Cretaceous Stratigraphy of the McCarthy A-4 Quadrangle Southern Alaska

GEOLOGICAL SURVEY BULLETIN 1180-A

Jones and Berg—CRETACEOUS STRATIGRAPHY, McCARTHY A-4 QUADRANGLE, SOUTHERN ALASKA—Geological Survey Bulletin 1180-A

Cretaceous Stratigraphy of the McCarthy A-4 Quadrangle Southern Alaska

By DAVID L. JONES *and* HENRY C. BERG

CONTRIBUTIONS TO STRATIGRAPHIC PALEONTOLOGY

GEOLOGICAL SURVEY BULLETIN 1180-A

A description of the lithology and paleontology of three units of formational rank in the upper Chitina Valley region of Alaska

---

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1964

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

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

CONTENTS

ILLUSTRATIONS

[Plate is in pocket]

CRETACEOUS STRATIGRAPHY OF THE McCARTHY A-4 QUADRANGLE, SOUTHERN ALASKA

By DAVID L. JONES and HENRY C. BERG

ABSTRACT

Cretaceous sedimentary rocks in the McCarthy A-4 quadrangle, south-central Alaska, have an aggregate thickness of more than 8,000 feet and are divided into three unnamed formations. The lowest formation, unit K_1, of Albian and Cenomanian ages, consists of 600 to 800 feet of interbedded conglomerate, sandstone, shaly siltsone, and siliceous shale which show marked facies changes throughout the area. The middle formation, unit K_2, unconformably overlies unit K_1 and consists of 4,000 or more feet of dominantly black silty shale and siltstone ranging in age from Coniacian to Campanian. The upper formation, unit K_3, comprises about 3,000 feet of massive conglomerate, sandstone, and interbedded gray siltstone of Campanian or Maestrichtian age; some of these beds may be of nonmarine origin. No diagnostic fossils are available to give a precise age for this unit.

The Cretaceous rocks rest on folded and eroded Triassic and older rocks, and are overlain by Quaternary glacial and fluvial deposits. The Cretaceous formations are gently folded into a series of broad westward-plunging anticlines and synclines; locally, the structure is complex owing to faulting and intrusion of many porphyritic dikes.

INTRODUCTION

This report summarizes the Cretaceous stratigraphy of the McCarthy A-4 quadrangle, southern Alaska. Only that part of the quadrangle north of the upper Chitina River is herein considered because that part south of the river has not been mapped in detail. This investigation, carried out by the U.S. Geological Survey, is part of a larger study of the areal geology, stratigraphy, and ore deposits of the upper Chitina Valley region (fig. 1).

This study is based primarily on geologic mapping in 1961 by D. J. Miller and Robert MacColl. Additional field observations and fossil collections were made by D. L. Jones in 1961 and by E. M. MacKevett, Jr., and the authors of this report in 1962. D. L. Jones is responsible for the stratigraphic section and fossil identifications, and H. C. Berg is responsible for detailed mineralogic description of the rocks.

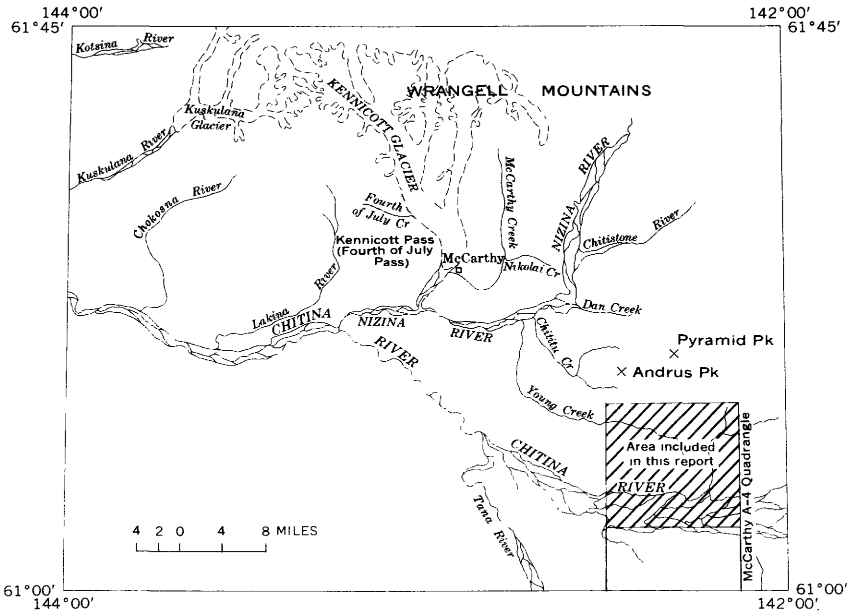

FIGURE 1.—Index map showing location of McCarthy A–4 quadrangle and position of geographic features mentioned in text.

One of the objectives of this project is to derive a system of stratigraphic nomenclature that will adequately reflect the character and will show the relationships of the complexly intertongued units of the Cretaceous rocks of the upper Chitina Valley. At the present time only two names, the Kennicott Formation and the Matanuska Formation, have been applied to the Cretaceous rocks, but the usage of these terms has not been consistent. For the most part, the name Kennicott has been applied on a faunal rather than lithologic basis, and changes in ideas on the ages of certain fossils have resulted in changes in correlation of rock units and in the nomenclature applied to them. A brief history of the vicissitudes in usage of the term Kennicott is presented and will serve as a general summary of previous investigations of the Cretaceous rocks of the upper Chitina Valley.

No stratigraphic names are herein applied to the Cretaceous rocks of the McCarthy A–4 quadrangle even though three units of formational rank are mapped. It was thought best to refrain from applying formal stratigraphic names until the data from the McCarthy A–4 quadrangle can be integrated with data obtained elsewhere from field studies now in progress.

The three Cretaceous formations (pl. 1) range in age from early Albian to Campanian or Maestrichtian. The lowest formation consists of sandstone and siltstone, the middle formation of black shale and siltstone, and the upper formation of massive conglomerate and sandstone with minor siltstone. Deposition of this sequence was not continuous, however, and at least two unconformities are present. The Cretaceous rocks rest on an eroded surface cut on Upper Triassic and older rocks, and are locally overlain by Pleistocene and Recent glacial and alluvial deposits. Thick Tertiary sedimentary and volcanic rocks crop out nearby but are absent in the McCarthy A–4 quadrangle.

The Cretaceous rocks are broadly folded into a series of gently westward-plunging anticlines and synclines, and in some places the structure is complex, owing mainly to faulting which has produced steep dips and local repetition of strata. Only the major faults have been mapped. Because of the prevalence of unmapped minor faults, discontinuous exposures, and rugged terrain and because the mapping was carried out in reconnaissance fashion, it has been impossible to measure any stratigraphic section in detail. The measured sections shown on plate 1 were made partly by pace and compass methods, partly by altimeter surveys, and partly by computing thickness from the topographic map. All these measurements are undoubtedly subject to wide error.

PREVIOUS WORK

Cretaceous rocks of the upper Chitina Valley and surrounding areas, including the A–4 quadrangle, have been studied by reconnaissance methods by several geologists, and the nomenclature applied to these rocks has not been consistent. Rohn (1900) first made geological observations in the Chitina Valley and applied the name Kennicott Series to light-gray rather coarse-grained *Aucella*-bearing arkose that crops out in and near Fohlin Creek and on the north side of Kennicott Pass, currently called Fourth of July Pass (see fig. 1). Black shales cropping out on the south side of the pass were noted but not included within the Kennicott Series. Other rocks correlated with the type Kennicott included massive conglomerate and dark shales exposed on the upper part of McCarthy Creek. These rocks were considered to be of Late Jurassic or Early Cretaceous age.

Schrader and Spencer (1901) adopted the term Kennicott and designated as Kennicott Formation a narrow strip of rocks in and west of Fohlin Creek and along the Kennicott Pass trail, a small patch near the headwaters of Nikolai Creek, and conglomeratic rocks capping the ridge between Young Creek and the Chitina River.

Moffit and Maddren (1909) followed this usage without modification, but Moffit and Capps (1911) applied the name Kennicott Formation to all upper Mesozoic rocks younger than the Upper Triassic and Lower Jurassic McCarthy Formation, including the black shale exposed from Young Creek to Copper Creek and sandstone capping Pyramid and Andrus Peaks. This usage includes almost all the rocks now known to be of Cretaceous age and is a great departure from Rohn's original concept.

Moffit and Overbeck (in Moffit, 1918) studied the rocks of the upper Chitina Valley, particularly those in the area between Young Creek and the Chitina River, but dropped the name Kennicott Formation and did not apply any formational names to the stratigraphic units recognized. They believed that both Upper Jurassic and Cretaceous rocks were present in this area; the Jurassic rocks were identified on the basis of the supposed presence of *Aucella* and were correlated with the type Kennicott.

Three Cretaceous lithologic units were recognized by Moffit and Overbeck. The lowest unit, not shown separately on the geologic map, included sandstone exposed north of the Chitina River, at the mouth of Canyon Creek, and near the big bend of Young Creek. These rocks correspond approximately to unit K_1 shown on plate 1. The so-called Upper Jurassic rocks shown by Moffit and Overbeck in a small patch west of Canyon Creek are now known to be of Cretaceous age and belong to unit K_1.

Moffit and Overbeck recognized a unit, overlying the lower sandstone unit, composed predominantly of black and reddish-brown shale with locally abundant limestone concretions and beds. This unit corresponds to unit K_2 shown on plate 1.

Moffit and Overbeck recognized a third unit, overlying the black shale, composed of conglomerate, sandstone, sandy shale, and arkose that crops out on the ridge between the Chitina Valley and Young Creek, and also caps Pyramid and Andrus Peaks to the north. This unit corresponds to unit K_3 shown on plate 1.

Fossils from the lower two units were submitted to T. W. Stanton and F. H. Knowlton for identification; the upper unit yielded no diagnostic fossils (see Moffit, 1918, p. 37–45). On the basis of the marine invertebrate fossils from the lower units, Stanton assigned a mid-Cretaceous age to some of the rocks and correlated them with the Haida Formation of the Queen Charlotte Islands; on the basis of plants, Knowlton assigned these same rocks to the Upper Jurassic. Since these early identifications were made, no paleobotanist has studied the Chitina Valley floras and attempted to rectify these disparate age assignments.

The reaction against the over-expanded usage of the term Kennicott was carried one step farther by Moffit and Mertie (1923, p. 50) who in a discussion of the geology of the Kotsina-Kuskulana district in the lower part of the Chitina Valley, stated that "it seems desirable to restrict it [the name Kennicott Formation] to Rohn's original definition and to include in the formation only beds containing the characteristic fossils of his localities." Martin (1926, p. 327–349) summarized in detail the previous history of investigations in the Chitina Valley, and followed Moffit and Mertie in restricting the Kennicott Formation to "the *Aucella*-bearing beds of Bear and Fohlin Creeks and Kuskulana Pass." Moffit (1938, p. 71) then confused this meaning by including in the Kennicott Formation the thick sequence of Upper Cretaceous black shale exposed in the mountain south of Fourth of July Pass. Moffit (1938, p. 72) stated that this shale is continuous with black shale exposed near the town of McCarthy and on Dan and Chititu Creeks, although he did not apply the name Kennicott to these beds.

On his geologic map, Moffit (1938) included all beds considered to be Cretaceous under one symbol and stated that the Kennicott Formation was included. Therefore, some doubt exists as to just which units Moffit included in the Kennicott Formation, and this confusion is reflected in the correlation chart by Imlay and Reeside (1954), who assigned Lower Cretaceous (Albian) deposits to the Kennicott Formation and the Upper Cretaceous deposits of Young and Chititu Creeks to the Matanuska Formation. However, in their discussion of the Lower Cretaceous rocks, they included 3,000 feet of black shale that is probably equivalent to beds elsewhere included in the Matanuska Formation. In a later paper, Imlay (1960) used the term Kennicott Formation in a table showing geographic distribution of Albian fossils, but no other mention of the term was made in the text.

Because of the various meanings attached to the term Kennicott Formation and because its recognition is based mainly on faunal rather than lithologic criteria, it seems best not to apply the term to rocks of the A-4 quadrangle until geologic mapping is completed in the vicinity of Fourth of July Pass and the stratigraphic section there worked out in detail. Preliminary unpublished studies by Imlay, Jones, and others have shown that only lower Albian deposits containing the *Moffitites* and *Brewericeras* faunas (Imlay, 1960) are present on the north side of the pass. These beds are overlain by a massive conglomerate containing large blocks of Triassic McCarthy shale, as well as reworked concretions from the underlying Cretaceous beds. The age of the conglomerate is not known but it may be Upper Cretaceous and represent the basal beds of a Coniacian transgression that has been recognized elsewhere. If this is so, the type Kennicott Formation should probably be restricted to the few hundred feet of Albian sandstone and shale below the conglomerate.

724-343 O—64——2

STRATIGRAPHIC SUMMARY

UNIT K_1

LITHOLOGY

The basal Cretaceous formation of the McCarthy A–4 quadrangle is a complexly intertongued assemblage of sandstone, siltstone, shale, siliceous siltstone, and minor conglomerate. This assemblage rests unconformably on older Mesozoic (Triassic) or Paleozoic (Mississippian) rocks. Facies changes within this unit seem to be abrupt, but, because of poor outcrops and numerous minor faults, these changes have not been traced out in detail. The upper contact is placed at the top of a light-brown-weathering siliceous siltstone unit that is especially conspicuous on the south side of MacColl Ridge west of Canyon Creek (pl. 1). Unit K_1 is overlain unconformably by the dominantly black shale unit K_2 that contains a few thin sandstone beds at and near the base.

The most complete sequence of unit K_1 is exposed on the south limb and nose of the anticline north of the Chitina River; the exposures at the mouth of Canyon Creek are particularly good (section 1 of pl. 1). The strata on the north side of the anticline, especially those immediately west of Canyon Creek, are structurally complex and probably do not represent a continuous section. The lower part of the formation at the mouth of Canyon Creek consists of a few feet of pebble conglomerate that grades upward into massive very fine grained to fine-grained greenish-gray fossiliferous sandstone that locally weathers pink. This basal sandstone unit, which is about 100 feet thick, is overlain by about 50 feet of pinkish-brown-weathering shaly siltstone, which underlies about 200 feet of dark-gray sandy siltstone. The upper part of the siltstone contains abundantly fossiliferous calcareous concretions. The uppermost 20 to 30 feet of the exposed Cretaceous rocks at the mouth of Canyon Creek consists of massive dark-greenish-gray very fine grained silty sandstone.

The basal sandstone unit is generally moderately well indurated, thin- to medium-bedded, fine and very fine grained, and poorly sorted. Locally, minor thin beds of conglomerate and coarse-grained sandstone are present. Because the unit contains considerable clay matrix and abundant unstable constituents, it is classified as lithic wacke or feldspathic wacke.[1] A small part of the unit, however, is sufficiently well sorted and free of clay matrix to be called arenite (lithic). Thin

[1] The term "wacke" is defined by Gilbert (in Williams, Turner, and Gilbert, 1954, p. 290) as an impure sandstone containing more than 10 percent argillaceous matrix. A lithic wacke contains more rock fragments than feldspar grains; a feldspathic wacke, more feldspar than rock fragments, feldstar constituting 10 to 25 percent of the rock.

section examination of the basal sandstone unit shows that it is composed chiefly of angular to subrounded detrital particles of quartz and feldspar, which together constitute about 50 percent of the rock; lithic fragments—mainly slate or phyllite, siltstone, volcanic rock, and chert—make up 15 to 45 percent of the rock; and potassium feldspar constitutes from 0 to 10 percent of the rock. Ferruginous "dust," biotite, muscovite, and pyrite are minor detrital constituents; apatite, zircon, and epidote are commonly present in trace amounts. The matrix—composed mainly of chlorite, clay, and calcite—generally constitutes 10 percent or more of the rock; in the arenites, calcite is the chief cementing material. Locally, glauconite is abundant and imparts a green color to the rock.

The sequence exposed about 4 miles to the west on the nose of the anticline (section 2 of pl. 1) differs from that at Canyon Creek in several respects. The 200 feet of siltstone overlying the basal sandstone unit weathers pinkish brown and contains calcareous concretions that weather light gray and are only sparsely fossiliferous. This unit is overlain by about 50 to 80 feet of massive coarse-grained maroon and greenish-gray sandstone that grades upward into light-gray brownish-yellow-weathering platy siliceous siltstone. This platy siltstone unit is 100 to 150 feet thick and crops out nearly continuously along the north limb of the anticline. Locally, the basal beds of this unit consist of conglomerate containing granitic debris. The siliceous siltstone contains fragments of *Inoceramus*, ammonites, Foraminifera, and abundant Radiolaria.

To the north along Young Creek (fig. 2), unit K_1 consists predominantly of fine-grained massive to thin-bedded gray sandstone that contains a minor amount of interbedded gray siltstone and weathers light brown (section 3 of pl. 1). A continuous sequence of beds is not exposed here, but the thickness is estimated to be about 150 feet. The pink-weathering basal sandstone found to the south is missing, as is the thick concretionary siltstone section. The uppermost observable beds consist of platy light-brown siliceous siltstone similar to that on the south side of MacColl Ridge. The underlying brown sandstone is abundantly fossiliferous and has yielded a prolific ammonite fauna.

The stratigraphic sequence of unit K_1 exposed east of Canyon Creek has not been worked out in detail, mainly because of inaccessibility, poor outcrops, and many unmapped small faults. These beds consist predominantly of fine- to medium-grained sandstone, subordinate gray siltstone, and minor conglomerate. The uppermost beds consist of black shale similar to that of the younger unit K_2 and are exposed only in a downfaulted block on an unnamed tributary to upper Canyon Creek, at the eastern margin of the McCarthy A–4 quadrangle.

FIGURE 8.—View northeastward across Young Creek Valley; bluffs west of big bend in the left central part of photograph are sandstone of unit K_1. The hills in the upper central part, east of Young Creek, are underlain by black shale of unit K_2.

FOSSILS AND AGE

The basal sandstone of unit K_1 contains an abundant molluscan fauna characterized by the following forms:

Moffitites robustus Imlay
"*Kennicottia bifurcata*" Imlay
Leconteites deansi (Whiteaves)
Hypophylloceras cf. *H. californicum* (Anderson)
Phyllopachyceras chitinanum Imlay
Anagaudryceras aurarium (Anderson)
Ptychoceras cf. *P. laeve* (Gabb)
Aucellina sp.

This assemblage, termed by Imlay (1960) the "*Moffitites robustus* fauna," is identical with that reported by Imlay (1960) from the basal Cretaceous beds in the Kennicott (= Fourth of July) Pass area. Localities in the McCarthy A–4 quadrangle from which this fauna were obtained are shown on plate 1 by open circles. Based on stratigraphic position and correlation with other areas, an early Albian age seems probable for this assemblage.

The siltstone unit exposed above the basal sandstone at the mouth of Canyon Creek and the buff to brown sandstone exposed along Young Creek have yielded another rich molluscan fauna dominated by the ammonite *Brewericeras hulenense* (Anderson). Localities yielding this fauna are shown on plate 1 by solid circles. The characteristic forms of this assemblage are:

Brewericeras hulenense (Anderson)
Puzosia alaskana Imlay
Grantziceras glabrum (Whiteaves)
Arcthoplites belli (McLearn)
Parasilesites bullátus Imlay
Hulenites sp.
Calliphylloceras nizinanum Imlay
Douvilleiceras mammillatum (Schlotheim)
Tetragonites kiliani (Jacob)

The presence of *Douvilleiceras mammillatum* and *Brewericeras hulenense* is indicative of a late early or early middle Albian age.

The upper beds of unit K_1 are, for the most part, sparsely fossiliferous, but sufficient fossils have been found to date them as latest Albian and Cenomanian and to show that deposition was not continuous throughout K_1 time. Localities yielding fossils of these ages are shown by triangles on plate 1.

Several crushed specimens of *Desmoceras* (*Pseudouhligella*) *dawsoni* (Whiteaves), indicative of a latest Albian age (Matsumoto, 1959, p. 59–61), have been found in the light-brown siliceous siltstone exposed on the south side of MacColl Ridge. No species of Middle Albian age, equivalent to those of the *Oxytropidoceras packardi* zone of California, have been found in the siliceous siltstone anywhere in the McCarthy A–4 quadrangle. Their absence may be related to an unconformity during that time, as suggested by the presence of conglomerate and sandstone at the base of the siliceous siltstone on MacColl Ridge. Apparently middle Albian rocks either were not deposited or were removed by erosion.

A single specimen of *Marshallites*, likewise indicative of a late Albian or Cenomanian age, was obtained from the uppermost beds of the sequence exposed at the mouth of Canyon Creek (USGS Mesozoic loc. M1330). No conglomerate or coarse sandstone is present there, nor is any stratigraphic break readily apparent, although these uppermost beds are somewhat coarser grained than the underlying siltstone. The presence of *Brewericeras hulenense* only 10 to 20 feet below the *Marshallites* suggests however, that a disconformity representing mid-Albian time may be present.

East of Canyon Creek, fossil localities of latest Albian or early Cenomanian age have been found. One locality (USGS Mesozoic loc. M1333), just east of the eastern margin of the McCarthy A–4 quadrangle, has yielded a prolific fauna characterized by:

Partschiceras japonicum (Matsumoto)
Neophylloceras seresitense (Pervinquiere)
Sciponoceras sp.
Zelandites inflatus Matsumoto
Marshallites cumshewaensis (Whiteaves)
    n. sp.
Anagaudryceras sacya (Forbes)
Desmoceras (*Pseudouhligella?*) n. sp.
Inoceramus concentricus Parkinson
    sulcatus Parkinson
    comancheanus Cragin

This fauna is probably equivalent to the lower part of the *D.* (*P.*) *dawsoni* zone, but its precise stratigraphic position cannot be determined as the beds from which it was obtained are in fault contact with Triassic rocks.

Desmoceras (*Pseudouhligella*) *japonicum* Yabe and *Sciponiceras* sp. were obtained from the black shale sequence exposed along an unnamed creek about 4½ miles east of the Young Lakes (USGS Mesozoic locs. M1292 and M1676; the latter is east of the A–4 quadrangle). These fossiles are indicative of a Cenomanian age.

UNIT K_2

LITHOLOGY

The intermediate Cretaceous formation, unit K_2, consists of black shale and siltstone but includes minor amounts of reddish-brown siltstone, greenish-gray fine-grained sandstone, and abundant gray to reddish-brown calcareous concretions. The thickness cannot be measured accurately because of structural complexities, but it is estimated to be at least 4,500 feet and may be much more. This unit unconformably overlies the light-brown siliceous siltstone of unit K_1 on MacColl Ridge and is overlain by massive conglomerate and sandstone of unit K_3 (pl. 1 and fig. 3).

The basal beds of unit K_2, which can only be observed in a few places, consist of medium-grained greenish-gray sandstone, a few to 5 or more feet thick, that grades up into dark-gray shale. This sandstone is glauconitic and is composed predominantly of quartz, lithic fragments, and plagioclase; matrix, which constitutes about 10 percent of the rock, is composed of calcite, clay, and minor chlorite. To the north, along Copper Creek in the McCarthy B–4 quadrangle, the basal beds of unit K_2 consist of several hundred feet of conglomerate that may rest unconformably on the McCarthy Formation, as no intervening unit K_1 having yet been recognized.

FOSSILS AND AGE

Fossils are locally abundant in calcareous concretions in unit K_2, although much of the unit is barren or contains few well-preserved specimens. The precise stratigraphic position of fossils within the formation is in places difficult to establish owing to local structural complexities.

The lower beds of unit K_2 are sparsely fossiliferous. They have yielded only fragments of *Inoceramus* similar to *I. uwajimensis* Yehara and are probably, therefore, of Coniacian age. In the middle part of the formation fossils are more common, and the following forms have been identified (see also Matsumoto, 1959, p. 87).

Kossmaticeras aff. *K. japonicum* Matsumoto
Damesites sp.
Bostrychoceras sp.
Baculites cf. *B. yokoyamai* Tokunaga and Shimizu
B. cf. *B. schencki* Matsumoto
Yokoyamaoceras jimboi Matsumoto
Scaphites sp.
Otoscaphites sp.
Gaudryceras sp.
Inoceramus yokoyamai Nagao and Matsumoto
  cf. *I. uwajimensis* Yehara
  aff. *I. cordiformis* Sowerby

This assemblage is of early Senonian age, probably late Coniacian or early Santonian.

FIGURE 3.—View westward on crest of MacColl Ridge showing faulted sandstone and conglomerate of unit K_3 overlying black shale of unit K_2 at right side of photograph.

The upper part of unit K_2 has yielded a meager fauna of Campanian age containing:

Eupachydiscus haradai (Jimbo)
Anapachydiscus sp.
Hauericeras aff. *H. gardeni* (Bailey)
Inoceramus schmidti Michael

The localities from which the fossils from unit K_2 were obtained are shown on plate 1 by open squares.

UNIT K_3

LITHOLOGY

Unit K_3, the uppermost Cretaceous formation exposed in the McCarthy A-4 quadrangle, crops out on MacColl Ridge (fig. 4) and is composed of a thick sequence of interbedded sandstone, conglomerate, and gray siltstone and shale. Similar rocks form Pyramid Peak (fig. 4), Andrus Peak, and other unnamed peaks to the north of the McCarthy A-4 quadrangle. These are the youngest known Cretaceous rocks in the upper Chitina Valley. The sandstone and conglomerate units are highly lenticular (fig. 5) and may be, in part, of nonmarine origin. Fragments of *Inoceramus* collected from siltstone units indicate that some parts of the formation are marine, but these fossils are not well enough preserved to furnish a precise age determination.

Detailed lithologic data were not collected during the present investigation, and little can be added to the description of these rocks given by Moffit and Overbeck (in Moffit, 1918, p. 34–36). As viewed on the north side of MacColl Ridge, unit K_3 overlies unit K_2 with apparent conformity, although locally the contact is disturbed by faults. Evidence of channeling can be seen on the crest of the ridge, however, and it seems likely that locally parts of unit K_2 have been removed by erosion during or before deposition of the basal beds of unit K_3. Ammonite fragments have been found in the basal conglomerate beds, but so far no diagnostic fossils have been found, and the magnitude, if any, of the time gap between these two units cannot be established.

The total thickness of unit K_3 is unknown; the exposed part has not been measured in detail, but estimates based on mapping show that between 3,000 and 4,000 feet of beds are present on MacColl Ridge. Almost 3,000 feet of nearly horizontal beds are exposed on Pyramid Peak and the nearby unnamed peak to the north in the southern part of the McCarthy B-4 quadrangle (fig. 4). Moffit and Overbeck (in

FIGURE 4.—Pyramid Peak on left (elev 8,875 feet) and unnamed peak on right (elev 8,910 feet) composed of sandstone and conglomerate of unit K_3, overlying soft black shale of unit K_2. View northward into McCarthy B–4 quadrangle from northern edge of McCarthy A–4 quadrangle.

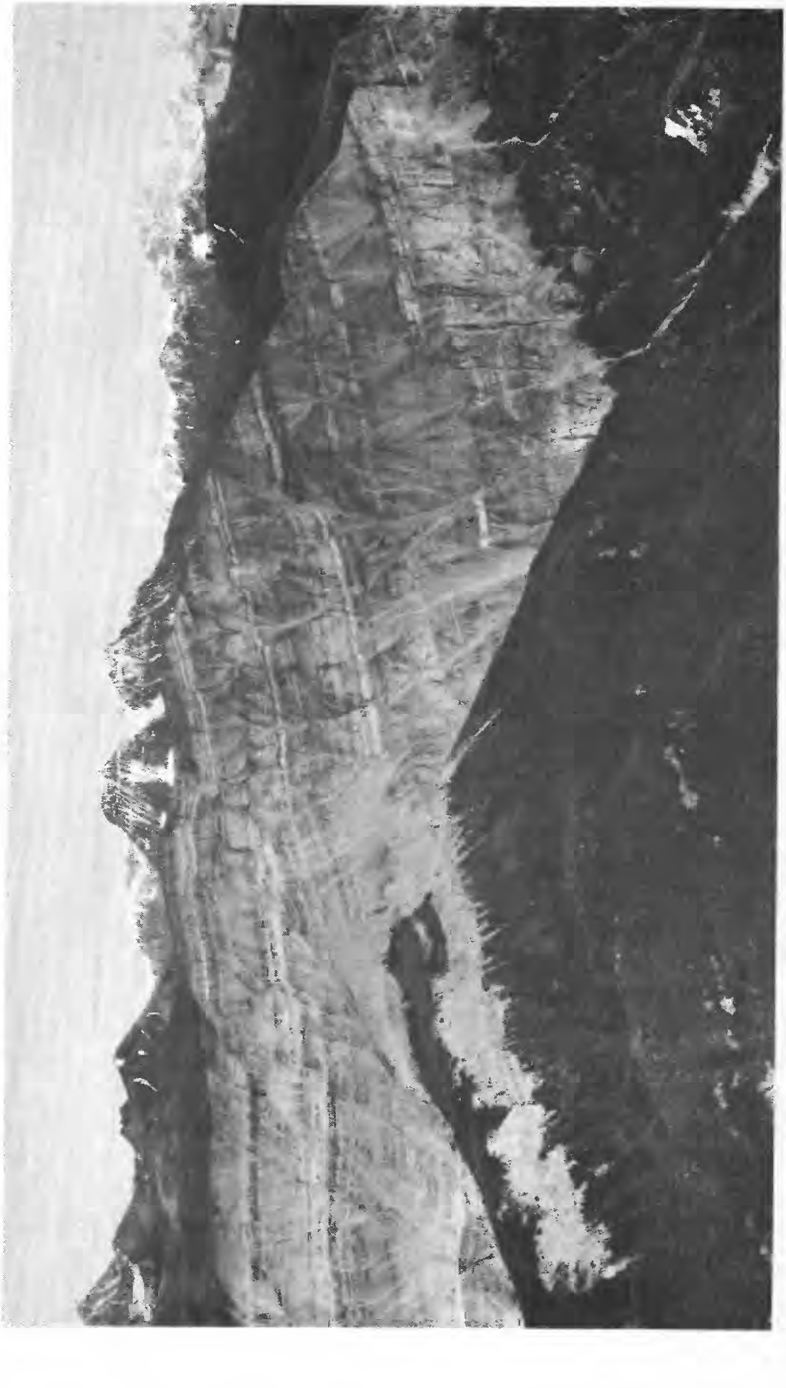

FIGURE 5.—Cliff composed of arkosic sandstone, conglomerate, and siltstone of unit K_s exposed on southern side of MacColl Ridge near western margin of McCarthy A-4 quadrangle. Height of exposed section is about 2,000 feet. Pyramid Peak, composed of same unit, is visible on skyline to left of center.

Moffit, 1918, p. 35) estimated a thickness of about 2,500 feet for the beds on MacColl Ridge. The generalized section is as follows:

	Feet
Sandstone, coarse, green and gray; interbedded with dark shales containing imperfect plant remains	700
Shale, brown and gray; subordinate dark beds	700
Sandstone, greenish or greenish-gray	100
Shale, fine-grained, brown, gray or greenish-gray	700
Conglomerate and sandstone	300
	2,500

FOSSILS AND AGE

Only poorly preserved plant remains, fragments of *Inoceramus*, and possibly reworked fragments of ammonites, have been found in unit K_3; consequently, the precise age of the unit cannot be established other than being Late Cretaceous, probably late Campanian or Maestrichtian based on superposition above Campanian beds.

ECOLOGIC CONDITIONS AND GEOLOGIC HISTORY

Deposition of unit K_1 in shallow marine waters commenced in early Albian time after a period of folding, faulting, and deep erosion. Within the McCarthy A–4 quadrangle, this orogenic episode can only be dated as post-Late Triassic. However, to the northwest in the McCarthy C–5 quadrangle, MacKevett and Imlay (1962) have shown that rocks as young as Late Jurassic (Kimmeridgian) are folded and overlain unconformably by Lower Cretaceous rocks; this evidence indicates that the major orogenic movements occurred during the Late Jurassic or Early Cretaceous.

The prevalence in units K_1 and K_2 of ammonites and *Inoceramus* and the absence or scarcity of a thick-shelled pelecypod and snail fauna indicate that most of the fossiliferous rocks were deposited at neritic depths below the zone of active wave agitation. The general coarsening of the middle part of unit K_1 from siltstone in the south to fine-grained sandstone in the north suggests a northerly source for these sediments. Likewise, the absence of rocks of the *Moffitites* zone in the Young Creek area suggests a northward transgression. No evidence is seen for a southern source from the Chugach Range, but the data are as yet too fragmentary to rule out such a provenance.

The absence of fossils of mid-Albian age and the local presence of conglomerate lenses at the base of the light-brown siliceous siltstone in unit K_1 indicate that a relatively minor break in sedimentation occurred during deposition of that unit. No angular discordance has been observed at the base of the siliceous siltstone, nor is there evidence of extensive erosion.

The unconformity between units K_1 and K_2 in the McCarthy A–4 quadrangle represents late Cenomanian and Turonian time (fig. 6).

Minor folding and erosion took place during this interval, as shown by the possible absence of unit K_1 to the north in the McCarthy B-4 quadrangle, where unit K_2 seems to rest directly on older rocks. In the McCarthy A-4 quadrangle no direct evidence is available to indicate source areas for the sediments that formed unit K_2, and the general similarity of this formation throughout the upper Chitina Valley indicates that fairly uniform marine conditions must have prevailed in contrast with the diverse conditions indicated by the rapid facies changes of unit K_1. A moderate neritic depth for deposition of most of this unit is indicated by the predominantly ammonite and *Inoceramus* fauna.

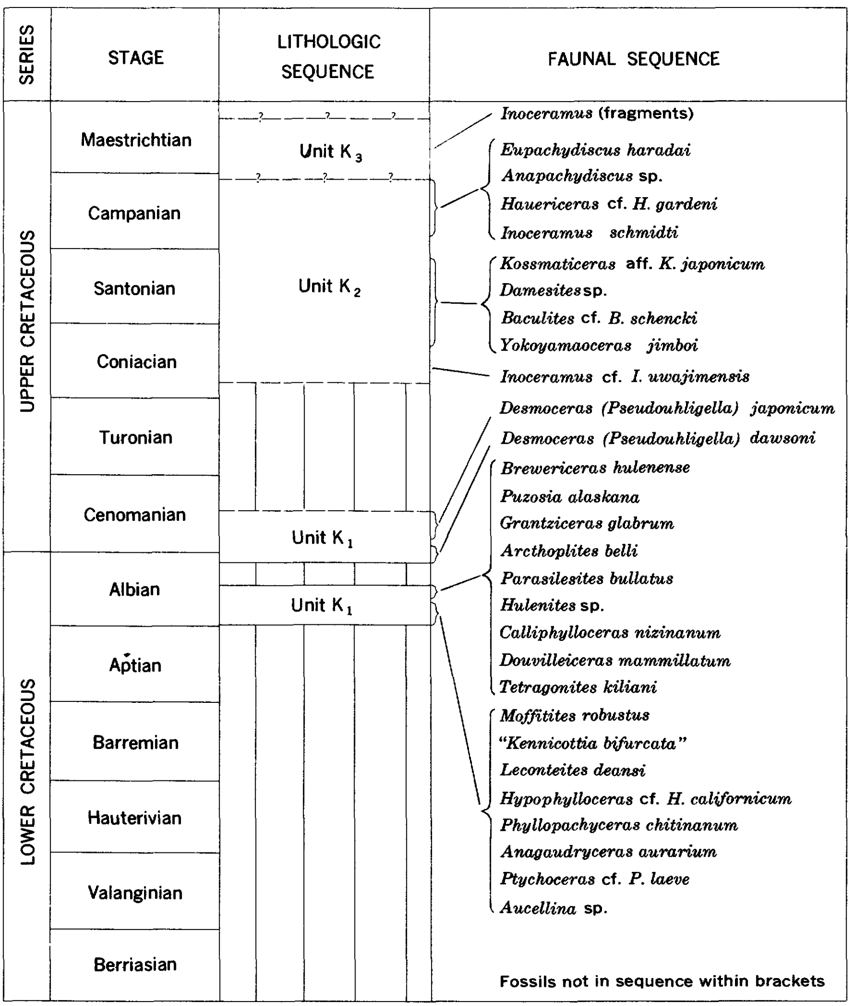

FIGURE 6.—Schematic columnar section showing age of Cretaceous formations and faunal sequence in McCarthy A-4 quadrangle.

Conditions of sedimentation changed drastically from the deposition of marine black shale and siltstone of unit K_2 to the perhaps partly continental coarse massive lenticular conglomerate, sandstone, and siltstone of unit K_3. On the basis of a few observations, unit K_3 seems to be coarser grained in the south than in the north, and more conglomerate seems to be present on MacColl Ridge than on Pyramid Peak. More data are needed to substantiate this assumption; however, if this is true, it indicates a source area to the south in the Chugach Range.

After deposition of the Cretaceous rocks, the region was subjected to uplift, gentle folding, and faulting. No evidence is available within the McCarthy A-4 quadrangle to date this deformation, but in nearby quadrangles the Cretaceous beds are overlain unconformably by less deformed continental sedimentary and volcanic rocks of early Tertiary (Eocene or Oligocene) age.

REFERENCES CITED

Imlay, R. W., 1960, Early Cretaceous (Albian) ammonites from the Chitina Valley and Talkeetna Mountains, Alaska: U.S. Geol. Survey Prof. Paper 354-D, p. 87-114.

Imlay, R. W., and Reeside, J. B., Jr., 1954, Correlation of the Cretaceous formations of Greenland and Alaska: Geol. Soc. America Bull. 65, no. 3, p. 223-246.

MacKevett, E. M., Jr., and Imlay, R. W., 1962, Jurassic stratigraphy in the McCarthy C-5 quadrangle, Alaska, *in* Geological Survey Research 1962: U.S. Geol. Survey Prof. Paper 450-D, art. 133, p. D49-D51.

Martin, G. C., 1926, The Mesozoic stratigraphy of Alaska: U.S. Geol. Survey Bull. 776, 493 p.

Matsumoto, Tatsuro, 1959, Cretaceous ammonites from the upper Chitina Valley, Alaska: Kyushu Univ. Mem. Fac. Sci, ser. D, Geology, v. 8, no. 3, p. 49-90.

Moffit, F. H., 1918, The upper Chitina Valley, Alaska, with a description of the igneous rocks by R. M. Overbeck: U.S. Geol. Survey Bull. 675, 82 p.

——— 1938, Geology of the Chitina Valley and adjacent area, Alaska: U.S. Geol. Survey Bull. 894, 137 p.

Moffit, F. H., and Capps, S. R., 1911, Geology and mineral resources of the Nizina district, Alaska: U.S. Geol. Survey Bull. 448, 111 p.

Moffit, F. H., and Maddren, A. G., 1909, Mineral resources of the Kotsina-Chitina region, Alaska: U.S. Geol. Survey Bull. 374, 103 p.

Moffit, F. H., and Mertie, J. B., Jr., 1923, The Kotsina-Kuskulana district, Alaska: U.S. Geol. Survey Bull. 745, 149 p.

Rohn, Oscar, 1900, A reconnaissance of the Chitina River and Skolai Mountains, Alaska: U.S. Geol. Survey Ann. Rept. 21, pt. 2, p. 393-440.

Schrader, F. C., and Spencer, A. C., 1901, The geology and mineral resources of a portion of the Copper River district, Alaska: U.S. Geol. Survey Spec. Pub., 94 p.

Williams, Howel, Turner, F. J., and Gilbert, C. M., 1954, Petrography—an introduction to the study of rocks in thin sections: San Francisco, Calif., W. H. Freeman and Co., 406 p. [reprinted 1958].

U. S. GOVERNMENT PRINTING OFFICE : 1964 O - 724-343