge to 0.5 ft in thickness	470. 8
*111. Limestone, medium-gray, fine-grained, nodular; beds 0.6–1.3 ft thick	468. 0
110. Limestone, medium-gray, medium-grained, bioclastic, containing single bed of medium-gray very fine grained nodular dense limestone 0.3–0.7 ft thick in middle part	464. 2
109. Limestone, medium-gray, medium-grained, bioclastic; beds 0.5–1.1 ft thick, with nodular beds of medium-gray very fine grained dense limestone 0.2–0.5 ft thick; very fine grained beds tend to be silicified. Unit forms distinct ledge	461. 1
108. Limestone, medium-gray, fine-grained, nodular, bioclastic, with sparse crinoid ossicles; beds 0.4–0.8 ft thick, interbedded with nodular beds of medium-gray very fine grained dense limestone 0.1–0.4 ft thick; base of unit similar to base of unit 28, section K. Unit forms conspicuous ledge	456. 7

Cumulative thickness above base of section (feet)

Alapah limestone—Continued

Banded limestone member (incomplete; see correlated stratigraphic section K)—Continued

**107. Limestone, light-brownish-gray, fine-grained, with interbedded nodular beds and nodules of grayish-black fine-grained limestone; dark nodular limestone beds 0.1–0.5 ft thick ---------- 453. 0

* **106. Limestone, light-brownish-gray, fine-grained, bioclastic; beds 0.4–0.6 ft thick, interbedded with grayish-black fine-grained bioclastic limestone in beds ranging from feather edge to 0.3 ft in thickness; basal part of unit is similar to basal part of unit 26 at 446.2 ft in section K. Unit forms conspicuous ledge ------ 448. 6

Thickness of banded limestone member measured ---------- 57. 3

Total thickness of banded limestone member (see pl. 6) ------ 209. 9

Platy limestone member:

* **105. Limestone, brownish black at base grading to light brownish gray at top; medium grained from 435.4 to 437.4 ft, grading upward to coarse grained from 437.4 to 442.1 ft, and becoming fine grained from 442.1 to 446.2 ft; bioclastic, with many crinoid columnals; numerous nodular beds and bands of nodular grayish-black dense chert (see pl. 6 for position in unit); large solitary corals common ---------- 446. 2

104. Chert, dense, grayish-black, nodular; beds 0.1–0.3 ft thick ---------- 435. 4

103. Limestone, brownish-black, fine-grained, massive, with rough weathered surface, which is brownish gray ---------- 434. 9

102. Covered; beds are chert and limestone (see correlated section K, units 8 to 20) ----- 433. 8

101. Limestone, light-brownish-gray to medium-gray, mottled, medium-grained, massive - 398. 2

100. Chert, light-gray, dense, irregularly bedded, nodular; appears somewhat calcareous; 2.3–3.6 ft thick; individual elliptical chert nodules as much as 0.5 ft thick; similar to bed 6, section K. Forms conspicuous ledge ---------- 397. 3

99. Limestone, light-brownish-gray, medium- to coarse-grained, massive; weathers brownish gray ---------- 393. 8

98. Chert, medium-gray to dark-gray, mottled, nodular, dense; bed 0.3–0.8 ft thick ----- 391. 3

97. Limestone, light-brownish-gray, medium- to coarse-grained, massive ---------- 391. 0

96. Limestone, light-brownish-gray, medium-grained; very irregular platy beds range from less than 0.1 to 0.5 ft in thickness -- 387. 9

95. Limestone, light-brownish-gray, medium- to coarse-grained; irregular, platy beds 0.3–1.2 ft thick; shaly partings within beds only a few millimeters apart ------ 383. 2

* 94. Limestone, pale-yellowish-brown, fine- to coarse-grained, dense; beds 0.4–0.5 ft thick at base, 0.1–0.2 ft at top ---------- 377. 1

Cumulative thickness above base of section (feet)

Alapah limestone—Continued

Platy limestone member—Continued

93. Limestone, pale-yellowish-brown, coarse-grained, bioclastic, with *Sulcoretepora*, *Batostomella*, and *Dictyoclostus;* irregular beds 0.1–0.3 ft thick ---------- 373. 7

** 92. Limestone, pale-yellowish-brown (10*YR* 6/2), fine- to medium-grained, bioclastic, with *Batostomella;* more dense than unit 91; 0.3–0.6 ft thick ---------- 372. 4

91. Limestone, light-brownish-gray, coarse grained at base grading upward to medium grained; irregular, platy beds 0.3–0.5 ft thick. Forms distinct ledge ------ 371. 1

90. Limestone, light-brownish-gray, medium-grained; shaly, platy, irregular beds a few millimeters thick ---------- 360. 8

89. Limestone, light-brownish-gray, fine-grained, hard ---------- 359. 7

88. Limestone, light-brownish-gray, coarse-grained; shaly, platy, irregular beds a few millimeters thick ---------- 358. 6

87. Limestone, similar to unit 89 ---------- 357. 7

86. Limestone, similar to unit 88 ---------- 357. 4

85. Limestone, similar to unit 89 ---------- 356. 5

84. Limestone, similar to unit 88 ---------- 356. 0

83. Limestone, similar to unit 89 ---------- 354. 4

82. Limestone, similar to unit 88 ---------- 354. 0

81. Limestone, light-brownish-gray, fine-grained, hard; 2 beds 0.3 ft thick ------ 352. 6

** 80. Limestone, similar to bed 88 ---------- 352. 0

** 79. Limestone, light-brownish-gray, fine-grained, massive, bioclastic; beds 0.3–0.5 ft thick ---------- 350. 5

78. Limestone, light-brownish-gray, massive, bioclastic, with sparse crinoid columnals at top; medium grained at base grading upward to very coarse grained; tabular beds 0.2–0.7 ft thick ---------- 349. 1

77. Limestone, light-brownish-gray, coarse grained at base grading upward to medium grained at top; thin wedging shaly, platy, irregular beds range from feather edge to 0.1 ft in thickness; contains *Sulcoretepora*, fenestrate bryozoans, *Chonetes*, and *Dictyoclostus* ---------- 347. 7

76. Limestone, light-brownish-gray, very coarse grained, massive, bioclastic, with comminuted brachiopod fragments ---------- 346. 4

75. Chert, medium-light-gray to dark-gray, mottled, fine, granular, calcareous; "woody" weathered surface; seminodular irregular bed 0.2–0.5 ft thick; similar to unit 1, section K ---------- 345. 7

74. Limestone, brownish-gray (5*YR* 4/1), medium-grained, bioclastic; irregular beds 0.2–0.5 ft thick ---------- 345. 4

73. Limestone, light-brownish-gray (5*YR* 6/1), fine- to medium-grained, thin-bedded, shaly, platy ---------- 342. 6

72. Limestone, light-brownish-gray (5*YR* 6/1), fine- to medium-grained, bioclastic; beds 0.1–0.8 ft thick ---------- 341. 8

Alapah limestone—Continued Platy limestone member—Continued	*Cumulative thickness above base of section (feet)*
71. Limestone and chert; light-brownish-gray (5*YR* 6/1) medium- to coarse-grained bioclastic limestone, interbedded with mottled medium-dark-gray to medium-gray dense chert nodules 0.2–0.4 ft thick	339. 6
70. Chert, light-brownish-gray (5*YR* 6/1), dense; nodular beds	338. 1
69. Limestone, pale-yellowish-brown (10*YR* 6/2), coarse-grained, bioclastic	337. 5
68. Chert, medium-gray, fine-grained; irregular, nodular beds 0.2–0.4 ft thick	337. 0
67. Limestone, pale-yellowish-brown, medium- to coarse-grained, bioclastic; thin, irregular beds 0.1–0.3 ft thick	336. 0
66. Limestone, pale-yellowish-brown, coarse-grained, irregular; unit ranges laterally from feather edge to 0.5 ft in thickness	332. 4
65. Chert, medium-gray to dark-gray, mottled, dense, calcareous, nodular; unit ranges laterally from 0.7 to 0.9 ft in thickness; composed of several nodular beds	332. 2
64. Limestone, light-brownish-gray, medium-grained, massive, bioclastic, with numerous crinoid columnals; bottom bed 0.4 ft thick, top bed 0.6 ft thick	331. 5
63. Limestone, light-brownish-gray, medium- to coarse-grained, bioclastic; thin, platy beds 0.2–0.7 ft thick, somewhat shaly with irregular bedding surfaces a few millimeters apart; weathers medium light gray	330. 5
62. Limestone, two beds; bottom bed pale-yellowish-brown medium-grained bioclastic limestone, 0.6 ft thick; top bed medium-light-gray very fine grained dense limestone, 0.4 ft thick; both with scattered small elliptical nodules of medium-gray calcareous dense chert	329. 1
61. Limestone, light-brownish-gray; grades upward from medium grained to fine grained; thin, platy, somewhat irregular beds 0.1–0.5 ft thick	328. 1
60. Limestone, light-brownish-gray, medium-grained, bioclastic, massive, with abundant crinoid columnals; 0.4-ft-thick bed at top of ledge formed by this unit	318. 0
59. Chert, grayish-black, nodular; beds 0.2–0.4 ft thick	312. 2
58. Limestone, light-brownish-gray, fine grained at base grading upward to medium grained at top, bioclastic; beds 0.5–1.8 ft thick from 294.9 to 305 ft, and 0.3–0.8 ft thick from 305 to 311.5 ft. Beds of units 58 through 60 form cliff	311. 5
57. Limestone, light-brownish-gray, medium- to coarse-grained; beds 0.4–0.9 ft thick.	294. 9
56. Limestone and chert; medium-dark-gray medium-grained bioclastic limestone, with several lenticular beds of dark-gray chert 0.2–0.3 ft thick	284. 1
** 55. Limestone, medium-dark-gray, medium-grained; thin, irregular, biohermal(?) beds, 0.2–0.6 ft thick	281. 6

Alapah limestone—Continued Platy limestone member—Continued	*Cumulative thickness above base o section (feet)*
54. Limestone, medium-dark-gray, medium-grained, bioclastic, with sparse invertebrate fossils	278. 4
53. Limestone and chert; dark-gray very fine grained hard nodular irregularly bedded limestone, with a few nodular beds and nodules of dark-gray chert; limestone beds 0.4–0.6 ft thick, chert beds from feather edge to 0.4 ft thick; similar to unit 51 but slightly coarser and thicker bedded, with fewer nodular beds and nodules of chert	277. 1
52. Limestone, dark-gray, very fine grained, semilithographic, hard, nodular, irregularly bedded, with a few lenticular bioclastic masses	271. 1
51. Limestone and chert; dark-gray very fine grained semilithographic hard nodular limestone; irregularly interbedded with nodular beds and nodules of dark-gray chert; limestone beds 0.2–0.4 ft thick, chert beds from feather edge to 0.3 ft thick	268. 1
Thickness of platy limestone member	186. 6
Dark limestone member:	
* 50. Limestone, brownish-gray, coarse-grained, hard, massive, bioclastic; becomes medium dark gray, medium grained, soft, and argillaceous above 250.6 ft; prismatic lithostrotionid corals abundant from 248.3 to 250.8 ft; crinoid ossicles present from 250.8 to 259.6 ft	259. 6
49. Limestone, brownish-gray, medium-grained, bioclastic, thin-bedded; grades upward into massive limestone of unit 50; beds 0.1–0.2 ft thick	247. 8
48. Limestone, brownish-gray, medium-grained, bioclastic; beds 0.3–0.4 ft thick	246. 6
47. Limestone, moderate yellowish brown at base, grading upward to light brownish gray and becoming medium dark gray at top; fine grained at base becoming medium grained at top; massive, with prismatic lithostrotionid corals	245. 5
46. Limestone, moderate-yellowish-brown, fine- to medium-grained, thin-bedded; beds 0.05–0.2 ft thick	243. 1
45. Covered; beds thought to be limestone similar to unit 44, perhaps shaly	242. 2
44. Limestone, medium-dark-gray, fine-grained; beds 0.4–0.9 ft thick	238. 2
43. Covered; beds thought to be limestone similar to unit 42; appear shaly	236. 4
* 42. Limestone, medium-dark-gray, fine-grained; beds 0.3–1.6 ft thick; prismatic lithostrotionid corals from 216.4 to 217.7 ft and from 218.7 to 219.3 ft. Weathers to rubble slope covered with thick limestone slabs	227. 4
41. Limestone, medium-dark-gray, fine-grained, very shaly	215. 8

Alapah limestone—Continued

Dark limestone member—Continued

	Cumulative thickness above base of section (feet)
40. Limestone, medium-dark-gray, fine-grained. Forms ledge with unit 39	212.7
39. Limestone, medium-brownish-gray, fine- to medium-grained, massive; beds 0.4–3.2 ft thick. Forms massive ledge with unit 40	210.5
38. Limestone, dark-gray, fine- to medium-grained, argillaceous, very thin bedded, shaly. Forms reentrant beneath overlying ledge	203.9
37. Limestone, dark-gray, fine-grained, hard, with single band of grayish-black silicified limestone nodules	199.0
36. Limestone, dark-gray, fine-grained, hard, with sparse invertebrate-fossil fragments	198.3
** 35. Limestone, medium-brownish-gray, fine- to medium-grained, bioclastic; somewhat argillaceous from 191.6 to 192.6 ft; beds 0.1–2.3 ft thick	194.2
34. Limestone, light-brownish-gray, medium-grained, thin-bedded, slabby	188.1
33. Limestone, medium-brownish-gray, medium-grained, slightly bioclastic; beds 1–2 ft thick	185.1
32. Limestone, dark-gray, very fine grained; appears to be argillaceous, shaly, and oolitic. Mostly covered	179.1
* 31. Limestone, dark-gray, very fine grained, argillaceous, massive, with sparse dark-gray fine-grained oolites	173.1
30. Limestone, dark-gray, very fine grained, oolitic, hard, with single zone of small silicified nodules of grayish-black limestone in middle of unit; sparse dark-gray fine-grained oolites	171.1
29. Limestone, dark-gray, very fine grained, hard, with sparse dark-gray fine-grained oolites	170.3
28. Limestone, dark-gray, very fine grained, hard, with a few slightly irregular small silicified nodules of grayish-black limestone and sparse dark-gray fine-grained oolites	169.3
27. Limestone, dark-gray, very fine grained, hard; massive bed from 166.2 to 167 ft, and thin beds from 167 to 167.5 ft; prismatic lithostrotionid corals occur from 166.2 to 167 ft	167.5
** 26. Limestone, dark-gray, very fine grained, hard, with a few light-colored invertebrate-fossil fragments and, in the middle part, two bands of grayish-black very fine grained silicified limestone nodules which look like chert	166.2
25. Limestone, grayish-black, fine-grained, shaly, laminated, with prismatic lithostrotionid corals	164.3
24. Limestone, grayish-black, fine-grained, shaly, with a few thin stringers of black chert; prismatic lithostrotionid coral colonies 0.7–1 ft in diameter	164.1
23. Limestone, grayish-black, fine-grained, shaly, laminated	163.2

Alapah limestone—Continued

Dark limestone member—Continued

	Cumulative thickness above base of section (feet)
22. Limestone and chert; dark-gray, fine-grained, argillaceous irregularly bedded limestone with small lentils of medium-dark-gray chert	163.0
21. Limestone, dark-gray to grayish-black, fine-grained, dense, with numerous small dark-brownish-gray fragments of corals, crinoids, bryozoans, and brachiopods	162.4
20. Limestone, dark-gray, fine-grained, argillaceous(?), thin-bedded	160.6
19. Limestone, dark-gray, fine- to medium-grained, argillaceous(?), hard, massive; top bed, 156.7–157.5 ft, grayish black	157.5
18. Limestone and chert; light-gray fine-grained argillaceous shaly limestone, with nodules of black chert	154.8
17. Limestone, grayish-black, fine-grained	153.0
16. Limestone and chert; grayish-black fine-grained argillaceous nodular limestone with thin soft shaly zones and thin black chert nodules which weather moderate brown (5*YR* 4/4); chert nodules 0.1–0.3 ft thick, shaly zones 0.1–0.4 ft thick	151.7
15. Limestone, dark-gray, fine-grained, hard	149.1
14. Limestone and chert; dark-gray fine-grained thin-bedded shaly limestone with thin lentils of black chert	148.3
13. Limestone, medium-brownish-gray (5*YR* 5/1), fine-grained, with irregular patches of dark-gray argillaceous(?) carbonaceous(?) material	147.9
12. Limestone, dark-gray, fine-grained, thin-bedded, shaly	147.0
11. Limestone, very dark gray, fine-grained, hard, massive, with large prismatic lithostrotionid corals	146.7
10. Limestone, dark-gray, fine-grained, massive, with abundant crinoid ossicles, and phaceloid and prismatic lithostrotionid corals. Units 7–10 form a ledge	144.6
9. Limestone, dark-gray, fine-grained, massive, with phaceloid and prismatic lithostrotionid corals; 0.4–0.5 ft thick	142.1
8. Limestone, dark-gray, fine-grained, thin-bedded, shaly, argillaceous; 0.7–0.9 ft thick	141.6
7. Limestone, medium-gray to medium-dark-gray, very fine grained, with a few crinoid ossicles and phaceloid lithostrotionid corals. Basal bed of ledge	140.8
6. Limestone, dark-gray, fine-grained, dense; thin, slightly irregular beds; weathers to light-gray thin, platy fragments	138.8
** 5. Limestone, dark-gray, very fine grained, hard, slightly argillaceous(?)	129.5
4. Limestone, dark-gray, fine-grained, dense; thin, irregular beds, with scattered crinoid ossicles; becomes thicker bedded in top 1.7 ft; beds in lower part 0.1–0.4 ft thick, in the upper part 0.3–0.5 ft thick; top 0.2 ft very shaly and soft	128.1

Alapah limestone—Continued *Cumulative thickness above base of section (feet)*

Dark limestone member—Continued

3. Limestone, medium-dark-gray, fine-grained, slightly argillaceous; thin irregular beds 0.3–0.5 ft thick; fossils less common than in unit 2 ---- 124. 2

* ** 2. Limestone, dark-gray, fine-grained, somewhat argillaceous, massive, bioclastic; very fossiliferous, with several types of lithostrotionid corals, solitary corals, *Syringopora*, and bryozoans; beds from 89 to 92.8 ft are biostromes; lower beds more platy and thin bedded than upper massive biostromal beds. Forms conspicuous ledge ---- 93. 3

Thickness of dark limestone member ---- 175. 1

Shaly limestone member:

* ** 1. Limestone and chert; dark-gray fine-grained shaly platy limestone; weathers to shaly chips about 0.1 foot in diameter; a few interbedded black chert beds and many black chert lentils; most lentils irregularly elliptical in cross section, 0.1–0.4 ft thick and 0.8–3 ft long, with some as long as 15 or 20 ft, and base of most is flat; lower part of sequence alternating shaly and massive zones; shaly zones from 8 to 11 ft, 18.5 to 22.5 ft, 27 to 33.5 ft, and 38 to 39.5 ft; unit less shaly in upper part; a few thin lenticular beds of dark-gray calcareous shale, ranging from a feather edge to 0.3 ft in thickness, occur sporadically throughout; upper 28.5 ft covered, but beds similar to lower part are present along strike near measured section; lithostrotionid and solitary corals common ---- 84. 5

Thickness of shaly limestone member ---- 84. 5

Thickness of Alapah limestone measured ---- 503. 5

Total thickness of Alapah limestone (see pl. 6) ---- 970+

Disconformity.

Wachsmuth limestone: Platy limestone member: See stratigraphic section I, a continuation of this section.

UPPER PART, ALAPAH LIMESTONE—SECTION K

This section, comprising the platy limestone member, the banded limestone member, the black chert-shale member, the light-gray limestone member, the fine-grained limestone member, the chert-nodule member, and part of the upper limestone member, was measured along a single line of traverse at the type locality of the Alapah limestone. It originates in the creek north of Sugarloaf Hill, extends up over the North Ridge, and down the north slope of the ridge to the edge of the gravels that mantle the foothills (pl. 1). The lower part of this section is correlated with the upper part of section J (see pl. 6). The beds at the top of this section are near the top of the Alapah limestone and are overlain by glacial deposits. Although the Alapah limestone is disconformably or unconformably overlain elsewhere by the sandstone and shale of the Siksikpuk formation (Permian?) (Patton, 1957) or the Shublik formation (Upper Triassic), this contact was not observed in the Shainin Lake area. It is believed that the top bed in section K lies only a few feet below the Siksikpuk formation.

Section on the west end of North Ridge of Mount Wachsmuth at lat 68° 20′ N., long 150°55′15″ W. (approximate)

[Measured with tape and hand level by the authors and C. J. Gudim in 1949. Graphic section, pl. 6; location, pl. 2. Datum is base of Alapah limestone as established in section J]

Covered: Gravel and tundra.

Alapah limestone: *Cumulative thickness above datum (feet)*

Upper limestone member (incomplete):

113. Limestone, dark-yellowish-brown, fine-grained, unfossiliferous; it appears that this unit forms the top of the Alapah limestone and may lie just below either the Triassic or Permian(?) rocks. Beds, with those of upper part of unit 112, form a small escarpment at northwest corner of the North Ridge of Mount Wachsmuth ---- 970+

**112. Limestone, dark-yellowish-brown (10*YR* 3/2), fine-grained, with a few small nodules of medium-gray to grayish-black chert; somewhat irregular beds, 1–6 ft thick; relatively unfossiliferous. Unit in part forms dip slope of North Ridge of Mount Wachsmuth ---- 960. 6

111. Limestone, yellowish-brown (5*YR* 5/2), fine-grained; beds 1–3 ft thick ---- 925. 6

Thickness of upper limestone member exposed ---- 69. 4+

Chert-nodule member:

110. Limestone, dark-yellowish-brown, fine-grained, with nodules and nodular beds of mottled brownish-gray to medium-gray chert; beds 0.7–1.2 ft thick; chert weathers to brownish-gray rubble ---- 900. 6

109. Limestone, dark-yellowish-brown, fine-grained, soft, shaly ---- 885. 3

*108. Limestone, dark-yellowish-brown, fine-grained, with a few very thin shaly zones and some nodules and nodular beds of mottled brownish-gray to medium-gray chert; topmost part, from 879 to 881.7 ft, very nodular with thin lenses of coarse-grained bioclastic limestone and chert; chert weathers to brownish-gray rubble ---- 884. 4

*107. Limestone, dark-yellowish-brown (10*YR* 4/2), fine-grained; beds 0.8–1 ft thick, with thin chert nodules which range

Alapah limestone—Continued

Chert-nodule member—Continued

	Cumulative thickness above datum (feet)
from feather edge to 0.2 ft thick; fewer chert nodules than in unit 106	872. 7
**106. Limestone and chert; dark-yellowish-brown (10YR 4/2) fine-grained limestone; basal beds nodular, with thin lentils of coarse-grained crinoidal debris; from 857 to 866.9 ft interbedded thin nodular-chert beds and chert nodules which range from feather edge to 0.4 ft in thickness	866. 9
**105. Limestone, brownish-gray (5YR 5/1), medium-grained, bioclastic	855. 4
* **104. Limestone and chert; light-brownish-gray fine-grained nodular limestone beds ranging from feather edge to 1.3 ft in thickness interbedded with large lenticular chert beds and nodules; very light gray to medium-gray chert nodules weather to brownish-gray surfaces resembling tripoli; chert nodules range from very small to 1.3 ft thick and 5 ft long; many nodules, 0.1–0. 3 ft thick and 0.3–0.5 ft long, occur within the limestone beds; the larger nodules and beds, as much as 1.3 ft thick, occur primarily between limestone beds; many large caninoid corals and brachiopods	852. 3
Thickness of chert-nodule member	79. 8

Fine-grained limestone member:

	Cumulative thickness above datum (feet)
103. Limestone, grayish-black, fine-grained, massive; occurs just below conspicuous ledge	820. 8
**102. Limestone, grayish-black, fine-grained, irregularly bedded, nodular, with ragged, irregular grayish-black chert nodules in top half	811. 8
*101. Limestone, light - brownish - gray, medium- to coarse-grained, bioclastic; beds 0.4–0.8 ft thick. Unit forms top of upper cliff along south face of North Ridge of Wachsmuth	807. 7
* **100. Limestone, light-brownish-gray (5YR 6/2) to pale-yellowish-brown (10YR 6/2), medium-grained, shaly; weathers to irregular chips as much as 0.2 ft thick; beds 2 ft thick. Forms receding slope above top of cliff formed by units 95 through 99	796. 7
99. Limestone, light-brownish-gray, fine-grained, interbedded with light-brownish-gray coarse-grained bioclastic limestone	784. 4
* 98. Limestone, light - brownish - gray, fine - to medium-grained; beds 1.2–2.4 ft thick; upper 0.6 ft shaly	775. 4
97. Limestone and chert; brownish-gray to brownish-black fine-grained massive limestone beds 1.5–2 ft thick, with medium-gray chert nodules 0.2–0.6 ft thick and 0.6–2 ft long in lower 10 ft; more abundant nodular chert beds alternate with limestone beds from 762 to 766.6 ft; limestone beds in top part 0.5–0.6 ft thick, and chert beds 0.2–0.4 ft thick; limestone is light brownish gray at top. Forms conspicuous ledge with units 95 and 96	766. 6
96. Limestone, brownish-gray to brownish-black, fine-grained, more nodular than beds in unit 95, but less nodular than beds in unit 94; irregular beds 0.4–0.5 ft thick, bedding not as distinct as in units 94 and 95	751. 6
95. Limestone, brownish-gray to brownish-black, fine-grained; somewhat irregular beds 0.2–0.4 ft thick	747. 0
**94. Limestone, brownish-gray to brownish-black, fine-grained, very nodular; beds 0.1–0.5 ft thick	743. 4
Thickness of fine-grained limestone member	80. 1

Light-gray limestone member:

	Cumulative thickness above datum (feet)
* ** 93. Limestone, brownish-gray, fine- to medium-grained, bioclastic; some beds with a few nodules of brownish-black, light-gray-weathering chert; tabular limestone beds from 731.2 to 738 ft 0.5–1.2 ft in thickness; top bed 2.7 ft thick; chert occurs in limestone beds from 734.1 to 734.5, at 735.6 ft, and from 740.2 to 740.7 ft; chert nodules are 0.1–0.3 ft in thickness; prismatic lithostrotionid corals profuse from 732 to 735 ft	740. 7
92. Limestone and chert; pale-yellowish-brown (10YR 6/2) medium-grained bioclastic limestone, with nodules of medium-gray chert 0.2–0.4 ft thick and 0.5–0.7 ft long; 2 beds, 0.7 and 0.8 ft thick	731. 2
91. Limestone, pale-yellowish-brown, medium-grained, bioclastic, soft, friable	729. 7
* **90. Limestone, pale-yellowish-brown, medium-grained, porous, dolomitic(?), with a few thin lenticular medium-gray chert nodules	727. 0
89. Limestone, pale-yellowish-brown (10YR 6/2), medium-grained; porous in lower and upper parts, shaly in middle part	723. 7
88. Limestone, pale-yellowish-brown, medium-grained, porous, dolomitic(?), with irregular masses of medium-gray chert	721. 9
87. Limestone, pale-yellowish-brown, medium-grained, shaly	718. 5
86. Limestone, pale-yellowish-brown, medium-grained, porous, dolomitic(?)	717. 8
**85. Limestone and chert; brownish-gray fine-grained limestone, with crinoid columnals as much as 6 mm in diameter, interbedded with medium-gray to light-brownish-gray nodular chert; limestone beds 0.1–0.6 ft thick and change thickness 0.1–0.2 ft laterally; chert beds 0.2–0.3 ft thick	714. 8

	Cumulative thickness above datum (feet)
Alapah limestone—Continued	
Light-gray limestone member—Continued	
84. Chert, medium-gray to light-brownish-gray, light-gray- and yellowish-gray-weathering, very finely granular, nodular, with a few thin lentils of light-brownish-gray fine-grained limestone still preserved; unit appears to be highly weathered nodular silicified limestone; nodular chert beds 0.1–0.4 ft thick; limestone lentils range from feather edge to 0.4 ft in thickness. Unit forms conspicuous ledge	709. 3
**83. Limestone, olive-gray, coarse-grained; irregular beds range from a feather edge to 0.5 ft in thickness; biohermal(?)	705. 2
*82. Limestone, coarse-grained, bioclastic; light brownish gray at base grading upward to olive gray or olive black (5*Y* 4/1); nodular lentils of light-gray chert at base grade upward to medium light gray and medium dark gray; chert weathers light gray, appears to be of both primary and replacement types, is primarily within the beds of limestone, and is most abundant at top of unit; tabular limestone beds 0.4–1 ft thick; chert nodules range from feather edge to 0.3 ft in thickness; few fossils	701. 6
Thickness of light-gray limestone member	46. 3
Black chert-shale member:	
81. Limestone, brownish-gray, fine-grained, argillaceous, with abundant irregular masses and nodular beds of black chert; bottom part, from 692.4 to 693.6 ft, is massive; remainder, from 693.6 to 694.4 ft, is almost completely laminated chert with abundant lenticular stringers of black chert	694. 4
* 80. Limestone and chert; brownish-gray fine-grained argillaceous fossiliferous limestone with abundant fossils and many irregular masses and nodules of black chert; lower nodular limestone beds 0.4 and 0.5 ft thick; from 690.9 to 692.4 ft is thin-bedded shaly limestone with many thin, lenticular chert beds; unit somewhat laminated, although chert laminae are very irregular	692. 4
79. Shale and phosphorite(?); grayish-brown (5*YR* 3/2) very calcareous irregularly bedded carbonaceous(?) shale of clay-size particles; thin beds of black shaly highly siliceous claystone or phosphorite(?) from 688.1 to 689.3 ft, separated by thin beds of shale; sequence is phosphorite(?), 0.2 ft; shale, 0.3 ft; phosphorite(?), 0.3 ft; shale, 0.2 ft; and phosphorite(?), 0.2 ft. Units 77 through 79 apparently absent east of the Shainin Lake area; thicken westward	690. 0

	Cumulative thickness above datum (feet)
Alapah limestone—Continued	
Black chert-shale member—Continued	
* ** 78. Limestone, brownish-gray, fine-grained, argillaceous, carbonaceous(?), very fossiliferous, with ragged grayish-black to black dense "earthy" chert nodules; from 683.6 to 684.9 ft is irregular and thin bedded, with layers of many small chert nodules 0.1–0.2 ft thick; upper part blocky, with larger and more irregular chert nodules; top beds, from 684.9 to 687 ft, irregular and thin bedded; beds at base are 0.1–0.2 ft thick; somewhat irregular beds in middle and upper part are 0.3–0.4 ft thick	687. 0
* ** 77. Shale and phosphorite(?); grayish-brown (5*YR* 3/2) very calcareous irregularly bedded carbonaceous(?) shale of clay-size particles, with thin nodules and nodular beds of black shaly highly siliceous claystone or phosphorite(?); phosphorite(?) beds from 678.4 to 678.7 ft, 679.4 to 679.8 ft, and 681.1 to 681.4 ft	683. 6
76. Limestone, brownish-black, fine-grained, argillaceous, shaly; beds 2–8 mm thick	676. 7
* 75. Limestone, slightly mottled, brownish-black, fine-grained, argillaceous; weathers dusky brown (5*YR* 2/2); beds 0.5 and 0.6 ft thick	676. 1
* 74. Limestone, similar to unit 76	675. 0
** 73. Limestone, similar to unit 75; beds 0.2–0.8 ft thick, becoming progressively thinner toward top	673. 9
72. Limestone, dark-gray, fine-grained, platy, shaly; somewhat irregular beds 0.1–0.2 ft thick	670. 6
71. Limestone, dark-gray, fine-grained, bioclastic, specularitic appearance; slightly undulatory beds 0.1–0.3 ft thick at base; beds thicken upward	668. 7
70. Limestone, pale-yellowish-brown (10*YR* 6/2), fine-grained, platy, shaly; somewhat irregular beds a few millimeters thick	667. 5
69. Limestone, dark-gray, fine-grained, hard, bioclastic, specularitic appearance; thin beds 1–8 mm thick; may be slightly dolomitic; tends to be silicified	667. 1
68. Limestone, pale-yellowish-brown (10*YR* 6/2), fine-grained, platy, shaly; somewhat irregular beds 0.1–0.3 ft thick	666. 7
67. Limestone, brownish-gray, medium-grained, somewhat argillaceous, bioclastic, with small slightly irregular nodular masses of grayish-black fine-grained to semilithographic partly silicified limestone; medium-grained beds 0.4–0.8 ft thick; fine-grained nodules 0.1–0.4 ft thick and 0.3–0.9 ft long	663. 8
Thickness of black chert-shale member	38. 3

Alapah limestone—Continued

Banded limestone member:

Cumulative thickness above datum (feet)

* ** 66. Limestone, brownish-gray, medium-grained, somewhat argillaceous, bioclastic, with very irregular masses of grayish-black fine-grained to semilithographic limestone; masses in lower part, shaped like pieces of jigsaw puzzle, become more nodular and elongate in upper part; in lower part masses are sparse and large, 0.5–0.9 ft in greatest dimension, but become abundant in upper part and are 0.2–0.5 ft thick and 0.4–1.5 ft wide; may be an intraformational breccia. Unit forms top of cliff ---------- 656. 1

** 65. Limestone, brownish-gray, medium-grained, somewhat argillaceous, with a few thin lentils of coarse-grained bioclastic limestone 0.1–0.3 ft thick; interbedded lentils and beds of grayish-black fine-grained nodular limestones 0.2–1.8 ft thick; medium-grained beds 0.6–3.6 ft thick in bottom part, 0.2–0.4 ft thick from 633 to 635 ft, and 0.6–1.5 ft thick in top part ---------- 647. 0

64. Limestone, brownish-black, medium-grained, bioclastic, with a few thin nodular beds of grayish-black fine-grained limestone 0.3–0.5 ft thick; medium-grained beds 0.8–2 ft thick ---------- 619. 2

** 63. Limestone, grayish-black, fine-grained, very nodular at base; beds 0.2–0.6 ft thick and include a few thin stringers of brownish-black medium-grained bioclastic limestone which range from a featheredge to 0.2 ft in thickness; beds of brownish-black medium-grained bioclastic limestone 0.8–1.2 ft thick from 578.8 ft to 579.7 ft, 582 to 583 ft, and 587 to 587.8 ft; from 577.2 to 585 ft, fine-grained limestone beds constitute about 75 percent of thickness; from about 585 to 590 ft, medium-grained beds are thicker and more abundant with fewer fine-grained beds; from 588 to 609.8 ft, fine-grained limestone beds constitute less than 50 percent of thickness; from 588 to 609.8 ft, medium- and coarse-grained limestone beds are 0.6–1.1 ft thick and fine-grained limestone beds are 0.5–0.9 ft thick; the ratio of fine- to coarse-grained beds changes gradually throughout unit. Unit forms massive upper part of cliff which includes strata from the base of unit 58 to the top of unit 66 ---------- 609. 8

62. Limestone, brownish-gray to brownish-black, medium-grained, argillaceous, with a few thin lentils of brownish-black fine-grained limestone ---------- 577. 2

61. Limestone, brownish-gray to grayish-black, fine-grained, nodular, slightly fossiliferous ---------- 572. 6

60. Limestone, dark-yellowish-brown (10*YR* 4/2) to grayish-brown (5*YR* 3/2), medium- to coarse-grained, bioclastic ---------- 569. 0

Alapah limestone—Continued

Banded limestone member—Continued

Cumulative thickness above datum (feet)

59. Limestone, brownish-gray, medium-grained, massive, nodular, with alternating beds of brownish-gray fine-grained nodular limestone; medium-grained beds are 0.4–1.3 ft thick but thicken and thin laterally as much as 0.4 ft; fine-grained beds are 0.2–0.5 ft thick ---------- 567. 4

58. Limestone, brownish-gray, medium-grained, bioclastic, nodular, alternating with brownish-black semilithographic to fine-grained slightly bioclastic nodular hard limestone beds; medium-grained beds, from 547.1 to 552.2 ft and from 556.3 to 560.7 ft, are 0.3–0.7 ft thick; fine-grained beds 0.2–0.4 thick; a thick bed of medium-grained bioclastic limestone occurs from 552.2 to 556.3 ft. Unit is base of a massive cliff that includes beds from base of this unit to the top of unit 66 ---------- 560. 7

57. Limestone, brownish-gray, medium-grained, bioclastic; tabular beds 0.4–1.7 ft thick ---------- 547. 1

56. Limestone, brownish-black, semilithographic to fine-grained; irregular beds 1.2–1.4 ft thick at base and 0.5–0.7 ft at top; thin lentils of brownish-gray medium- and coarse-grained bioclastic limestone, ranging from featheredge to 0.4 ft in thickness, with crinoid ossicles, bryozoans, and brachiopods; thin lentils alternate with fine-grained limestone beds; although coarse-grained bioclastic beds predominate in similar alternating sequences lower in the formation, in this unit the fine-grained limestone beds predominate ---------- 543. 7

55. Limestone, brownish-black, semilithographic; tabular beds 0.3–1.9 ft thick ---------- 531. 6

54. Limestone, brownish-black, medium-grained, bioclastic, with many very irregular nodules of grayish-black chert throughout; beds 0.5–1.3 ft thick ---------- 524. 2

53. Limestone, brownish-gray to dark-gray, medium-grained, bioclastic; top of unit contains single layer of grayish-black dense chert nodules 0.2–0.3 ft thick and 0.4–0.8 ft long ---------- 514. 8

52. Limestone, brownish-black, medium-grained, bioclastic, with single layer in middle of bed of grayish-black dense very irregular chert nodules 0.2–0.4 ft thick and 0.4–0.6 ft long ---------- 513. 9

51. Limestone, brownish-black, medium-grained, bioclastic; bottom bed 1.3 ft thick, top bed 0.8 ft thick ---------- 512. 5

*50. Limestone and chert; grayish-black fine-grained nodular limestone, with abundant small irregular nodules of dense grayish-black chert; limestone beds 0.3–0.8 ft thick; chert nodules 0.2–0.5 ft thick ---------- 510. 4

Alapah limestone—Continued

Banded limestone member—Continued

		Cumulative thickness above datum (feet)
49.	Limestone, dark-grayish-brown, medium-grained, bioclastic; tabular beds 0.2–0.3 ft thick	507. 2
48.	Limestone, dark-grayish-brown, medium-grained, bioclastic; bottom bed 1 ft thick, top bed 0.9 ft thick	506. 5
47.	Limestone, brownish-gray, medium-grained, bioclastic, slightly shaly	504. 6
46.	Limestone, dark-brownish-gray, medium-grained, bioclastic	504. 5
45.	Limestone, brownish-gray, medium-grained, bioclastic	503. 4
**44.	Limestone, brownish-gray, semilithographic, somewhat dolomitic(?), weathers yellowish gray (5*Y* 8/1); beds 0.2–0.4 ft thick	503. 3
43.	Limestone, brownish-black, medium-grained, bioclastic	501. 6
42.	Limestone, grayish-black, semilithographic, nodular; ranges from featheredge to 0.2 ft in thickness	500. 7
41.	Limestone, brownish-black, medium-grained, bioclastic	500. 5
40.	Limestone, grayish-black, semilithographic, nodular	499. 1
39.	Limestone, brownish-black, fine- to medium-grained, nodular, bioclastic; beds 0.3–0.6 ft thick	498. 5
38.	Limestone, brownish-black, fine- to medium-grained, bioclastic	497. 6
37.	Covered; beds thought to be brownish-gray medium-grained bioclastic limestone	496. 4
**36.	Limestone, brownish-gray, medium-grained, bioclastic	490. 2
**35.	Limestone, brownish-gray, medium-grained, nodular, bioclastic, interbedded with brownish-black to dark-gray hard semilithographic nodular limestone; medium-grained beds 0.8–1.6 ft thick; semilithographic beds 0.3–0.9 ft thick	487. 5
34.	Limestone, brownish-black, medium-grained, bioclastic	470. 8
33.	Limestone, brownish-black, semilithographic	470. 0
32.	Limestone, brownish-gray, medium-grained, bioclastic	469. 0
31.	Limestone, brownish-black, fine-grained, with fenestrate bryozoans	467. 0
30.	Limestone, brownish-gray, medium-grained, bioclastic	466. 6
29.	Limestone, brownish-gray to brownish-black, medium-grained, nodular, bioclastic, interbedded with brownish-black fine-grained nodular limestone; beds 0.4–0.7 ft thick	465. 8
28.	Limestone, brownish-gray, medium- to coarse-grained, nodular, bioclastic, interbedded with grayish-black semilithographic hard dense somewhat silicified limestone; beds 0.2–0.5 ft thick	460. 5
27.	Limestone, brownish-gray, medium- to coarse-grained, bioclastic; bottom bed 0.5 ft thick, top bed 1.3 ft thick	452. 7
* 26.	Limestone, dark-gray to brownish-black, fine-grained, bioclastic, nodular, alternating rhythmically with grayish-black nodular semilithographic limestone; fine-grained beds 0.2–0.5 ft thick; semilithographic beds 0.1–0.4 ft thick; denser, more resistant, semilithographic beds stand out on weathered surfaces; base of this unit is correlated with the base of unit 106 of section J (see pl. 6). Unit forms ledge	450. 9
	Thickness of banded limestone member	209. 9

Platy limestone member (incomplete):

		Cumulative thickness above datum (feet)
25.	Limestone, similar to unit 26; fine-grained beds 0.4–0.6 ft thick, semilithographic beds 0.2–0.5 ft thick	446. 2
24.	Limestone, brownish-gray, very coarse grained, bioclastic	441. 4
23.	Limestone, grayish-black to brownish-black, fine-grained	440. 1
22.	Limestone, brownish-gray, medium-grained, bioclastic	439. 9
21.	Limestone, grayish-black and brownish-black, mottled, fine-grained, with bed of dark-gray medium-grained limestone from 436.8 to 437.5 ft	438. 2
** 20.	Limestone, brownish-gray, coarse-grained, unevenly bedded, bioclastic, with nodules and nodular beds as much as 0.4 ft thick of brownish-gray fine-grained limestone at 430.3 and 434.2 ft	435. 4
** 19.	Limestone and chert; brownish-gray medium-grained nodular bioclastic limestone, interbedded with medium-gray to dark-gray mottled chert nodules and nodular-chert beds, with abundant fenestrate bryozoans; unit approximately 75 percent chert; limestone beds 0.2–0.6 ft thick	428. 5
18.	Limestone, brownish-gray, medium-grained, bioclastic; beds 0.3–1.4 ft thick	425. 9
17.	Limestone, medium-gray, fine-grained, with nodular beds of grayish-black to brownish-gray mottled fine granular chert from 417.7 to 418.8 ft; chert weathers moderate yellowish brown; single bed of grayish-black chert 0.4–0.6 ft thick from 420.5 to 421.1 ft	421. 1
16.	Limestone and chert; brownish-gray fine-grained bioclastic limestone at base, grading upward to dark-gray coarse-grained bioclastic limestone with interbedded slightly mottled light- to dark-gray chert beds from 414.8 to 415.3 and 415.8 to 416.1 ft	416. 1
15.	Limestone and chert; brownish-gray to brownish-black medium-grained bioclastic limestone, with light- to dark-gray slightly mottled chert beds from 412.2 to 412.4 ft, 413.1 to 413.3 ft, and 413.6 to 413.9 ft	413. 9

	Cumulative thickness above datum (feet)
Alapah limestone—Continued	
Platy limestone member (incomplete)—Continued	
14. Limestone, brownish-gray to brownish-black; fine grained at base grading upward to coarse grained; tabular beds 0.3–1.1 ft thick	412. 2
13. Chert, medium-dark-gray, with fenestrate bryozoans	406. 2
12. Limestone, brownish-gray, coarse-grained, bioclastic	405. 4
11. Limestone, brownish-black (5*YR* 2/1), medium- to coarse-grained, bioclastic	404. 7
10. Limestone and chert; brownish-gray, medium- to coarse-grained, hard, bioclastic, with brownish-gray to dark-gray mottled irregular beds and nodules of chert within the limestone; in places unit is 80 percent chert	402. 8
9. Limestone, medium-gray, fine- to medium-grained, bioclastic; identifiable fossil fragments more abundant in upper part	400. 7
8. Covered; beds thought to be limestone	400. 1
7. Limestone, brownish-gray, medium-grained, bioclastic	394. 7
6. Limestone and chert; dark-brownish-gray coarse-grained dense irregularly bedded limestone, interbedded with dark-brownish-gray calcareous nodular chert	394. 0
5. Limestone, brownish-gray (5*YR* 4/1), medium-grained, bioclastic	391. 7
* ** 4. Limestone, light-gray to white, coarse-grained, bioclastic; composed of crinoid ossicles, *Sulcoretepora*, brachiopod, and trilobite fragments; 65 percent of crinoid columnals greater than 3 mm in diameter; abundant phosphate nodules, 1–5 mm in diameter, from 388.2 to 389.9 ft, about 4 per square inch; a few phosphate nodules sporadically distributed in lower part	391. 1
* 3. Limestone, light-gray, medium-grained, slightly crosslaminated, bioclastic; composed largely of comminuted crinoid ossicles; tabular beds 2–3 ft thick appear massive where exposed in steep cut along creek and are like those in units 76–96 of section J (plate 6) where weathered on slope	385. 6
2. Limestone, dark-brownish-gray, medium-grained, bioclastic, with abundant crinoid columnals and dark-gray argillaceous material of unknown composition; 70 percent of crinoid columnals less than 2 mm in diameter, 20 percent between 2 and 3 mm, and 10 percent greater than 3 mm	343. 6
1. Chert, very-light-gray, fine, granular; elliptical nodules as much as 0.5 ft thick and 2 ft in length. Unit is 0.5 ft thick	342. 1
Thickness of platy limestone member measured	104. 6
Total thickness of platy limestone member (see pl. 6)	187. 0
Alapah limestone—Continued	
Thickness of Alapah limestone measured	628±
Total thickness of Alapah limestone (see pl. 6)	970+

REFERENCE LIST OF FOSSIL-COLLECTION AND ROCK-SAMPLE NUMBERS

Fossil collections and rock samples examined in the course of this study were obtained from the stratigraphic positions indicated below. The symbols for members are those used in figure 4.

FOSSIL COLLECTIONS

Coll. no.[1]	Section	Member	Unit no.	Position in section (feet)
USNM 3087	J	Mad	2	84. 5–93. 3
3087a	J	Mas	1	50. 0
3091	I	Mwc	3	141. 6–148. 0
3092	F	Mka	18	765±
3096	I	Mwc	4	149. 5–167. 0
3099	H	Mwc	2	21. 0–24. 0
3102	H	Mwc	8	81. 0–90. 0
3103	H	Mwc	9	124. 2
3104	I	Mwc	11	233. 0
3111	I	Mwd	98	709. 2
3112	I	Mwd	108	797. 5
3113	I	Mwb	126	957. 0
3115	I	Mwb	112	845. 0–849. 0
3116	I	Mwd	102	726. 3
3117	I	Mwb	125	954. 2
3118 [2]	I	Mwd	101	720. 1–721. 5
3119	I	Mwd	109	800. 0
3121	H	Mws	1	10. 0–14. 0
3123	I	Mwc	5	182. 5
3124	I	Mwc	6	194. 8
3126	G	Mku	36	898. 7
3127 [3]	G	Mka	3-8	739–0–749. 0
3127a[4]	G	Mka	3–8	739. 0–749. 0
3137	F	Mka	19	796. 0
3138	G	Mkr	41	948. 5–952. 7
3139	G	Mka	16–17	774. 8–783. 3
3140 [2]	G	Mkr	41	949. 0
3142	F	Mkr	24	955. 7–960. 0
3162	I	Mwb	149	1, 229. 9
3163	J	Mas	1	38. 0
3179	J	Map	50	294. 2
3180	J	Mas-Mad	1–2	0–93. 3
3186	J	Mad	31	172. 0
3188	J	Mad	31	172. 3
3189	J	Mab	106	448. 0
3190	J	Mab	111	467. 2
3191	J	Map	94	374. 5
3192	J	Mad	42	216. 2
3193	K	Map	3	376. 0
3194	J	Map	94	374. 5
3195	K	Map	4	388. 5
3196	K	Map	4	389. 7
3198	K	Mac	74	674. 5–675. 0
3199	J	Map	105	437. 2
3202	J	Mab	111	465. 6
3204	K	Mac	80	692. 2–692. 4
3205	K	Mac	78	685. 5
3206	K	Mac	80	690. 9–692. 4
3207	K	Mac	75	675. 8
3208	K	Mac	77–78	677. 5, 683–683. 9
3209	K	Mal	82	700. 5
3210	K	Mal	93	732. 0–735. 0
3211	K	Mal	93	739. 0
3212	K	Mal	90	725. 9
3215 [5]	K	Man	104	840. 0–850. 0
3216 [2]	K	Maf	98	771. 0

See footnotes at end of table, p. 35.

FOSSIL COLLECTIONS—Continued

Coll. no.[1]	Section	Member	Unit no.	Position in section (feet)
USNM 3218	K	Man	107	86.9
3219 [5]	K	Man	104	840.0–850.0
3221 [5]	K	Man	104	840.0–845.0
3227	I	Mwc	9	226.0
3228	I	Mwb	125	956.0
3230	H	Mwc	11	135.5
3234	G	Mkr	41	948.5
3236	G	Mka	14	772.0
3237	F	Mka	20	798.0
3239	F	Mkr	23–24	955.7–960.0
3240	G	Mka	3	725.9–737.5
3241	G	Mka	13	766.0
3242	G	Mka	3	725.9–731.0
3244 [2]	G	Mku	28	820.0
3247	G	Mka	25	795.3–798.0
3249	G	Mku	33	848.0–851.0
3254 [2]	J	Mad	2	84.5–93.3
3256	I	Mwb	125	952.8
3259	G	Mku	37	899.0
3260 [2]	H	Mwc	16	183.0–197.0
3261	I	Mwd	49	543.8
3262 [2]	I	Mwd	91	664.0
3263	I	Mwd	102	722.0
3264	I	Mwb	116	869.0
3265	I	Mwb	130	975.1
3266	I	Mwb	134	1,051.5
3267	I	Mwd	24	407.6
3377	C	Dks	7	81.0–85.0
3380	C	Dks	5	50.0–51.0
3381	C	Dks	5	46.3
3382	C	Dks	4, 5	37.0–47.0
3383	C	Dks	1	0–1.0
3384 [6]	C	Dkm	--------	1,025.0
3385	D	Dks	66	859.4
3386	D	Dks	63	850.5–855.5
3387	D	Dks	57–61	837.0–846.0
3388	D	Dks	60	841.0–842.0
3389	D	Dks	50	751.0
3390	E	Mks	5	26.0
3391	F	Mks	9	91.0
3392	G	Mka	14	773.0
3393	G	Mka	3	727.0
USGS 3382 [1]	A	Ds	1	0–50
14951 [7]	I	Mwb	116	870.0
14952	I	Mwb	121	920.0
14953 [2]	K	Man	100	786.0
14954 [2]	I	Mwb	121	918.5
14955	K	Maf	100	795.8
14956	K	Maf	100	790.0
14957	K	Mal	93	732.0–735.0
14959	J	Mas	1	3.3
14960	K	Man	107	869.0
14961	I	Mwd	26	413.3
14965	H	Mwc	2	21.0–24.0
14970	D	Dks	53	761.0
14971 [2]	D	Dks	2	141.0
14972	I	Mwb	116	875.5
14973	I	Mwc	1	122.3–126.3
14974	J	Mad	2	84.5–93.3
14975	J	Mas	1	48.0
14976	K	Man	108	879.0
14977	K	Maf	101	802.0
14978	K	Maf	100	785.0
14979	K	Mab	50	509.0
14980	K	Map	26	449.2
14981 [2]	F	Mkr	23	955.0
14982	I	Mwb	116	871.0

[1] USNM refers to United States National Museum numbers (red) for 1949 collections; and USGS refers to United States Geological Survey Upper Paleozoic numbers for 1950, with the exception of USGS 3382 (Lower Paleozoic).
[2] Float.
[3] Channel sample from shale only.
[4] Channel sample from limestone only.
[5] From west side of Shainin Lake.
[6] From traverse below section C.
[7] Float; probably from 910 feet.

ROCK SAMPLES

Sample no.[1]	Section	Member	Unit no.	Position in section (feet)
49 ABo 1	J	Map	105	438.1–439.3
2	I	Mwd	75	602.0
3	J	Mab	106	447.0
4 [2]	K	Map	20	430.7
5	I	Mwd	71	569.9
6	I	Mwd	87	645.1
7	J	Mad	2	87.9
8	I	Mwd	91	663.2
9	I	Mwd	28	428.2
10	I	Mwd	34	457.1
11	J	Map	79	350.3
12	I	Mwd	57	550.4
13 [3]	K	Map	20	429.1
14	I	Mwb	136	1,061.0
15	J	Mas	1	33.0
16	J	Mab	114	488.7
17	J	Map	92	372.2
18	K	Map	19	428.1
19	J	Map	80	350.8
20	J	Mab	107	451.3
21	I	Mwb	148	1,216.5
22	I	Mwb	117	883.2
23 [4]	I	Mwd	107	777±
24	I	Mwd	18	382.5
25	H	Mws	1	6.0–9.0
26	I	Mwd	16	371.5
27	I	Mwd	106	753.0
28	I	Mwd	23	403.5
29	I	Mwb	149	1,223.8
30	H	Mwc	6	38.9
31	D	Dks	48	740.6
32	I	Mwd	28	429.6
33	D	Dks	48	749.0
34	D	Dks	60	841.5
35	I	Mwb	148	1,215.1
36	D	Dks	27	374.0
37	F	Mkr	23	951.8
38	H	Mwc	8	61.0
39 [4]	I	Mwb	149	1,218±
40	D	Dks	16	246.7
41	D	Dks	20	258.7
42	I	Mwd	22	397.5
43	D	Dks	56	834.6
44	D	Dks	31	695.0
45	K	Map	4	338.0
46	D	Dks	7–9	152.0–156.4
47	D	Dks	24	342.0
48	D	Dks	35	705.0
64	G	Mkl	1	657.0–660.0
66	G	Mkl	1	657.0–660.0
67 [5]	C	Dkm	--------	1,025.0
68	C	Dks	4–5	37.0–47.0
69	D	Dks	61	842.6
70	C	Dks	12, 13	105.0–108.5
71	C	Dks	7	79.0
72	C	Dks	5	50.5
73	K	Mau	112	946.0
74	K	Mab	66	650.0
75	K	Maf	102	808.8
76	K	Maf	94	742.0
77	K	Mal	90	725.9
78	K	Mac	73	673.0
79	K	Mac	78	685.5
80	K	Mal	83	702.3
81	K	Mac	77	679.7
82	J	Mad	5	129.2
83	K	Mab	44	502.6
84	J	Mad	35	188.8
85	J	Mad	26	165.3
86	K	Mab	63	593.3
87	K	Man	105	853.0
88	K	Man	104	838.0
89	K	Mal	93	734.0
90	K	Mab	36	488.0
91	K	Mab	35	479.4
92	K	Man	106	859.5

See footnotes at end of table, p. 37.

ROCK SAMPLES—Continued

Sample no.[1]	Section	Member	Unit no.	Position in section (feet)
49 ABo 93	K	Man	104	839.2
94	K	Mal	85	711.5
95	I	Mwb	111	816.5
96	K	Mab	65	632.0
97	K	Maf	100	785.6
98	I	Mwb	121	816.8
99	I	Mwd	107	770±
100	I	Mwb	116	874.0
101	I	Mwd	54	548.9
102	I	Mwd	40	492.0
105	I	Mwb	112	842.9
107	I	Mwd	45	496.2
108	I	Mwd	49	544.3
109	I	Mwd	66	564.1
110	I	Mwd	31	450.2
111	I	Mwd	92	671.2
112	I	Mwd	112	680.0
113	I	Mwd	35	468.7
115	I	Mwd	105	745.7
117	I	Mwd	98	701.0
118	I	Mwd	19	387.0
177	I	Mwc	1	123.6
178	J	Map	55	279.8
179	I	Mwc	3	147.0
180 [6]	H	Mwc	8	112±
181	D	Dks	64	856.3
182	I	Mwd	13	291.4
183	I	Mwc	8	214.3
184	I	Mwd	14	338.0
185	D	Dks	51	752.0
186	I	Mwc	7	206.0
187	I	Mwc	2	138.0
188	D	Dks	63	853.5
189	I	Mwd	13	247.0
190	I	Mwc	9	230.6
191	I	Mwc	6	195.7
192	G	Mka	9	750.2
193	G	Mka	25	800.0
194	G	Mka	3	729.0
195	G	Mka	13	768.8
196	G	Mka	3	732.4
197	E	Mks	6	56.5
198	I	Mwd	13	262.7
199	D	Dks	52	758.0
200	G	Mku	32	845.4
201	D	Dks	63	851.8
202	G	Mka	10	751.9
204	I	Mwd	84	633.7
205	I	Mwb	149	1,229.9
207	E	Mks	7	80.0
49 AMi 1	H	Mwc	8	90.0
2	I	Mwd	16	368.0
3	I	Mwd	20	395.0
4	I	Mwd	24	407.3
6	I	Mwd	75	602.0
50 ABe 1	I	Mwc	9	231.0
2	I	Mwc	12	236.5
3	I	Mwd	13	241.5
4	I	Mwd	13	246.5
5	I	Mwd	13	251.5
6	I	Mwd	13	256.5
7	I	Mwd	13	261.5
8	I	Mwd	13	266.5
9	I	Mwd	13	271.5
10	I	Mwd	13	276.5
11	I	Mwd	13	281.5
12	I	Mwd	13	286.5
13	I	Mwd	13	291.5
14	I	Mwd	13	296.5
15	I	Mwd	13	301.5
16	I	Mwd	13	302.0
17	I	Mwd	13	306.5
18	I	Mwd	13	311.5
19	I	Mwd	13	316.5
20	I	Mwd	13	321.5
21	I	Mwd	13	326.5

See footnotes at end of table, p. 37.

ROCK SAMPLES—Continued

Sample no.[1]	Section	Member	Unit no.	Position in section (feet)
22	I	Mwd	14	347.5
23	I	Mwd	14	348.0
50 ABo 1	I	Mwd	16	368.0
2	I	Mwd	17	378.0
3	I	Mwd	19	386.4
4	I	Mwd	22	396.6
5	I	Mwd	24	406.5
6	I	Mwd	26	416.6
7	I	Mwd	27	426.5
8	I	Mwd	29	436.4
9	I	Mwd	30	445.7
10	I	Mwd	31	449.1
11	I	Mwd	32	456.1
12	I	Mwd	35	466.3
13	I	Mwd	37	475.5
14	I	Mwd	39	485.8
15	I	Mwd	40	492.7
16	I	Mwd	41	492.9
17	I	Mwd	46	502.8
18	I	Mwd	45	497.5
19	I	Mwd	49	531.8
20	I	Mwd	49	535.4
21	I	Mwd	49	541.5
22	I	Mwd	49	546.4
23	I	Mwd	58	551.7
24	I	Mwd	62	560.0
25	I	Mwd	71	566.4
26	I	Mwd	71	571.1
27	I	Mwd	72	576.1
28	I	Mwd	73	581.1
29	I	Mwd	73	586.1
30	I	Mwd	74	591.1
31	I	Mwd	74	596.1
32	I	Mwd	75	600.3
33	I	Mwd	76	604.2
34	I	Mwd	76	609.1
35	I	Mwd	78	614.1
36	I	Mwd	79	619.1
37	I	Mwd	81	624.1
38	I	Mwd	82	629.0
39	I	Mwd	84	633.9
40	I	Mwd	85	638.9
41	I	Mwd	87	644.1
42	I	Mwd	89	647.1
43	I	Mwd	89	652.1
44	I	Mwd	90	657.1
45	I	Mwd	91	663.0
46	I	Mwd	92	669.0
47	I	Mwd	93	672.9
48	I	Mwd	95	678.3
49	I	Mwd	95	683.2
50	I	Mwd	97	688.3
51	I	Mwd	97	693.3
52	I	Mwd	98	701.8
53	I	Mwd	98	706.8
54	I	Mwd	100	716.0
55	I	Mwd	102	725.6
56	I	Mwd	104	736.0
57	I	Mwd	105	746.1
58	I	Mwd	106	756.2
59	I	Mwd	107	766.1
60	I	Mwd	107	776.1
61	I	Mwd	107	786.1
62	I	Mwd	108	796.0
63	I	Mwb	111	805.7
64	I	Mwb	111	815.7
65	I	Mwb	111	825.7
66	I	Mwb	112	835.7
67	D	Dks	19	255.0
68	D	Dks	20	259.3
69	D	Dks	21	265.0
70	D	Dks	22	273.0
71	D	Dks	22	276.0
72	D	Dks	31	694.5
73	D	Dks	32	697.8
74	D	Dks	53	761.0

See footnotes at end of table, p. 37.

ROCK SAMPLES—Continued

Sample no.[1]	*Section*	*Member*	*Unit no.*	*Position in section (feet)*
50 ABo 75	F	Mks	13	115.0
92	A	Ds	1	0–50
93	A	Ds	3	180–210
94	A	Ds	5	350–400
95	A	Ds	9	1,000–1,030
96	A	Ds	13	1,350–1,400

[1] 49 ABo 1 designates sample 1 collected by Bowsher in Alaska in 1949, and so forth; Be refers to W. P. Brosgé, and Mi refers to R. L. Miller.
[2] From both fine- and coarse-grained limestone.
[3] From coarse-grained bioclastic limestone.
[4] From traverse above section H.
[5] From traverse below section C.
[6] From traverse below section I.

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INDEX

A New Upper Paleozoic Formation, Central Brooks Range, Alaska

By WILLIAM W. PATTON, JR.

EXPLORATION OF NAVAL PETROLEUM RESERVE NO. 4 AND ADJACENT AREAS, NORTHERN ALASKA, 1944–55

PART 3, AREAL GEOLOGY

GEOLOGICAL SURVEY PROFESSIONAL PAPER 303-B

Type section of a new upper Paleozoic formation. Prepared and published at the request of and in cooperation with the U. S. Department of the Navy, Office of Naval Petroleum and Oil Shale Reserves

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1957
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ILLUSTRATIONS

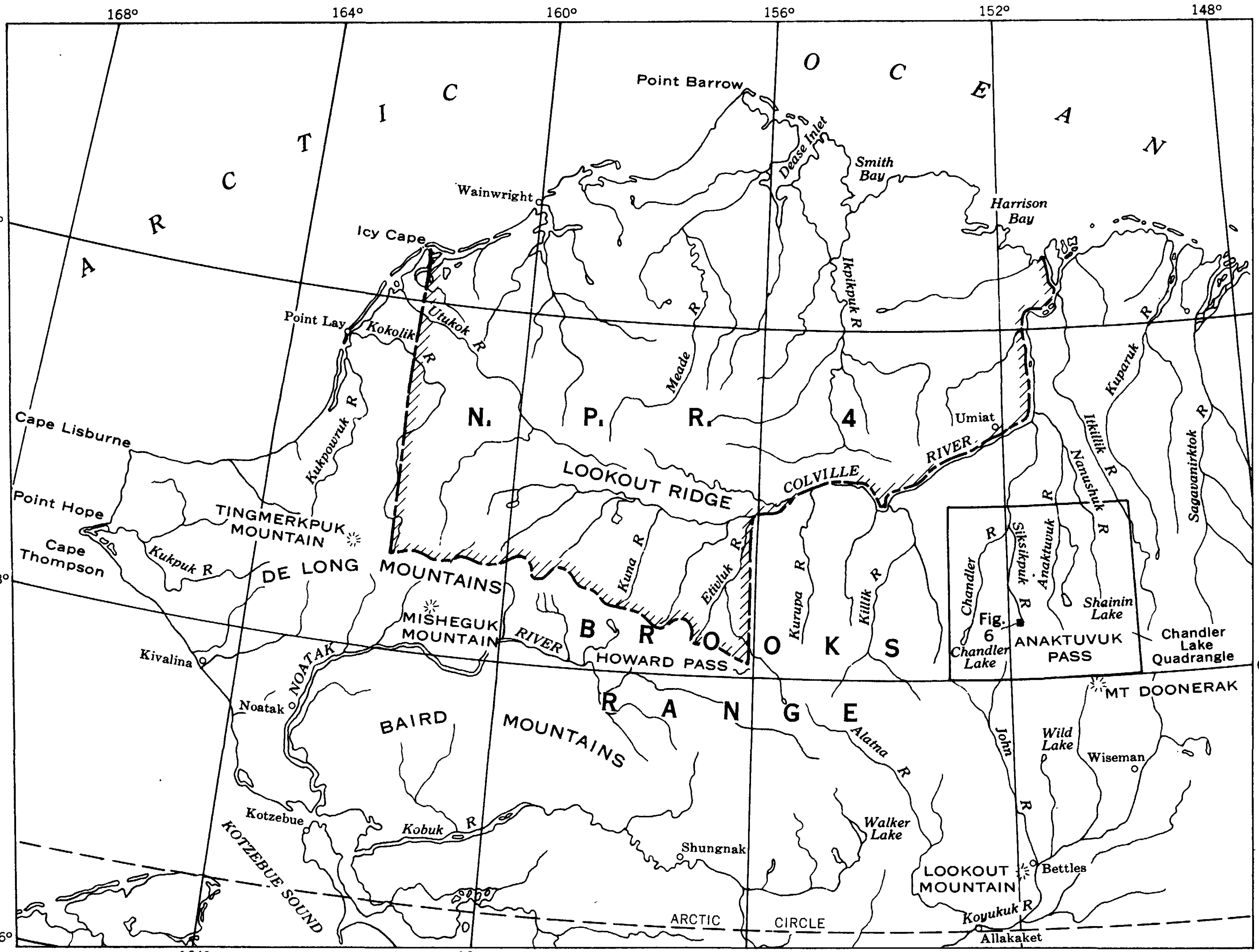

FIGURE 5.—Index map showing location of area of this report, Chandler Lake quadrangle, and Naval Petroleum Reserve No. 4. Scale: 1 inch=about 60 miles.

A NEW UPPER PALEOZOIC FORMATION CENTRAL BROOKS RANGE, ALASKA

By William W. Patton, Jr.

ABSTRACT

The Siksikpuk formation, a new upper Paleozoic rock unit in northern Alaska, consists of about 350 feet of variegated shale and siltstone of probable Permian age. It rests disconformably on rocks of the Lisburne group (Mississippian) and is disconformably overlain by the Shublik formation (Triassic) and, possibly, by younger Mesozoic formations.

The Siksikpuk formation, together with older and younger strata, crops out in the highly disturbed overthrust belt adjacent to the north front of the Brooks Range and is everywhere intensely folded and faulted.

INTRODUCTION

The name Siksikpuk formation is introduced to designate a heretofore undescribed sequence of shale and siltstone that occurs above the Lisburne group (Mississippian) (Bowsher and Dutro, 1957) and below the Shublik formation (Triassic) (Leffingwell, 1919) in the central Arctic Foothills and Brooks Range provinces of northern Alaska (see fig. 5). This sequence forms a well-defined stratigraphic unit and has been mapped from the Anaktuvuk River as far west as the Kiligwa River. It is typically exposed in a series of cutbanks on Tiglukpuk Creek and its tributaries, and derives the name from the Siksikpuk River, to which Tiglukpuk Creek is a major tributary.

TYPE LOCALITY

The Siksikpuk formation is not completely exposed at any one locality. The type section is a composite of 2 separate outcrops, approximately 2 miles apart, along a narrow belt of Siksikpuk exposures that parallels and lies immediately adjacent to the north front of the Brooks Range. Both outcrops have enough distinctive marker beds so that the two can be correlated and a complete section compiled. The composite thickness totals 354 feet, of which the basal 62 feet was measured in the cutbank on the east side of Skimo Creek at about lat 68°17′ N. and long 151°53′ W. The remainder of the section was measured in the cutbank on the east side of a small tributary to Tiglukpuk Creek at about lat 68°17′ N. and long 151°48′ W. (see fig. 6). Another section was measured along the Kiruktagiak River, 25 miles west of the type locality. There the formation thins to 250 feet, apparently because of pre-Shublik erosion.

DESCRIPTION

The Siksikpuk formation is composed chiefly of variegated green, gray, and dark red shale and siltstone that locally are notably calcareous, cherty, or ferruginous. All gradations from thin, fissile clay shale to platy silty shale to 6-inch beds of siltstone occur. Ellipsoidal concretions of barite characterize the lower two-thirds of the sequence. The variegated nature and the bright yellow and orange weathering of the ferruginous beds serve to distinguish, even at a distance, the Siksikpuk formation from the gray limestone and dark shale and chert of the underlying Lisburne group and from the dark shale of the overlying Shublik formation.

The composite section as measured in the type area is given below. The youngest beds are at the top; color names conform to usage in the National Research Council rock-color chart (Goddard and others, 1948).

Composite type section of Siksikpuk formation, Tiglukpuk Creek area, northern Alaska

[Basal 32 ft. exposed at loc. A, fig. 6; upper 292 ft. at loc. B, fig. 6]

	Thickness (feet)
Triassic: Shublik formation.	
Disconformity.	
Permian(?): Siksikpuk formation:	
6. Shale, medium- to dark-gray and dusky-yellow-green, silty and cherty, breaks with a hackly fracture; minor grayish-red shale and medium-gray calcareous siltstone that weathers grayish orange	75
5. Siltstone, dark-greenish-gray and medium- to medium-dark-gray, cherty; in beds 4–12 inches thick; minor dark-gray shale interbeds; locally weathers dark yellowish orange	40
4. Shale, dusky yellow green at base, dark gray near top, silty; scattered ellipsoidal barite concretions as much as 2 feet long and 10 inches in diameter	32
3. Shale and siltstone; grayish-red and dusky-yellow-green calcareous shale intercalated with beds of grayish-red-weathering dusky-yellow-green cherty siltstone 4–12 inches thick; minor amounts of medium- to dark-gray siltstone and shale	145
2. Siltstone, medium-gray and dusky-yellow-green, calcareous, in beds 4–12 inches thick; fossiliferous, with pyrite nodules and pyritized fossils	30
1. Shale, grayish-red and dusky-yellow-green	32
Total thickness	354
Disconformity.	
Mississippian: Lisburne group.	

AGE

A faunule of corals, brachiopods, and gastropods occurs in the basal 50 feet of this formation. Most significant for age determination are the corals, which have been studied by Helen Duncan. Concerning the age significance of the corals, Miss Duncan states (written communication, 1955):

A very few horn corals, mainly plerophyllid types, were found in the formation. A composite list of the corals obtained at three localities includes *Allotropiophyllum* sp. undet., *Euryphyllum* sp. undet., *Sochkineophyllum* cf. *S. artiense* (Soshkina), *Tachylasma* sp. undet., and *Ufimia*? sp. undet. The corals provide somewhat better evidence than the other elements in the faunule for assignment of the formation to the Permian system. *Tachylasma, Euryphyllum,* and *Allotropiophyllum* (s. s.) have been recorded only from the Permian in other parts of the world. The specimens of *Sochkineophyllum* are comparable to *S. artiense* (Soshkina), which occurs in the Artinskian of the Urals. *Ufimia* ranges into the Carboniferous but is more common in Permian rocks. The genera of corals here reported from the Siksikpuk formation have also been identified in collections from Permian formations in other parts of Alaska. So far, comparable assemblages have not been identified from rocks that are older than Permian.

Most of the gastropods appear to belong to a species which, because of its persistence throughout northern Alaska, may be considered a guide to this faunal zone. Ellis Yochelson has examined all the specimens from this faunule and has made the following comments.

Because most of the gastropods can be referred to the genus *Straparollus,* it is appropriate to comment on some of the morphologic features of that genus. *Straparollus* shells have two distinct layers. Although only the outer layer shows the true shape and ornamentation of the shell, the inner shell may show lines that might be mistaken for growth lines. It has been my experience that the shape exhibited by this inner shell is more rounded than the true shape, as shown by the outer shell in well-preserved specimens.

Deformation is another factor that may modify the true shape. Because the apex and first few whorls are planispiral, specimens of *Straparollus* may be compressed and not show a cracking of the shell or any other obvious evidence of deformation.

Taking these facts into consideration, I believe that all the *Straparollus* specimens in the Siksikpuk faunule represent a single species, in spite of a considerable diversity of form exhibited. The species itself is indeterminate and indicates no age other than post-Ordovician Paleozoic.

The brachiopods have been examined by J. Thomas Dutro, Jr., whose comments are included below.

In the type area of the Siksikpuk formation, the most significant of several brachiopod forms is a small spiriferoid referred tentatively to the genus *Spiriferella.* This genus is found in Permian rocks in Russia, India, Oregon, and west Texas and is present in collections of Permian fossils from elsewhere in Alaska. Species of this genus are also found in upper Pennsylvanian and Upper Carboniferous rocks in various places. The martinioid and phricodothyrid types, not distinctive enough to indicate any definite age, are ubiquitous in late Paleozoic faunas.

Collections made near Galbraith Lake in 1950 by W. P. Brosgé and H. N. Reiser, although not in the type area of the Siksikpuk formation, are undoubtedly from that unit and provide some additional information. A spiriferoid, perhaps assignable to *Purdonella,* occurs about 400–500 feet above the base of the section. Associated with it are a chonetid, perhaps *Chonetina,* and a martinioid species similar to that which is present in the type area. This fauna also contains a straparollid gastropod very like the species found in the lower zone. It seems to be a good Permian fauna.

The lower 50 feet of the Galbraith Lake section contains a faunule similar to that of the type area, where it also occurs near the base of the formation. There appears to be no reason to believe that this faunule is anything but Permian in age. The spiriferellid, phricodothyrid, and straparollid species are the same in both areas. It is probable that the fauna from the type area is also of Permian age.

The overall aspect of the fauna, particularly when compared with Permian fossil assemblages from elsewhere in Alaska, suggests a probable Permian age for the Siksikpuk formation.

GEOLOGIC SETTING

Everywhere the Siksikpuk formation appears to rest disconformably upon rocks of the Lisburne group. At the type locality the contact is marked by several feet of thoroughly oxidized clay and silt. In most places the Siksikpuk formation is overlain disconformably by

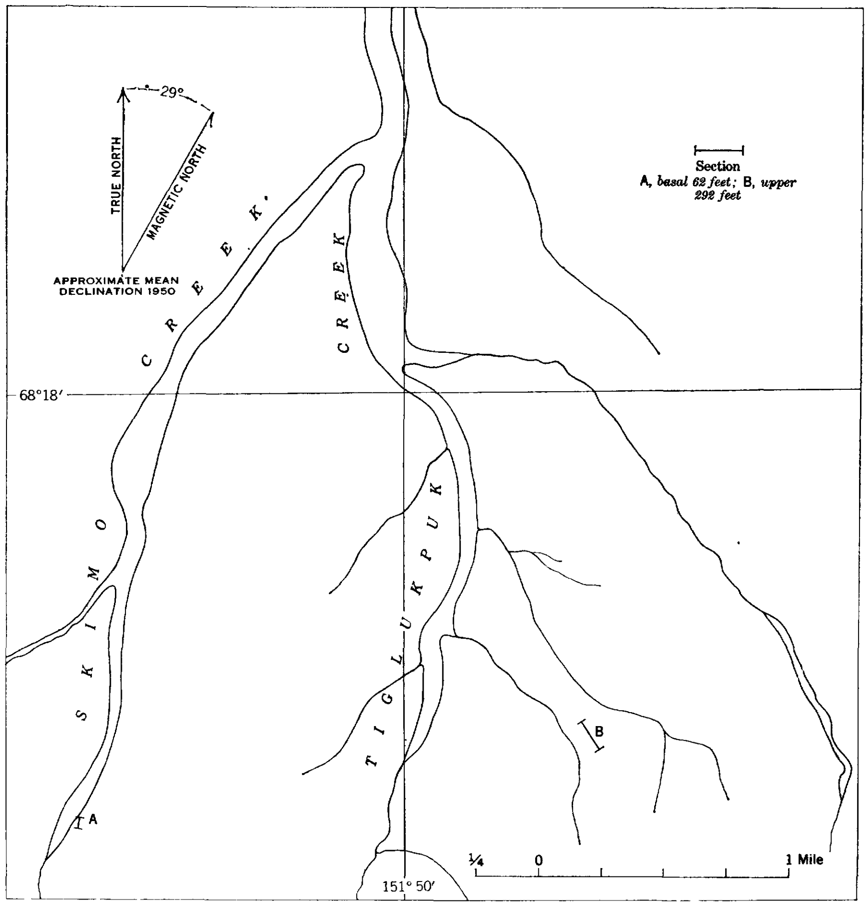

FIGURE 6.—Map showing location of type section.

the Shublik formation, although locally there is a suggestion that it is overlain by younger Mesozoic formations. Basal beds of the Shublik formation rest upon the Siksikpuk formation at the type locality. At the top of the Siksikpuk formation are several feet of heavily oxidized shale underlain by 115 feet of silicified(?) shale and siltstone.

The Siksikpuk formation, together with overlying Mesozoic and underlying late Paleozoic formation, is everywhere intensely faulted and folded, particularly along the highly disturbed overthrust belt that borders the north front of the Brooks Range. Because of its nonresistant nature, exposures are limited almost exclusively to small, scattered cutbanks along the nonglaciated, northward-flowing streams.

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