Summit Island Formation, a New Upper Cretaceous Formation in Southwestern Alaska

GEOLOGICAL SURVEY BULLETIN 1529–B

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CONTRIBUTIONS TO STRATIGRAPHY

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CONTRIBUTIONS TO STRATIGRAPHY

SUMMIT ISLAND FORMATION, A NEW UPPER CRETACEOUS FORMATION IN SOUTHWESTERN ALASKA

J. M. HOARE, W. L. COONRAD, and SCOTT MCCOY

ABSTRACT

The Summit Island Formation (new) in southwestern Alaska consists of nonmarine strata that were previously included in the Gemuk Group and in an unnamed unit thought to include strata of Cretaceous and early Tertiary age. The Summit Island Formation consists of thick-bedded conglomerate, sandstone, siltstone, and carbonaceous mudstone in which there is much carbonized plant material and a few thin coal seams. No complete section is exposed; the base and the thickest known section, about 850 m, are exposed in the sea cliffs on the northwest end of Summit Island. The top and about 160 m of section are exposed on the mainland northeast of Summit Island. The beds are gently folded and cut by several faults. The formation apparently rests with angular unconformity on highly deformed older Mesozoic rocks and is unconformably overlain by Tertiary volcanic rocks. Palynomorphs, fossil leaves, and the radiometric age of a dike that cuts the Summit Island Formation indicate a Late Cretaceous, probably Maestrichtian, age.

INTRODUCTION

Summit Island is in Togiak Bay, in the Hagemeister Island D-1 quadrangle in southwestern Alaska (fig. 1). The island, 4.5 km long and .5-1.5 km wide, is elongated northwestward and shaped something like a dumbbell. Much of the island is underlain by moderately deformed nonmarine strata consisting of intertonguing beds of conglomerate, sandstone, siltstone, and carbonaceous mudstone of Late Cretaceous age. These rocks are here named the Summit Island Formation for exposures on Summit Island.

The type section for the Summit Island Formation (fig. 1), which includes the base and overlying 850 m, is here designated as the exposures in the sea cliffs on the northwest end of Summit Island, sec. 25, T. 15 S., R. 66 W., Hagemeister Island D–1 quadrangle. A section that includes the top and uppermost part of the formation is exposed in the sea cliffs on the east side of an unnamed headland on the mainland 6 km northeast of Summit Island, SE¼ sec. 15, NE¼ sec. 22, T. 15 S., R. 65 W., Hagemeister Island D–1 quadrangle; this section

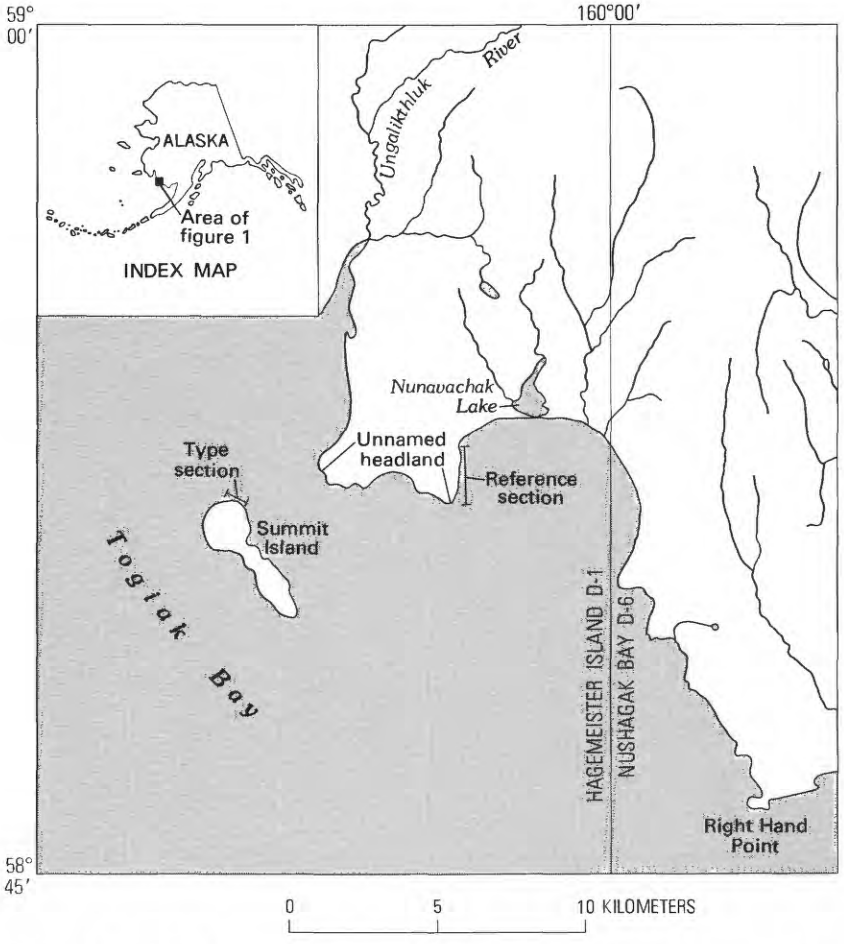

FIGURE 1.—Parts of Hagemeister Island D–1 and Nushagak Bay D-6 quadrangles, Alaska, showing location of type section and reference section of the Summit Island Formation.

is here designated a reference section. The total exposed thickness of Summit Island Formation is 1,000–1,200 m; a few hundred meters of additional section may be concealed by water northwest of Summit Island.

During earlier reconnaissance mapping (Hoare and Coonrad, 1961a, b), some of these strata were either included in an unnamed map unit thought to contain rocks of Cretaceous and Tertiary ages or were assigned to the upper part of the Gemuk Group (Carboniferous to Cretaceous). New fossil evidence and more detailed mapping (Hoare and Coonrad, 1978) showed that the rocks are of Late Cretaceous, probably Maestrichtian, age.

DISTRIBUTION, STRUCTURAL RELATIONS, AND THICKNESS

The distribution of the Summit Island Formation in the Goodnews A–3, Nushagak Bay D–6, and Hagemeister Island D–1 quadrangles is shown in figure 2. The Summit Island Formation presumably rests with angular unconformity upon older more highly deformed rocks of Mesozoic age, but no depositional contact is exposed. At three or four localities, massive beds of pebble-cobble conglomerate that constitute the base of the Summit Island Formation are in fault contact with the older rocks. Gently folded Tertiary volcanic rocks overlie the Summit Island Formation. The contact is apparently an angular unconformity because the Summit Island Formation was folded and eroded before the volcanic rocks were deposited and the volcanic rocks also overlie the older Mesozoic rocks. Little or no angular discordance, however, can be detected where the contact between the Summit Island and the overlying volcanic rocks is exposed because both units dip gently.

The bulbous ends of Summit Island are on the limbs of an asymmetrical anticline that trends northeastward across the island. Strongly deformed rocks of Jurassic age—the graywacke of Kulukak Bay—are exposed in the core of the anticline and are juxtaposed with the Summit Island Formation on the northwest and southeast limbs of the anticline along two northeast-trending faults that dip 70°–80° SE. The amount and direction of movement of the two faults are not known but may reflect slippage on the angular unconformity between overlying Summit Island Formation and the underlying more competent graywacke of Kulukak Bay. In the northwest limb of the anticline, the Summit Island Formation dips 45°–80° NW. (fig. 3*A*), and about 850 m of section is exposed in the sea cliffs. In the southeast limb of the anticline, the Summit Island Formation dips 10°–15° SE. (fig. 3*B*) and is overlain by pyroclastic volcanic rocks and intruded by many mafic sills. A vertical fault trending northwest, too small to show on the geologic map, truncates the beds near the southeast end of the island, juxtaposing a pile of mafic sills with the Summit Island Formation. The downthrown side of the fault is on the northeast. Defined by a vertical white vein of magnesite and dolomite several meters thick, the fault is highly visible (fig. 4).

The anticline and northeast-trending faults on Summit Island can be recognized on the mainland to the northeast. The Summit Island Formation forms the sea cliffs on the west and east sides of the unnamed headland 3–6 km northeast of Summit Island, and the graywacke of Kulukak Bay forms the cliffs on the southwest end of the headland. The rocks on the west side of the headland resemble

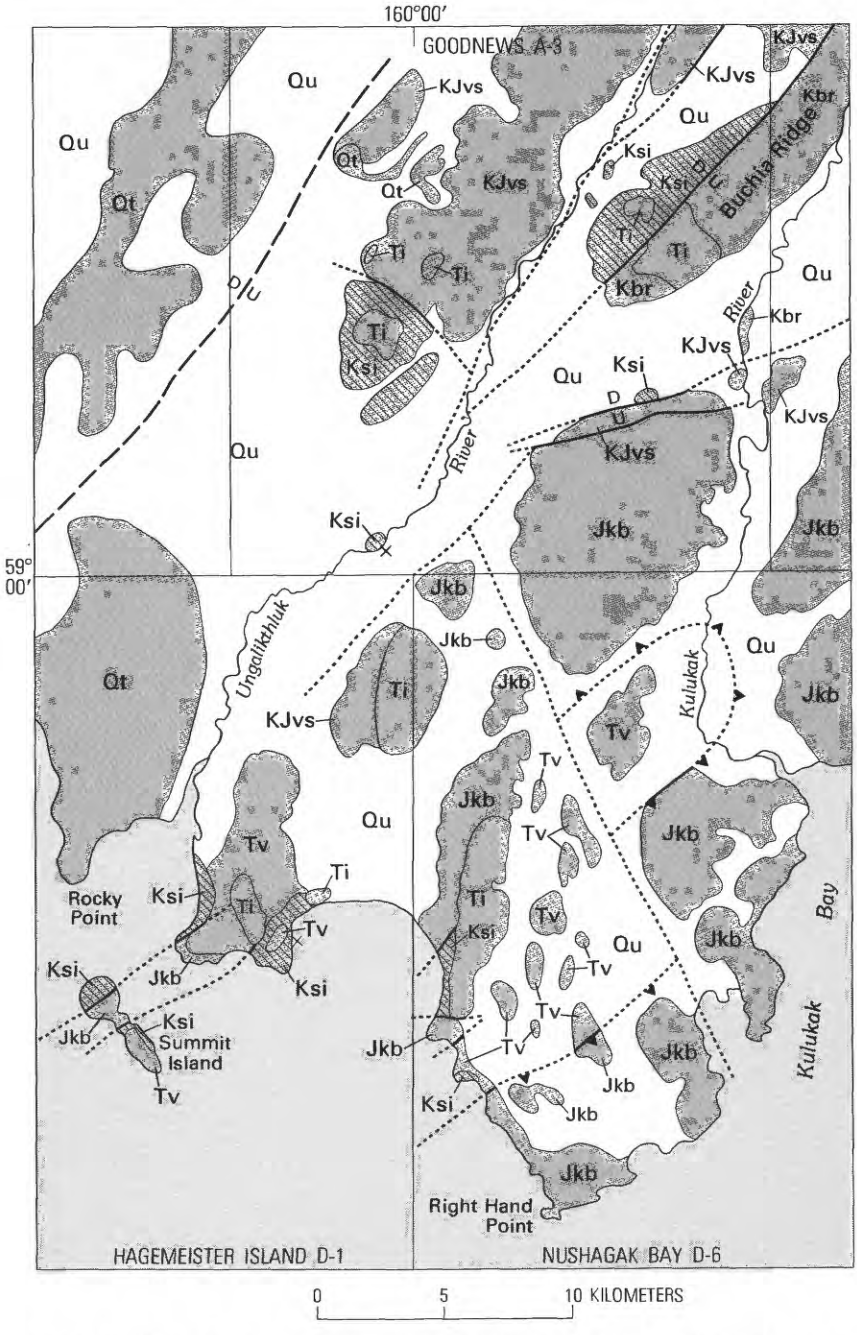

FIGURE 2.—Generalized geologic map showing distribution of Summit Island Formation in Goodnews A–3, Hagemeister Island D–1, and Nushagak Bay D–6 quadrangles, Alaska.

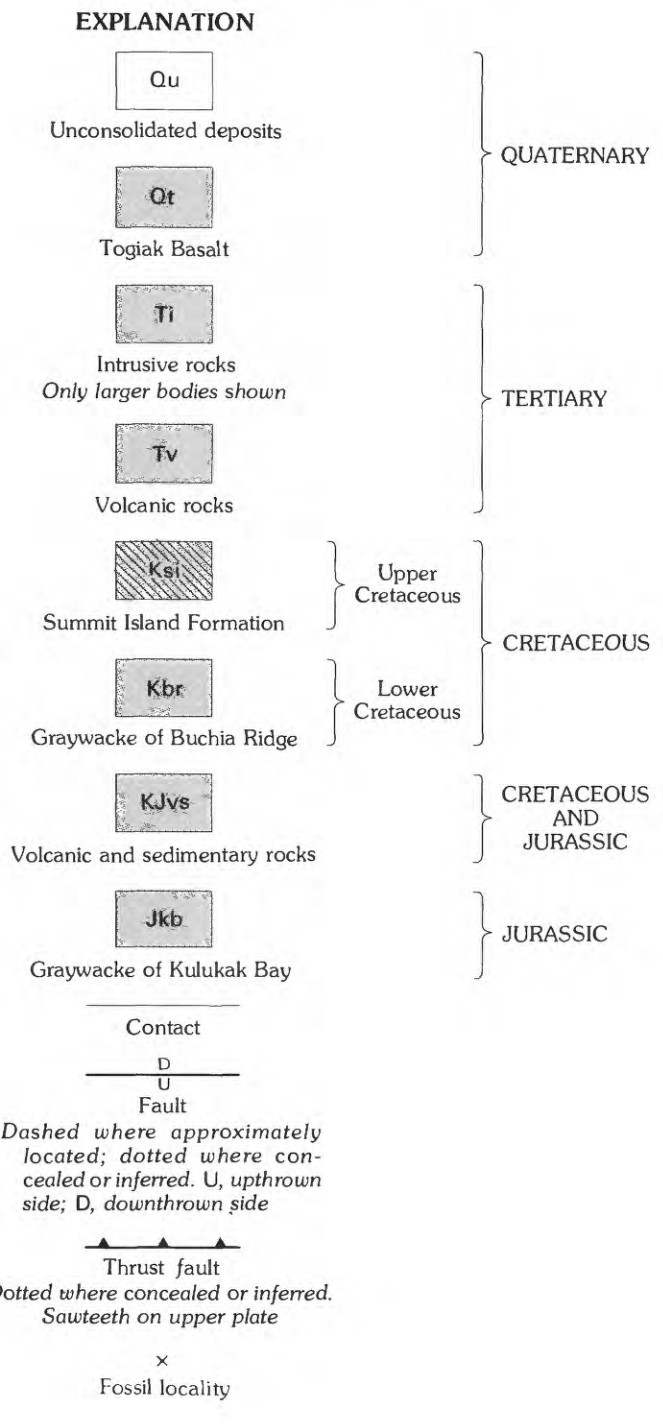
EXPLANATION
Qu
Unconsolidated deposits
Qt
Togiak Basalt
QUATERNARY
Ti
Intrusive rocks
Only larger bodies shown
Tv
Volcanic rocks
TERTIARY
Ksi
Summit Island Formation
Upper Cretaceous
Kbr
Graywacke of Buchia Ridge
Lower Cretaceous
CRETACEOUS
KJvs
Volcanic and sedimentary rocks
CRETACEOUS AND JURASSIC
Jkb
Graywacke of Kulukak Bay
JURASSIC
Contact
D
U
Fault
Dashed where approximately located; dotted where concealed or inferred. U, upthrown side; D, downthrown side
Thrust fault
Dotted where concealed or inferred. Sawteeth on upper plate
Fossil locality

FIGURE 3.—Summit Island Formation on Summit Island. *A*, Steeply dipping siltstone and sandstone beds with pebble lenses, at type section of Summit Island Formation, northwest end Summit Island. Dip of bedding is shown by alinement of flowering plants that grow from bedding-plane fractures extending from upper left to lower right. View southwest. *B*, Gently dipping conglomerate, sandstone, and siltstone of Summit Island Formation, southeast end Summit Island. View northwest.

FIGURE 3.—Continued

FIGURE 4.—Sheared vein of magnesite and dolomite in vertical fault between massive mafic Tertiary sills (left) and Summit Island Formation (right), southeast end of Summit Island. View south.

those in the type section on Summit Island. They dip 25°–75° NW. and are chiefly massive pebble-cobble conglomerate and sandstone with some interbedded siltstone and mudstone. These rocks are faulted out on the east side of the headland, where the Summit Island Formation dips gently southeast and consists of at least 160 m of carbonaceous mudstone, siltstone, and shale with some interbedded sandstone and pebbly sandstone (figs. 5*A*, 5*B*).

The contact between the Summit Island Formation and overlying Tertiary volcanic rocks is exposed on the east side of the headland where coarse volcanic breccia overlies the gently dipping sedimentary rocks. The structure east of the unnamed headland is probably that of a broad, shallow syncline in which the Summit Island Formation and the graywacke of Kulukak Bay are juxtaposed by northeast-trending faults at three or four places. In the outcrop area about 10 km northwest of Right Hand Point (fig. 2), the Summit Island Formation dips 20° westward. Here it consists of about 40 m of soft massive carbonaceous mudstone with some sandstone beds overlain by a thick felsic sill.

The easternmost coastal exposure of Summit Island Formation, about 6 km northwest of Right Hand Point (fig. 2), consists of about 50 m of massive sandy pebble-cobble conglomerate (fig. 6) and a few meters of soft carbonaceous siltstone, shale, and sandstone in which there are one or two thin coal seams. The rocks dip 25° NW. and form the sea cliffs for a distance of 100–150 m. They are overlain and flanked on either side by Tertiary volcanic rocks. The thickness and massive character of the conglomerate suggests that it may be near the base of the Summit Island Formation. If it is, this exposure of the Summit Island Formation is probably near an anticlinal axis or in an uplifted fault block that was truncated by erosion before the Tertiary volcanic rocks were deposited.

The distribution of the Summit Island Formation north of the coast (fig. 2) is rather poorly known because it is largely restricted to low-lying areas mantled by unconsolidated deposits. However, it clearly extends inland up the valley of the Ungalikthluk River, which is bounded on either side by faults and is structurally low. A section of gently dipping soft black shale that flanks Buchia Ridge on its northwest side probably is part of the Summit Island Formation. To the southeast, the shale is juxtaposed with much harder sedimentary rocks of the graywacke of Buchia Ridge of Early Cretaceous age along a southeast-dipping reverse fault. The south end of the ridge on the west side of the Ungalikthluk River valley is underlain by interbedded conglomerate, sandstone, and shale that dip gently southward and contain abundant carbonized plant debris. These rocks are assigned to the Summit Island Formation. Similar rocks that crop out along

FIGURE 5.—Carbonaceous mudstone, siltstone, shale, and sandstone in reference section of Summit Island Formation on east side of unnamed headland on mainland, 6 km northeast of Summit Island (figs. 1, 2). *A*, North view of nearly flat lying Summit Island Formation exposed in central part of reference section. *B*, Sea-cliff exposures at north end of reference section. Plant fossils occur at base of cliff near center of photograph. Boulders in foreground from a large rhyolite sill. Beds dip eastward; view north.

FIGURE 6.—Summit Island Formation on mainland 6 km northwest of Right Hand Point (fig. 2). Rock is chiefly massive sandy pebble-cobble conglomerate. Man at base of cliff provides scale. Beds dip northwest; view north.

the east side of the Ungalikthluk River valley southeast of Buchia Ridge juxtaposed with volcanic and sedimentary rocks of Jurassic and Early Cretaceous age by a southeast-dipping reverse fault are also assigned to the Summit Island Formation.

LITHOLOGIC CHARACTER

The Summit Island Formation consists of lenses and intertonguing beds of conglomerate, sandstone, carbonaceous siltstone, mudstone, and shale. The discontinuous character of the bedding is best seen in the lower part of the formation, where thick conglomerate beds commonly grade laterally and (or) vertically into pebbly sandstone and sandstone. Bedding in the Summit Island Formation tends to be thick to massive. Sandstone and conglomerate beds 1–3 m thick are common (fig. 3*B*) and some conglomerate beds are much thicker. Carbonaceous siltstone and mudstone in beds 1–3 m thick are also common, particularly in the upper part of the formation (figs. 5*A*, 5*B*). Beds and lenses of pebbly sandstone occur throughout the Summit Island Formation, but in general the formation becomes finer grained upward.

At its type section on the north end of Summit Island, the Summit Island Formation (fig. 7) consists of about 200 m of massive and thick-bedded pebble- cobble conglomerate overlain by about 650 m of inter-

bedded sandstone, siltstone, and mudstone and a few conglomerate beds. At its reference section, about 6 km northeast of Summit Island, the formation (figs. 5*A*, 5*B*) is about 75 percent carbonaceous mudstone, siltstone, and shale and 25 percent interbedded sandstone and pebble grit (fig. 7). About 6 km farther east along the seacoast, the uppermost part of the Summit Island Formation consists of about 40 m of soft carbonaceous mudstone capped by a massive felsic sill (fig. 8).

Conglomerate clasts are well rounded, generally no larger than 10 cm in diameter, and are mostly derived from flows, tuffs, and sedimentary rocks of Jurassic and Early Cretaceous age. The conglomerate also contains white quartz and sparse schist and plutonic clasts. The schist clasts probably derive from tectonically metamorphosed rocks that occur locally along some of the larger faults. The Summit Island Formation consists of rocks that are mostly various shades of gray except for the highly carbonaceous rocks, which are black. Sandstone and conglomerate beds are commonly brown on weathered surfaces. By its color, texture, and composition, the sandstone is graywacke. Sandstone and siltstone beds are made up largely of lithic fragments (60–70 percent) and lesser amounts of quartz and feldspar (commonly 10–15 percent). The lithic fragments are chiefly very fine grained cherty tuff and other volcanic rocks, "argillite," quartzite, and chert. Quartz appears to be more abundant in sandstone and siltstone than in conglomerate. Most feldspar is twinned plagioclase. There is a little secondary calcite on some of the feldspar, but the rocks are essentially noncalcareous. The cementing material is a claylike paste. The rocks are fairly hard but not tough; under the hammer, they generally fracture around the larger rounded grains. The hardness of the rocks appears to vary with their structure. On the northwest end of Summit Island and on the west side of the unnamed headland northeast of Summit Island, the rocks dip 45°–80° and are relatively hard and well indurated; on the southeast end of Summit Island and elsewhere on the mainland where the dip angle is low, the rocks are not so hard.

The general character of the Summit Island Formation suggests that it was probably deposited by shifting streams on a coastal plain that was underlain by previously deformed rocks of earlier Mesozoic age. The nonmarine character of the rocks is indicated by the occurrence of large-scale crossbedding, abundant ripple marks, lensing conglomerate beds, cut-and-fill structures, leaf impressions, abundant carbonized plant remains, carbonaceous mudstone and shale with coal seams, and the apparent absence of marine fossils.

A large number of dikes and sills intrude the Summit Island Formation. Dikes and sills also intrude the older Mesozoic rocks nearby but they appear to be much more numerous in the Summit Island Forma-

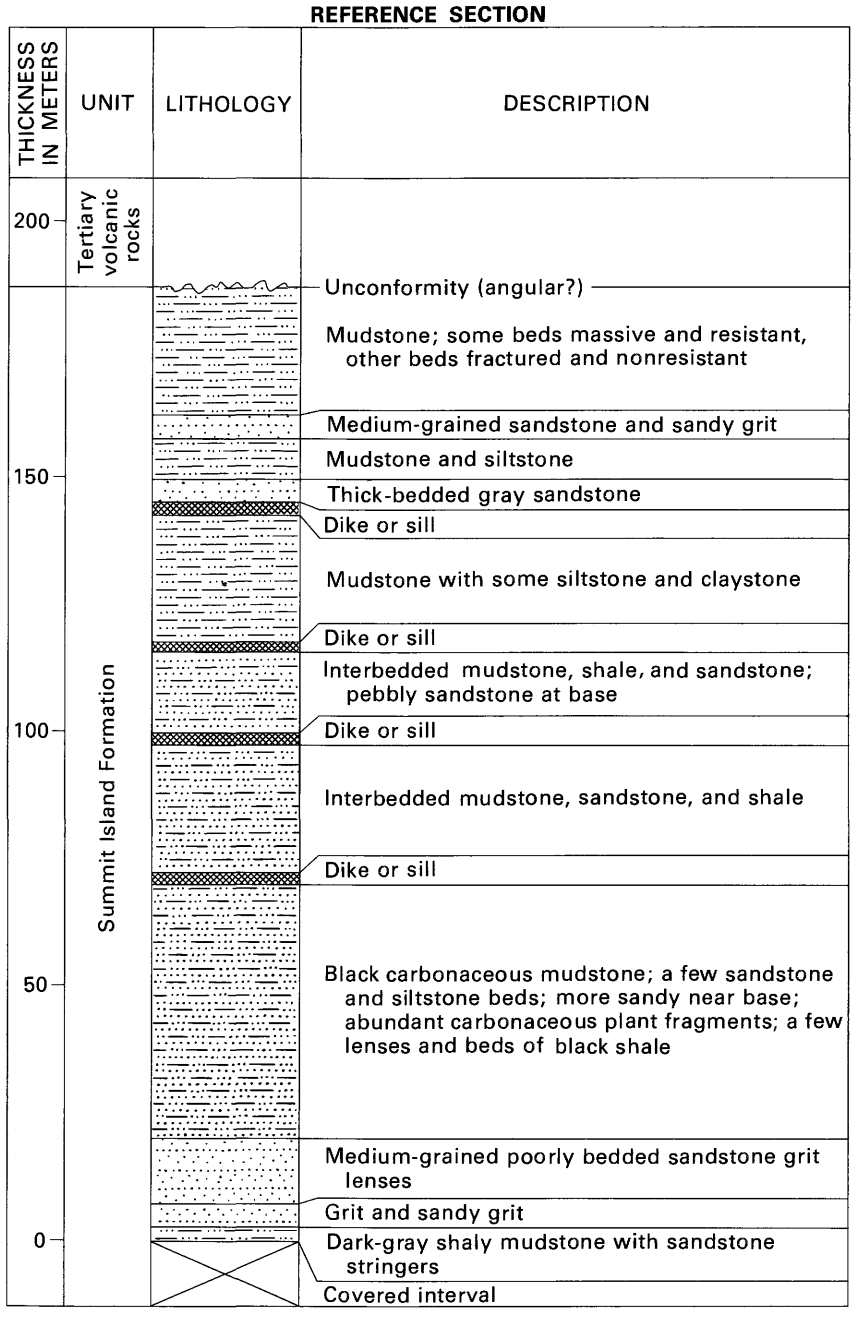

FIGURE 7.—Sections of the Upper Cretaceous Summit Island Formation in southwestern Alaska. Location of sections shown on figure 1.

TYPE SECTION

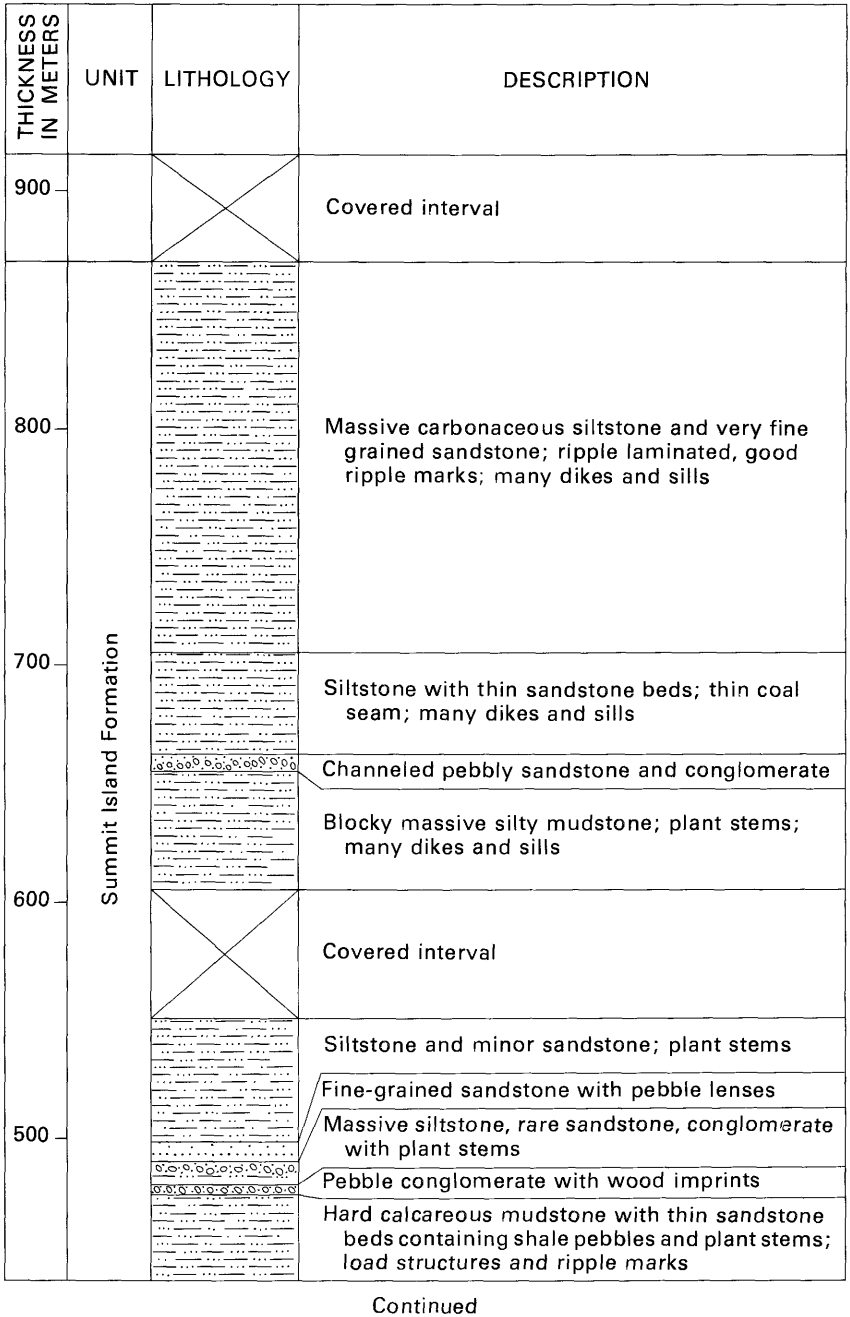

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FIGURE 7.—Continued

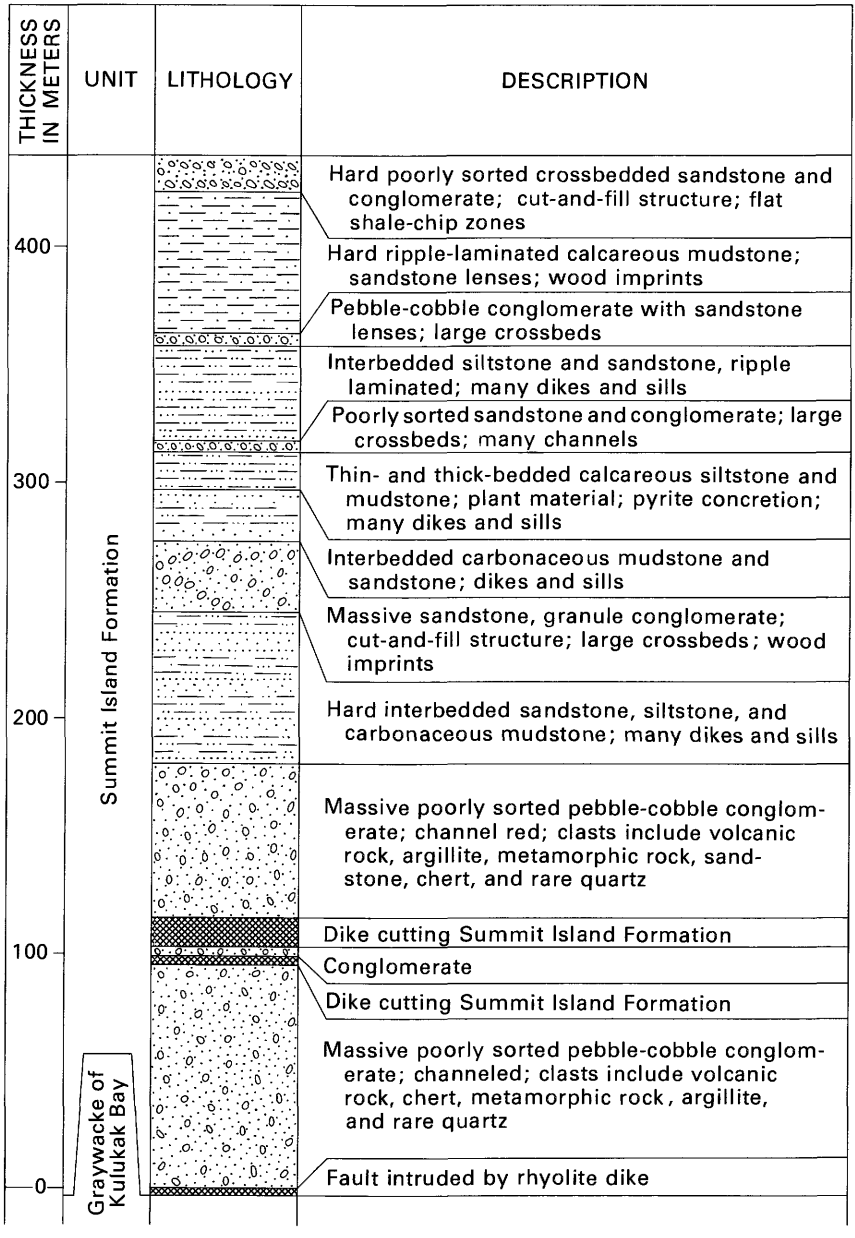

FIGURE 7.—Continued

tion. Sea cliffs on the mainland that expose the gently dipping dark-colored rocks of the Summit Island Formation are crisscrossed by

a maze of near-horizontal sills and near-vertical dikes (fig. 8). These intrusive rocks are highly visible because they are harder and lighter colored than the enclosing sedimentary rocks. On Summit Island, however, the intrusive rocks are generally more difficult to recognize because they are mostly dark-colored sills that are concordant with, and about the same color as, the enclosing sedimentary rocks.

The composition of the intrusive rocks ranges from fine-grained dark-colored basaltic and andesitic rocks to light-colored quartz and orthoclase porphyries of rhyolitic and dacitic composition. Most of the dikes and sills are a few centimeters to several meters thick, but at least two light-colored rhyolitic bodies are much larger. One of these sills, probably 50–150 m thick and at least 8 km^2 in area, caps a high sea cliff on the mainland 12 km northeast of Summit Island, apparently fed by a felsic dike that cuts up through the underlying Summit Island Formation (fig. 8).

Radiometric dating shows that the dikes and sills that intrude the Summit Island Formation are both early and late Tertiary age. Biotite from one of the large rhyolitic sills on the mainland gave a potassium-argon age of about 13 m.y., biotite from a mafic dike an age of 64 ± 2 m.y. (Hoare and Coonrad, 1978, table 1, samples B and D).

FIGURE 8.—Dikes and sills intruding the Summit Island Formation on mainland 10 km northwest of Right Hand Point (fig. 2). Light-colored rocks in sea cliff are rhyolitic and basaltic dikes and sills. Height of cliff, about 100 m. Fault in gully to right juxtaposes Jurassic graywacke of Kulukak Bay (foreground) with Summit Island Formation (background). View northwest.

AGE AND CORRELATION

Identifiable plant fossils were found near the base of the reference section for the Summit Island Formation on the east side of the unnamed headland on the mainland 6 km northeast of Summit Island, SE¼ sec. 15, T. 15 S., R. 65 W., Hagemeister Island D–1 quadrangle. R. W. Brown (written commun., 1952) identified the following forms:

Metasequoia occidentalis (Newberry) Chaney
Populus zaddachi Heer?
Cercidiphylum arcticum (Heer) Brown
Fraximus inordinata Hollick
Viburnum contortum Lesqrereux

Brown stated: "The foregoing identifications are chiefly in accordance with those of Hollick in USGS Professional Paper 182 and in some instances are not the names I would now use in publication. The material is somewhat fragmentary and my age assignment of early Tertiary should, therefore, be considered tentative."

Jack Wolfe, after examining a second collection from the same locality, stated (oral commun., 1974) that the fossil plants could be either Late Cretaceous or early Tertiary in age. A Late Cretaceous age is more probable on the basis of the radiometric age of 64±2 m.y. (Hoare and Coonrad, 1978, table 1, sample D) obtained on a mafic dike that intrudes the formation.

The best fossil evidence of the age of the Summit Island Formation is provided by palynomorphs (loc. No. D4733) collected in a small cutbank exposure on the Ungalikthluk River near the south edge of the Goodnews A–3 quadrangle, sec. 31, T. 13 S., R. 64 W. (fig. 2). The fossils occur in about 15 m of carbonaceous mudstone and siltstone containing coaly seams. R. H. Tschudy identified the following palynomorphs (written commun., 1975):

Expressipollis accuratus
Inoperturopollenites
Stereisporites cf. *S. princeps*
Stereisporites sp.
Cicatricosisporites
Hamulatisporis
aff. *Liliacidites* (*Schizoporis*) *complexus*
Osmundacidites
Alisporites grandis?
Lycopodiumsporites
Ovoidites
Tsugaepollenites
Gleicheniidites
Tricolpites
Aquilapollenites saginatus?

Aquilapollenites sp.
Azonia pulchella

Tschudy stated:

"This assemblage is unlike any Cretaceous assemblage from the United States or from southern Canada. Several of the taxa have been reported previously from Arctic Canada (Ellef Ringnes Island) and from the Ust-Yenisey botanical-geographical subprovince of Samoilovich in the western Siberian lowlands. The assemblage does not correlate exactly with plant microfossil assemblages from either region, but no other reference material from Arctic Canada or Alaska yielding assemblages even remotely resembling the assemblage from this sample is available. The presence of specimens *Expressipollis accuratus*, *Aquilapollenites*, aff. *Liliacidites complexus*, and *Azonia pulchella* almost certainly indicates a Late Cretaceous age. I strongly suspect that this sample represents the Maestrichtian, but in the absence of adequate well-dated reference material, I am reluctant to assign this sample to a definite Late Cretaceous stage."

The fossil evidence indicates that the Summit Island Formation is Late Cretaceous, probably Maestrichtian, in age.

The Summit Island Formation may be correlative with the rocks that underlie the interior lowland of Hagemeister Island about 40 km southwest of Summit Island. These rocks consist of interbedded sandstone, siltstone, and shale containing abundant fine carbonized plant debris and a few thin coal seams. Massive carbonaceous mudstone and siltstone and thick beds of pebble-cobble conglomerate such as occur on Summit Island are either absent or covered by unconsolidated deposits. The sandstone and siltstone generally contain much primary and secondary calcium carbonate and chlorite, neither of which is characteristic of the Summit Island Formation.

These rocks underlie a belt 2–3 km wide that extends from the south coast of Hagemeister Island northward to, or nearly to, the northwest coast. Except for one or two minor reversals, the beds dip 60°N–85° eastward. If not duplicated by faults, the section is at least 1,000–1,500 m thick. The belt is apparently bounded on the west and east by two steep southeast-dipping reverse(?) faults that juxtapose older volcanic and sedimentary rocks of earlier Mesozoic age.

Lithologically, the Hagemeister Island section resembles the Lower and Upper Cretaceous Kuskokwim Group (Cady and others, 1955) more than the Summit Island Formation. But the nearest exposed rocks of the Kuskokwim Group are almost 100 km north, whereas Summit Island is only 40 km northeast. At this time, the assignment of the Hagemeister Island section is uncertain.

The only diagnostic fossil in the Hagemeister Island section is *Metasequoia*, which ranges in age from Early Cretaceous (Albian) into the Tertiary (Jack Wolfe, written commun., 1976); *Metasequoia* also

occurs in the Summit Island Formation on the mainland. The relative nearness of Summit Island and the possible Late Cretaceous age of the Hagemeister Island section suggest a possible correlation with the Summit Island Formation, but if the same rocks were exposed 150 km north, they would undoubtedly be mapped as part of the Kuskokwim Group.

Other possibly correlative rocks occur on the Alaska Peninsula 300 km south and southeast, where strata of Late Cretaceous age are widespread. According to Burk (1965), the Chignik Formation of Campanian age and the overlying Hoodoo Formation of late Campanian and Maestrichtian age constitute a transgressive sequence grading upward from nonmarine to marine strata. The probable Maestrichtian age and the character of the Summit Island Formation suggest that it may be the nonmarine equivalent of Burk's Hoodoo Formation.

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