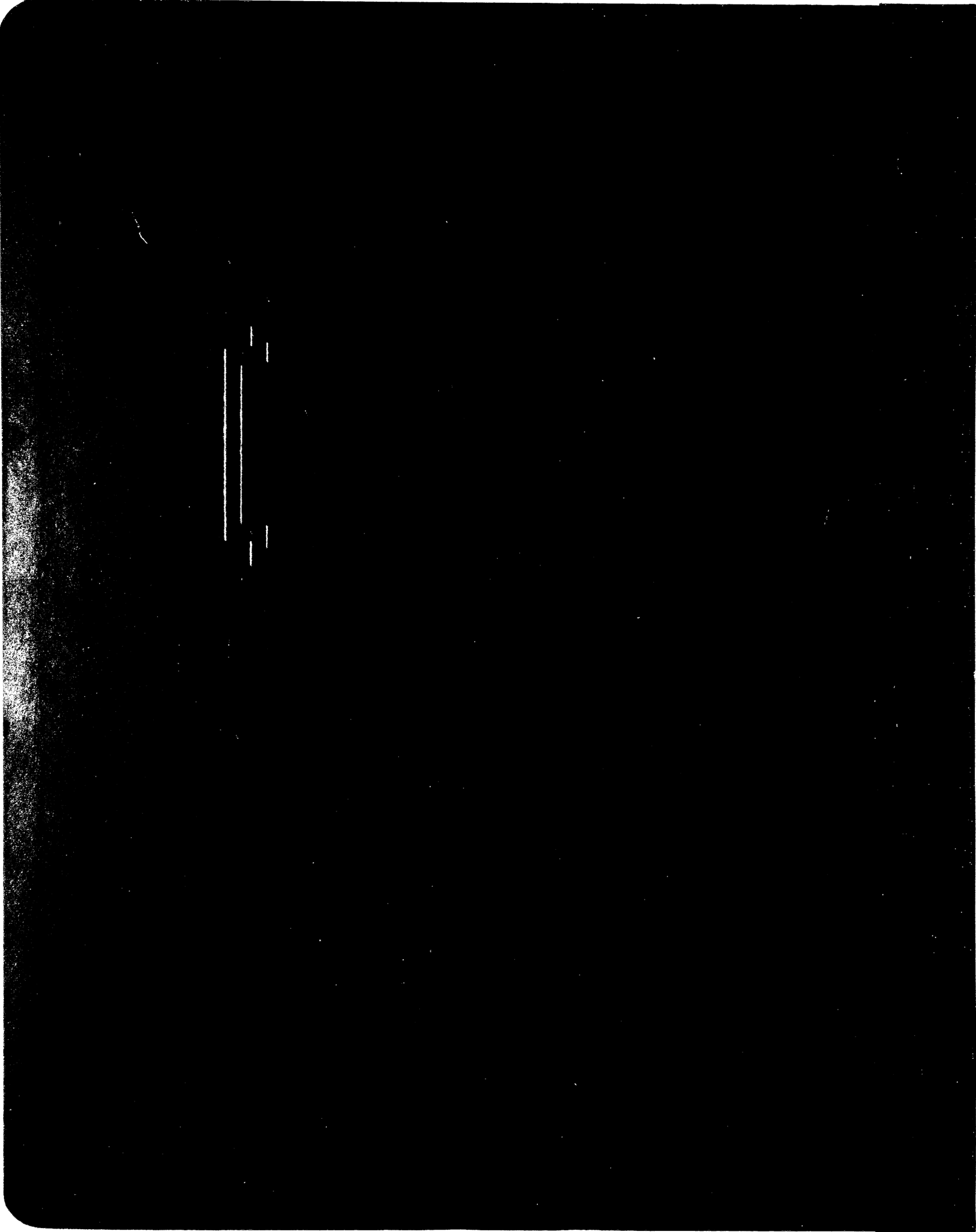
GUIDE FOSSILS OF THE MIDDLE JURASSIC TUXEDNI SANDSTONE, ALASKA

June 1940

Marilyn Norton



GUIDE FOSSILS OF THE MIDDLE JURASSIC TUKEDNI SANDSTONE, ALASKA

By

Marilyn Norton

A dissertation submitted in partial fulfillment of the requirements for the degree of Master of Arts in the Department of Geology of the University of Michigan

6-22-46

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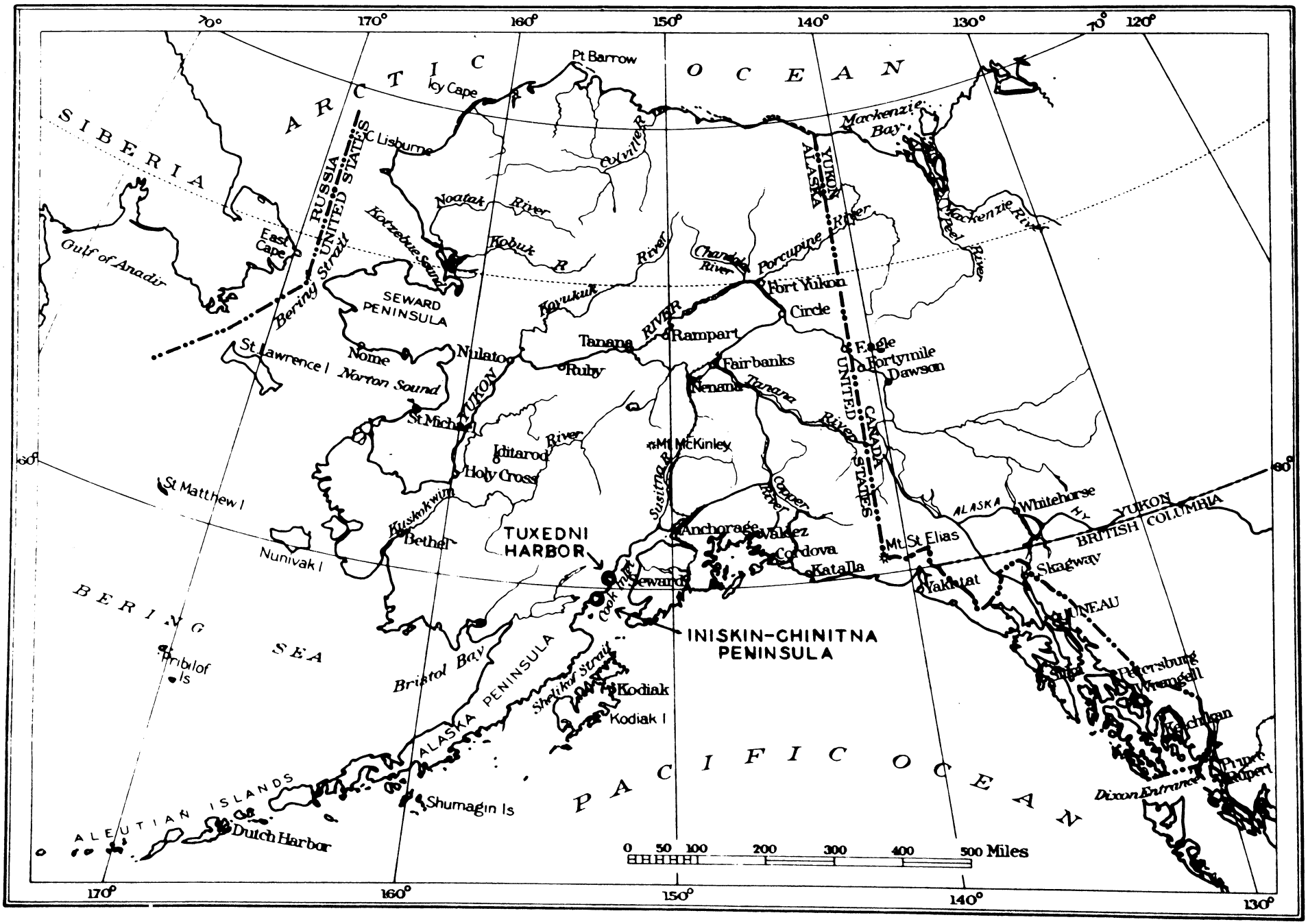
INTRODUCTION

The Tuxedni sandstone is a well-known Middle Jurassic formation in southwestern Alaska (Fig. 1). It has been described in several areas by geologists whose published stratigraphic sections contain preliminary fossil determinations upon which its age was based. No fossils definitely known to be from the Tuxedni sandstone have been previously described, although Martin (1926, p. 140) states that the fossils described by Eichwald (1871, pp. 138-200) from the "Chasik Island" and "Tukusitnu" (Tuxedni) Bay and probably at least part of those from undescribed localities on Cook Inlet and "Alaska" or Alaska Peninsula belong in this formation.

In 1944 L. B. Kellum was in charge of petroleum investigations on the Alaska Peninsula for the United States Geological Survey and had the opportunity to study numerous sections of Jurassic rocks which include the Tuxedni sandstone. Large collections of marine invertebrate fossils were made from every observed fossiliferous bed, and subsequently were studied in the Museum of Paleontology of the University of Michigan. Preliminary identifications have been used in the preparation of reports on the geology of several areas. These recent investigations showed that the strata referred to the Tuxedni sandstone on the west shore of Cook Inlet include, at the base, beds which now are correlated with the Kialagvik formation, considered to be of Lower Jurassic age. Fossils characteristic of the Tuxedni have been reported by previous authors in the type area of the Kialagvik formation (Martin: 1926, p. 191). In the present paper the name Tuxedni sandstone is restricted to strata of Middle Jurassic age, in


ARCTIC OCEAN
SIBERIA
RUSSIA
UNITED STATES
Pt Barrow
Icy Cape
C Lisburne
Colville R
Mackenzie Bay
YUKON
ALASKA
Noatak River
Kotzebue Sound
Kobuk R
River
Porcupine River
Mackenzie River
East Cape
Gulf of Anadir
Bering Strait
SEWARD PENINSULA
Koyukuk
Fort Yukon
Circle
Rampart
TANANA RIVER
Eagle
Fortymile
Dawson
St Lawrence I
Norton Sound
Nome
Nulato
Ruby
Fairbanks
Nenana
Tanana
YUKON
St Michael
Iditarod River
Mt McKinley
Susitna R
Copper River
CANADA
UNITED STATES
Holy Cross
St Matthew I
Kuskokwim
Bethel
TUXEDNI HARBOR
Anchorage
Valdez
Cordova
Mt St Elias
Whitehorse
YUKON
BRITISH COLUMBIA
ALASKA
Nunivak I
Cook Inlet
Seward
Katalla
Yakutat
Skagway
BERING SEA
INISKIN-CHINITNA PENINSULA
Bristol Bay
Pribilof Is
Shelikof Strait
Kodiak
Kodiak I
ALASKA PENINSULA
JUNEAU
Petersburg
Wrangell
Ketchikan
Prince Rupert
Dixon Entrance
ALEUTIAN ISLANDS
Shumagin Is
Dutch Harbor
PACIFIC OCEAN
0 50 100 200 300 400 500 Miles
70°
170°
160°
150°
140°
130°
120°
60°

39602

conformity with the original definition. The recognition of the Kialagvik in the basal part of the Tuxedni (sensu lato) on Cook Inlet by Stanton (Capps: 1923, p. 97) and confirmed by the later studies (Kellum and Wedow: MS) explains the heretofore anomalous occurrence of Kialagvik fossils in the fauna of the Tuxedni.

The purpose of this paper is to describe some of the more significant guide fossils of the Tuxedni sandstone and to compare the Tuxedni sandstone section of the Iniskin-Chinitna Peninsula which has been studied in some detail in the field with the published type section of the formation on Tuxedni Bay. Evidence for several successive ammonite zones in the Tuxedni sandstone is presented, and the age and correlation of these zones with other Middle Jurassic deposits in western North America are discussed.

EARLIER INVESTIGATIONS OF THE TUXEDNI SANDSTONE

The name Tuxedni sandstone was first used by Martin and Katz (1912, p. 59) for the "lowest known member of the Middle Jurassic of southwestern Alaska." They described two sections of the formation, one located on the south shore of Tuxedni Bay and the other on the east shore of Iniskin Bay. The former was designated the type section "because it not only shows the most complete known representation of these rocks but both marine invertebrates and fossil plants are present." It has a thickness of 1128 feet and is made up predominately of sandstone with considerable shale and a few thin beds of limestone and conglomerate.

The section on the east shore of Iniskin Bay published by Martin and Katz had been published earlier by Stanton and Martin (1904, pp. 399-400), with slight changes in terminology, under the name Enochkin formation. The description of the section was compiled from a study of several disconnected outcrops so that less than half of the total thickness was exposed. The strata were grouped into four "zones" designated alphabetically, with Zone A at the base and Zone D at the top. Zones A, B, and C of Martin's Enochkin formation subsequently were included in the Tuxedni sandstone, and Zone D was placed in the Chinitna shale. The exposed beds of the Tuxedni in this section totaled 342½ feet, but the thicknesses of the covered intervals were not given. The formation here is chiefly shale with subordinate sandstones. There is a coarse conglomerate 20 feet thick at the base of Zone A and streaks of conglomerate were noted at the base of Zone C. Neither the lithologic succession nor the preliminary determinations of the fossils from this section by Stanton furnish a basis for correlation.

The thickness of the Tuxedni at the type locality was estimated by Martin (1926, p. 141) to be "at least 1500 feet and may be 2000 feet or more". Moffit (1922, p. 142) and Brooks (1922, p. 143), however, suggested a thickness of the formation at Tuxedni Bay of approximately 3000 feet.

After a geologic reconnaissance of the Tuxedni Bay area in 1920, Moffit (1923) made a detailed investigation of the Middle Jurassic sediments in the Iniskin Bay district. A composite section of the Tuxedni sandstone of this district showed a greater variation in the lithology of the lower part of the section exposed than was noted in the upper part which consists of sandy shale with thin interbeds of sandstone and a few

conglomerate beds. Although no complete exposure was found and only the top of the formation could be determined by paleontologic evidence, Moffit (1927, p. 14) re-estimated the thickness of the Tuxedni on the Iniskin-Chinitna Peninsula to be about 7000 feet.

Strata which yielded a fauna of Middle Jurassic were described by Martin (1921, pp. 58-61) in the Cold Bay (Puale Bay) district. On the occurrence of Eumicrotis? cf. E. curta Hall from localities believed to be on the "west shore of Dry Bay" and "near Becharof Lake," Martin (1926, p. 191) suggests the possible presence of the Tuxedni sandstone on the Alaska Peninsula. The oldest rocks of undoubted Jurassic age on Cold (Puale) Bay, however, are sandstones, shales, and conglomerates which contain the Cadoceras fauna of the Upper Jurassic Chinitna shale.

Mather, Smith, and Martin (1925, pp. 165-166) described a section of Tuxedni sandstone forming the shore of Kamishak Bay "in the vicinity of Amakdedori, a short distance north of Chenik." The exposure includes a series of dark carbonaceous shale, sandstone, grit, and volcanic tuff, with a few thin beds of conglomerate. The fauna which was collected was identified by Stanton as Middle Jurassic in age.

A recent detailed investigation of the Tuxedni sandstone in the Chinitna Bay area was undertaken by Kellum and Wedow during the field season of 1944 (Fig. 2). Several sections of the Tuxedni sandstone were measured, a large fauna was collected and identified, and the contact between the Tuxedni and the underlying Kialagvik formation was determined on the basis of excellent paleontologic evidence (Kellum and Wedow: MS).

FIGURE 2

TUXEDNI SANDSTONE FOSSIL LOCALITIES

FIGURE 2

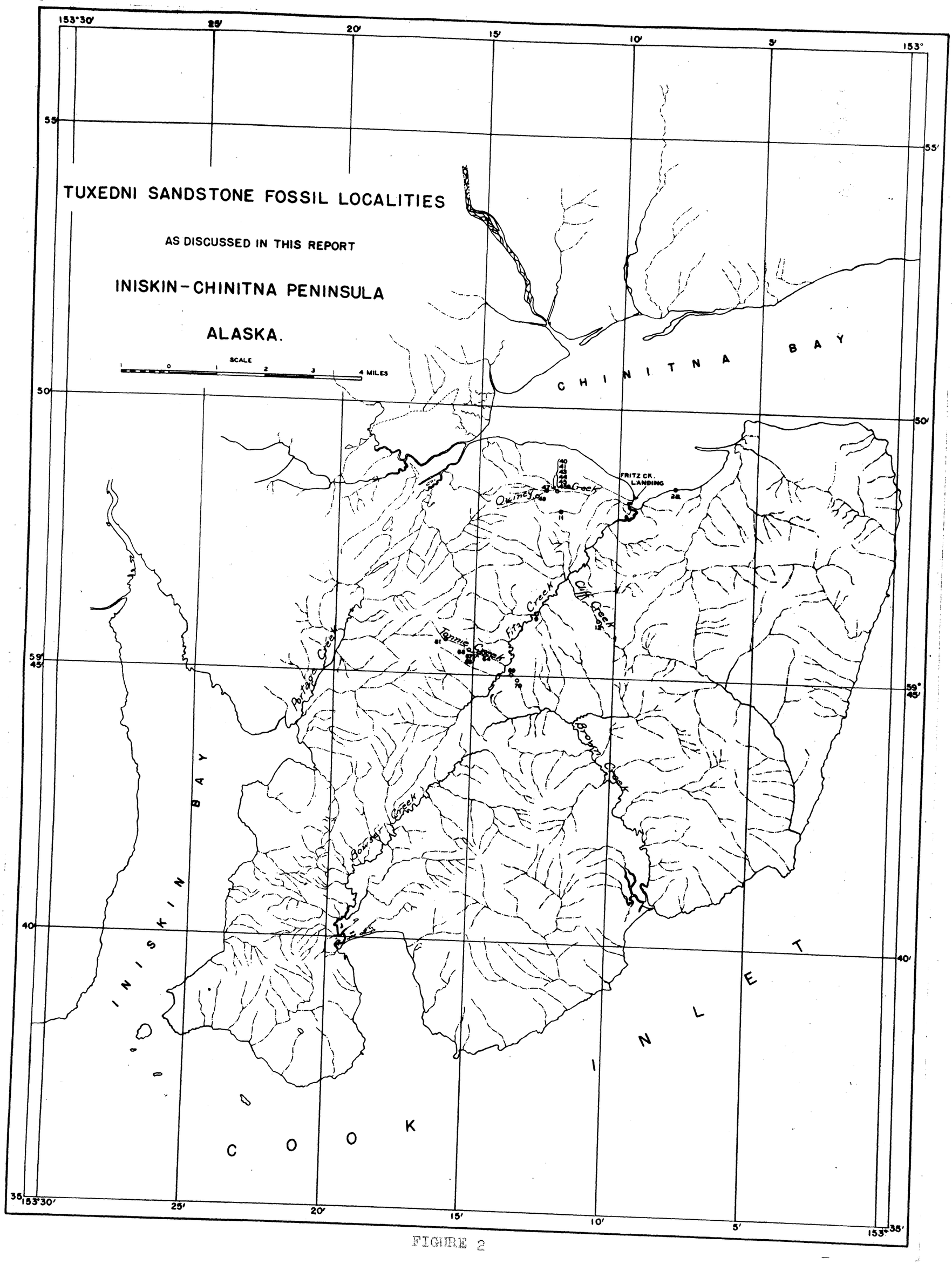


FIGURE 2

STRATIGRAPHIC SIGNIFICANCE OF THE GUIDE FOSSILS

Zemistephanus

Seven new species of Zemistephanus are reported by Kellum and Wedow (MS) from the lower sandy shale member at the base of the Tuxedni sandstone. Six of these species occur in the lower part of this member, and one is found in the upper part. On the basis of the widespread occurrence of Zemistephanus on the Iniskin-Chinitna Peninsula, particularly Zemistephanus moffiti n. sp., and the limited stratigraphic range of the genus, the lower part of the lower sandy shale member has been designated as the Zemistephanus moffiti zone.

The Z. moffiti zone contains the genus Kanastephanus which is also associated with Zemistephanus in the lower part of the Yakoun formation on Maude Island, MacKenzie Bay, British Columbia (McLearn: 1929, pp. 21-26). Other genera present are Terebratula, Parallelodon, Cucullaea, Trigonia, Astarte, Gonodon, Lucina, Protocardia, Arctica, Pleuromya, Goniomya, Pholadomya, Eumicrotis, Pteria, Pinna, Inoceramus, Lima, Camptonectes, Pecten, Ostrea, Actaeonina, Aptychus, Phylloceras, Sonninia, Defonticeras, and Belemnites.

The genus Zemistephanus was first described by McLearn (1927, p. 72) who compares it with the genus Emileia Buckman which occurs in the lower Bajocian and with the genus Tulites of the middle Bathonian (Roman: 1938, pp. 199, 203-205). McLearn (1927, p. 63) concludes that "the Zemistephanus and Defonticeras faunas have affinities with those of late Sonninian age in the English Jurassic." These faunas "are therefore of about middle Bajocian or lower Middle Jurassic time, and the beds containing them are correlated with the middle part of the Middle Inferior Oolite of England."

The genus Kanastephanus which occurs with Zemistephanus in the lower Yakoun formation on Maude Island, MacKenzie Bay, B. C. McLearn compares with the genus Epalxites Mascke of Stepheoceratan age (Buckman: Yorkshire Type Ammonites, v. 7, p. 34) and with the genus Otoites Mascke of Sonninian age, both of which are Bajocian or lower Middle Jurassic.

The presence of Zemistephanus associated with Defonticeras and Kanastephanus in the lower sandy shale member of the Tuxedni, therefore, establishes the age of the lower member as early Middle Jurassic.

Defonticeras

Two new species of Defonticeras occur in the upper part of the lower sandy shale member of the Tuxedni sandstone, designated the Defonticeras stantoni zone (Kellum and Wedow: MS). This zone and the underlying Zemistephanus moffiti zone comprise the basal member of the formation on the Iniskin-Chinitna Peninsula.

With Defonticeras in the D. stantoni zone is a species of Stephanoceras which is close to S. caomanoi McLearn (1932, p. 55) described from the lower Yakoun formation on Logan Island, B. C. The lower Yakoun has been determined to represent about middle Bajocian time. Other genera in the D. stantoni zone on the Iniskin-Chinitna Peninsula are Cucullaea, Pleuromya, Pholadomya, Eumicrotis, Inoceramus, Phylloceras, Zemistephanus, and Belemnites. Of the 12 species of mollusca found in this zone, only one, Inoceramus sp. V which extends downward into the zone of Zemistephanus moffiti, is known to have a longer range.

McLearn (1929, p. 3) ascribes a late Sonninian or middle Bajocian age to both Defonticeras and Zemistephanus. According to Spath (1932, p. 11) the genus Defonticeras may be middle and probably is not later than upper

Bajocian in age. The closest affinities of Defonticeras (McLearn: 1929, p. 13) are with Chondroceras Mascke of Stepheoceratan age and Emileia of Sonninian age, i. e., of Bajocian or early Middle Jurassic time.

Oppelia

Martin (1926, pp. 148-152) lists Oppelia? from collections made by A. A. Baker at three localities in the Tuxedni sandstone on the Iniskin-Chinitna Peninsula. On Moffit's geologic map (1927, plate 2) one of these localities (11048) is shown within an area of the Chinitna shale, and another (11047) is in an area of the Tuxedni sandstone very close to the contact of the Chinitna shale. The third locality (11053) is not shown on the map but is described as being "a short distance above the assumed Tuxedni-Chinitna contact." It is evident, therefore, that an Oppelid-like fossil occurs near the top of the section considered by Stanton to be in the Tuxedni sandstone. (The preliminary identifications in Martin's faunal lists were made by Stanton).

In the description of the section given by Martin on the south shore of Tuxedni Bay, however, Oppelia? (lot 3000) is reported from bed 19 where it is associated with Stephanoceras richardsoni, the genotype of Zemistephanus. Oppelia also is found in talus probably derived from the stratigraphically higher beds 11 to 14. Beds 1 to 14 of the type section of Tuxedni sandstone have been correlated tentatively (p.) with the lower part of the Defonticeras stantoni zone of the Iniskin-Chinitna Peninsula.

The stratigraphic range of Oppelid-like ammonites, therefore, would appear to be from the top of the Tuxedni to the base of the zone of Defonticeras stantoni. Oppelia chinitnaensis n. sp., however, was found

by L. B. Kellum only in the first 100 feet of shaly strata overlying the Cynthia Falls member on the Iniskin-Chinitna Peninsula. These beds yielded a distinctive fauna and have been designated the Oppelia chinitnaensis zone (Kellum and Wedow: MS).

Other genera which occur in the O. chinitnaensis zone are Terebratula, Parallelodon, Grammatodon, Cucullaea, Protocardia, Meretrix, Inoceramus, Pecten, Mytilus, Phylloceras, and Defonticeras.

The genotype of Oppelia is Waagen's species O. subradiata of Stepheoceratan age. The genus in Europe ranges from Bajocian to Oxfordian (Roman: 1938, p. 157).

Miccocephalites

Buckman (1929, pp. 22-23) notes that Miccocephalites and other genera of the Macrocephalitidae of North America show the closest affinity with European forms which are limited in range to the beginning of Callovian or to the end of the Bathonian.

A fragmentary specimen of Miccocephalites sp. cf. M. concinnus Buckman was found by L. B. Kellum above a thick conglomerate in the Tuxedni sandstone known as the Tonnie conglomerate. Although this fragment is the only diagnostic ammonite collected from the Tonnie member, two pelecypods are present which are closely related to characteristic species of the Corbula munda fauna of western Canada. Cucullaea sp. cf. C. livingstonensis McLearn is reported from a lower horizon of the same member, and Pecten sp. cf. P. leachi McLearn occurs near the top of the Tuxedni section on the Iniskin-Chinitna Peninsula (Kellum and Wedow: MS). The Corbula munda fauna is considered to be of Callovian or early Upper Jurassic age by McLearn (1929, p. 99), although Spath (1932, p. 145) limits the fauna to

an upper Bathonian age.

Other genera present in the Tonnie member on the Iniskin-Chinitna Peninsula are Cucullaea, Trigonia, Astarte, Praeconia, Tancredia, Lucina, Protocardia, Arctica, Tellina, Pleuromya, Thracia, Eumicrotis, Inoceramus, Pecten, Anomia, and Ostrea.

Until the fauna of the Tonnie member is better known and has been compared with the fauna of the Chinitna shale, this member must remain tentatively in the Tuxedni sandstone.

CORRELATION OF THE TUXEDNI SANDSTONE

The Tuxedni sandstone, on the south shore of Tuxedni Bay, was described by Martin and Katz (1912, p. 59)as consisting of 1128 feet of sandstone and shale with a few thin beds of limestone and conglomerate and comprising the lowest known member of the Middle Jurassic of southwestern Alaska (Table 1). Moffit's (1927, p. 14) composite section of Tuxedni sandstone on the Iniskin-Chinitna Peninsula was described as being at least 7000 feet thick. As a result of later detailed studies by Kellum and Wedow (MS) in this area and further studies of the fauna (Kellum: 1945, p. 203), a revision of the section was proposed to conform with the original definition of Martin and Katz which limited the Tuxedni sandstone to strata of Middle Jurassic age. The lower 2500 feet of strata exposed on the Iniskin-Chinitna Peninsula was correlated with the Lower Jurassic Kialagvik formation and so designated. Approximately 4000 feet of strata was included in the Tuxedni sandstone (sensu strictu), and some of the highest beds contained fossils suggesting an Upper Jurassic age, a fact which, if confirmed, would place them above the Tuxedni sandstone.

EUROPEAN TIME SCALE	SOUTHWESTERN ALASKA	CANADIAN ROCKIES, ALBERTA	CANADIAN PACIFIC COAST	OREGON	WESTERN INTERIOR OF THE UNITED STATES	BIGHORN and WIND RIVER BASINS, WYOMING	SWEETGRASS ARCH MONTANA
Callovian or Upper Bathonian	TUXEDNI SANDSTONE: Miccocephalites sp. A cf. M. concinnus	FERNIE FORMATION: Corbula munda	YAKOUN FORMATION: Toricelliceras		TWIN CREEK LIMESTONE		
BATHONIAN					Arctocephalites		SAWTOOTH
		Chlamys mcconnelli			Cranocephalites	GYPSUM SPRINGS	
BAJOCIAN	Oppelia chinitnaensis	Teloceras Stemmatoceras Defonticeras Saxitoniceras Zemistephanus	Teloceras	IZEE GROUP	Defonticeras Stemmatoceras		
	Defonticeras stantoni		Defonticeras				
	Zemistephanus moffiti Kanastephanus tonniensis		Zemistephanus Kanastephanus	COLPITTS GROUP			
		Sonninia					

TABLE 1. CORRELATION CHART JURASSIC OF NORTHWESTERN AMERICA

Revision of the Tuxedni sandstone section on the Iniskin-Chinitna Peninsula, as proposed in this paper, and its correlation with the published type section of the formation on the south shore of Tuxedni Bay make it necessary to restrict the name in the type area to the upper 850 feet of strata measured by Martin and Katz.

Four members, based on lithologic and faunal characteristics, are recognized on the Iniskin-Chinitna Peninsula. They are, from top to bottom:

(4) Tonnie member

(3) Upper sandy shale member

(2) Cynthia Falls member

(1) Lower sandy shale member

Only the lowest of these members is present in the type section. As shown in Plate 1, this member on the Iniskin-Chinitna Peninsula includes two faunal zones, the Zemistephanus moffiti zone in the lower 820 feet and the Defonticeras stantoni zone in the upper 595 feet.

Type section, Tuxedni Bay

In their description of the type section of the Tuxedni sandstone, Martin and Katz (1912; pp. 60-61) number the lithologic units consecutively from 1 to 37 beginning at the top. On the basis of the following fossils identified by Stanton and listed by Martin and Katz in the beds indicated, the present author has tentatively included beds 30 to 37, at the bottom of the section, in the Kialagvik formation:

Lima cf. L. gigantea	Beds 30 and 36
Inoceramus lucifer	Bed 30
Harpoceras	Bed 33

All three of these are reported from the Kialagvik formation in its type

PLATE 1

COLUMNAR SECTIONS

COLUMNAR SECTIONS
TUXEDNI BAY AND INISKIN–CHINITNA PENINSULA
ALASKA.

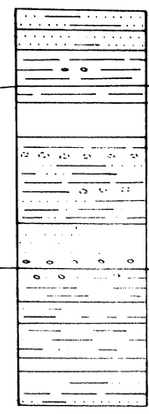
TONNIE CREEK
INISKIN-CHINITNA PENINSULA

SERIES	FORMATION	MEMBER	ZONE		
JURASSIC	TUXEDNI	TONNIE	MICCOCEPHALITES SPECIES	FINE GRAINED, THIN BEDDED SANDSTONE AND SILTSTONE.	
				HARD, DARK GRAY, THICK BEDDED SANDSTONE CONTAINING COQUINA BEDS.	F82
				SANDY SHALE WITH STRINGERS OF SHALY SANDSTONE WHICH BECOME THICKER AND MORE NUMEROUS TOWARD TOP.	
				COARSE CONGLOMERATE WITH INTERBEDS OF COARSE GRAINED SANDSTONE.	F81
				THIN BEDDED SHALY SANDSTONE WITH INTERBEDDED HARD GRAY-GREEN SANDSTONE AND CONGLOMERATE.	F80
				ALTERNATING LEDGES OF SHALY AND HARD SANDSTONE; FEW CONGLOMERATE BEDS; SEVERAL COQUINA BEDS NEAR BASE.	F79
				INTERBEDDED FERRUGINOUS SANDSTONE AND GRAY-GREEN TO GREEN ARGILLACEOUS SANDSTONE. UPPER 10 FEET GRAY SANDSTONE.	F78 F77 F74
		SANDY SHALE	UPPER SANDY	SANDY GRAY SHALE.	
				CONGLOMERATE AND THIN-BEDDED SANDSTONE GRADING LATERALLY INTO COARSE VOLCANIC COBBLE CONGLOMERATE. GRAY SANDY SHALE, WEATHERED YELLOW-BROWN.	
				UPPER 10 FEET CONGLOMERATE WITH SANDSTONE COBBLES. SANDY SHALE WITH ARKOSIC AND CONGLOMERITIC SANDSTONE STRINGERS.	F73
				SANDY GRAY SHALE WITH STRINGERS OF FINE-GRAINED GRAY SANDSTONE; SHALE CONTAINS NUMEROUS CONCRETIONS.	
				VERY SHALY DARK GRAY SANDSTONE; INCH SANDSTONE BRECCIA AT BASE.	
			OPPELIA CHINITNENSIS	SANDY SHALE, WEATHERING YELLOW-BROWN; CONTAINS IRREGULARLY SHAPED CONCRETIONS.	F68
		CYNTHIA FALLS		MASSIVE, COARSE ARKOSIC SANDSTONE, GREEN-GRAY WEATHERING TO GRAY; CONTAINS ONE THIN SANDY SHALE BED AND ONE PEBBLY CONGLOMERATE.	
				SANDY SHALE AND SHALY SANDSTONE POORLY EXPOSED.	
				MASSIVE, COARSE ARKOSIC SANDSTONE, GREEN-GRAY WEATHERING GRAY.	
		LOWER SANDY SHALE	DEFONTICERAS STANTONI	SANDY GRAY SHALE WITH FEW SHALY SANDSTONE STRINGERS.	
				COVERED INTERVAL.	
				GRAY SANDY SHALE WITH LEDGES OF ARKOSIC SANDSTONE AND GREEN PLATY SANDSTONE; SMALL GRAY SANDY CONCRETIONS AT NUMEROUS HORIZONS.	F67
				COVERED INTERVAL.	F66
				DARK SHALE WITH LAYERS OF FERRUGINOUS SHALE AND SHALY SANDSTONE.	
				COVERED INTERVAL.	
				SANDY SHALE AND SHALY SANDSTONE; GRAY-GREEN SANDSTONE LEDGES.	
				COVERED INTERVAL.	
			ZEMISTEPHANUS MOFFITI	BLUE-GRAY TO GRAY-GREEN SANDY SHALE; IN LOWER PART ALTERNATING WELL INDURATED AND POORLY INDURATED BEDS; THIN BEDS OF SHALY SANDSTONE INCREASING IN NUMBER TOWARD TOP.	F65 F7 F64 F63
LOWER JURASSIC	KIALAGVIK			SANDSTONE, ARKOSIC, FINE-GRAINED.	F60 F6
	KOLOSH			RIDGE-FORMING SERIES OF ALTERNATING SANDSTONES, ARKOSIC SANDSTONES, SHALY SANDSTONE, AND COARSE CONGLOMERATES.	

VERTICAL SCALE

500 0 250 500 FEET

TYPE SECTION
(AFTER MARTIN AND KATZ)
TUXEDNI BAY



SHALY SANDSTONE. (LOT 2993)

BLACK SANDSTONE, DARK SHALE, GRAY SANDSTONE. (LOTS 3995, 10519)

DARK SHALE WITH CONGLOMERATE BEDS GRADING UPWARD INTO FINE GRAINED GRAY SHALE. (LOTS 2996, 2997, 2998, 10518)

GRAY SHALE WITH THIN INTERBEDDED SANDSTONES. (LOTS 10520, 3000)

CONCEALED BY FAULT.

GRAY SHALE WITH SANDSTONE AND CONCRETIONARY BANDS. (LOT 3013)

GRAY SANDSTONE WITH BASAL LIMESTONE CONGLOMERATE. (LOTS 3001, 3002, 10521, 3303)

SANDY SHALE WITH FEW INDURATED SANDSTONE BANDS AND SHALY SANDSTONE; CONGLOMERATE AT TOP. (LOTS 3005, 3006)

INDURATED SANDSTONE LEDGES; SHALE AND CLAY. (LOTS 3008, 3009)

SANDY SHALE WEATHERING YELLOWISH. (LOT 3011)

SANDSTONE WITH CLAY PARTINGS. (LOT 3012)

SOFTER SANDSTONE AND SHALE TO BASE OF EXPOSURE.

area on the Alaska Peninsula (Martin: 1926, p. 190), and two of them (Lima cf. L. gigantea and Harpoceras) are present in the Kialagvik part of the section on the Iniskin-Chinitna Peninsula (Kellum and Wedow: MS).

Beds 15 to 28 in the type section are tentatively correlated with the zone of Zemistephanus moffiti. They are predominately shale and have conglomerates at the base and top. The faunal list of bed 19 includes "Stephanoceras richardsoni" which is the genotype of Zemistephanus. The faunal list of bed 22 contains "Stephanoceras cf. S. humphriesanum." Roman (1938, p. 193) refers Sowerby's Ammonites humphriesi to the genus Cadomites which he considers to have priority over Stephanoceras. A well-preserved specimen of Cadomites humphriesi was found in the float on the Iniskin-Chinitna Peninsula and another species of this genus was found in place in the zone of Zemistephanus moffiti. The occurrence of "Stephanoceras humphriesi" in bed 22 of the type Tuxedni and "Stephanoceras richardsoni" in bed 19 therefore implies a correlation with the zone of Zemistephanus moffiti.

Beds 1 to 14 are tentatively correlated with the zone of Defonticeras stantoni because the genus Sphaeroceras is listed at four horizons. Before 1927 when F. H. McLearn (p. 72) defined the genus Defonticeras, species now referred to Defonticeras were placed in the genus Sphaeroceras. These beds in the type section have a thickness of about 220 feet and are predominately shale with conglomerate at the base and shaly sandstone at the top. The part of the type section on Tuxedni Bay which comprises the Tuxedni sandstone (sensu strictu) is lithologically similar to, though much thinner than, the lower sandy shale member of the Tuxedni sandstone on the Iniskin-Chinitna Peninsula where this member attains 1250 feet in thickness.

Fernie shale of western Canada

The Rock Creek member of the Fernie shale of western Canada contains a prolific fauna of Middle Jurassic age (Warren: 1934, p. 66). Two distinct paleontologic divisions have been recognized, the Chlamys mcconelli fauna at the top and the Teloceras fauna at the base. The Teloceras fauna is represented in the lower sandy shale member of the Tuxedni sandstone by the ammonites Defonticeras and Zemistephanus and by numerous other molluscan genera. The Zemistephanus moffiti zone in the lower part and the Defonticeras stantoni zone in the upper part of the lower sandy shale member on the Iniskin-Chinitna Peninsula suggest that the Teloceras fauna in Canada may be a composite fauna.

The Corbula munda fauna, considered by Buckman to be of early Upper Jurassic age, but by Spath (1932, pp. 14, 33) to be of upper Bathonian age, is present in the Fernie shale about 500 feet above the Rock Creek member. It contains Miccocephalites, Metacephalites, and Paracephalites, and is correlated with the Seymourites fauna found on the Karanaskis River, Alberta. The Corbula munda fauna appears to be represented in the Tonnie member of the Tuxedni sandstone on the Iniskin-Chinitna Peninsula. Four species from the Tonnie member closely related to species described by McLearn and Buckman (1929) from the Corbula munda fauna of the Blairmore region, Alberta, are:

Cucullaea sp. S cf. C. livingstonensis

Pecten sp. AH cf. P. leachi

Pleuromya sp. AD cf. P. postculminata

Miccocephalites sp. A cf. M. concinnus

The faunal affinities suggest a correlation between the Corbula munda fauna in the upper part of the Fernie and the Tonnie member of the Tuxedni.

If future work supports this conclusion, and if Buckman's age determination is accepted, the Tuxedni on the Iniskin-Chinitna Peninsula should be restricted to beds below these fossil-bearing beds and the Tonnie member treated as a facies of the Upper Jurassic Chinitna shale.

Twin Creek limestone of southeastern Idaho

The lower sandy shale member of the Tuxedni sandstone is correlated with the middle part of the Twin Creek limestone of southeastern Idaho by the occurrence in the latter of the Defonticeras fauna. Imlay (1945, p. 1021) correlates the beds containing this lowest known fauna of the Twin Creek with the Rock Creek member of the Fernie shale which also contains the Defonticeras fauna in its lower part. In addition to the characteristic ammonite genera, Stemmatoceras and Defonticeras, he lists Gryphaea impressimarginata McLearn which occurs in the Chlamys mcconelli fauna at the top of the Rock Creek member.

The upper sandy shale member of the Tuxedni on the Iniskin-Chinitna Peninsula contains the Oppelia chinitnaensis fauna. This has not been recognized in the Twin Creek limestone of the Western Interior, but Imlay states that most of the species from the Yellowstone National Park area referred by Stanton to Oppelia? sp. belong to the genus Arctocephalites. The Arctocephalites fauna contains species of pelecypods belonging to McLearn's Corbula munda fauna of Canada and is regarded by Imlay (1945, p. 1022) of upper Bathonian age. The species of Buckman's genus Miccocephalites which occur in the Corbula munda fauna are placed by Spath in the genus Arctocephalites. As Miccocephalites occurs in the Tonnie member of the Tuxedni sandstone, it seems probable that the Twin Creek limestone represents the same time interval as the Tuxedni sandstone.

Ellis formation of Montana

Two faunal zones of upper Bathonian age occur in the lower part of the Ellis formation (Imlay: 1945, p. 1022) in the Western Interior region. Both zones, the Cranocephalites zone and the overlying Arctocephalites zone, are characterized in part by the genera of Buckman's Corbula munda fauna of the Fernie shale as reclassified by Spath (1932, pp. 13, 14, 36).

Collections from the Arctocephalites zone in several localities in the Sawtooth Range of Montana yielded species referred by Stanton to Oppelia? sp. (Imlay: 1945, p. 1025). On the Iniskin-Chinitna Peninsula, Oppelia is restricted to the upper sandy shale member of the Tuxedni sandstone (Kellum and Wedow: MS); this occurrence suggests a correlation of the Arctocephalites zone of the Ellis formation with the upper part of the Tuxedni sandstone. The stratigraphic position of the Cranocephalites zone directly above the Arctocephalites zone in the Western Interior, and the presence of the Corbula munda fauna above the Oppelia chinitnaensis zone suggest a possible correlation of this part of the Ellis formation with the Tonnie member of the Tuxedni.

Yakoun formation of British Columbia

On the Queen Charlotte Islands, Jurassic strata are grouped into two formations, the Maude below and the Yakoun above. The Maude is generally considered to be of Lower Jurassic age (McLearn: 1927, p. 63), although the faunas have not been studied in detail. The Yakoun formation, however, has yielded four distinct faunas including the Seymourites fauna of early Upper Jurassic age (McLearn: 1929, pp. 2 and 3). McLearn had suggested the possible presence of the Defonticeras and Zemistephanus faunas in the

Tuxedni sandstone of Alaska on the basis of preliminary faunal lists made by Stanton which contained Sphaeroceras oblatum Whiteaves, Sphaeroceras sp. and Stephanoceras richardsoni Whiteaves. McLearn placed Whiteaves' species S. oblatum in the genus Defonticeras and S. richardsoni in the genus Zemistephanus. The present study of the Tuxedni sandstone shows that Defonticeras and Zemistephanus occur in successive zones in the lower sandy shale member. Associated with Zemistephanus, both on the Queen Charlotte Islands and on the Iniskin-Chinitna Peninsula, is the genus Kanastephanus. This tends to strengthen the correlation between the lower Yakoun and the lower Tuxedni.

The Seymourites fauna of early Upper Jurassic age in the upper part of the Yakoun formation indicates that these beds are younger than the Tuxedni sandstone which is limited by definition to the Middle Jurassic. McLearn (1929, p. 2) suggested the possible occurrence of the Seymourites fauna in the overlying Chinitna shale of Alaska on the basis of Kepplerites? cf. K. loganianus (Whiteaves) reported by Stanton (Martin: 1926, p. 165). McLearn (1929, p. 6) places Whiteaves' species K. loganianus in the genus Seymourites. The Chinitna shale is chiefly characterized by the Cadoceras zone which occurs also in the lower Shelikof formation on the Alaska Peninsula where it is associated with Seymourites. Buckman (1929, p. 22) noted the close resemblance between his species of Miccocephalites from the Fernie formation of Alberta and Cadoceras grewingki Pompeckj from the Chinitna shale of Alaska. The occurrence of Miccocephalites in the Tonnie member of the Tuxedni implies that this highest unit is above the true Tuxedni which is limited to the Middle Jurassic.

On the basis of this comparison, the Yakoun formation is correlated with the Tuxedni sandstone including the Tonnie member, but it is

recognized that the Tonnie member may prove to be equivalent to a part of the Chinitna shale. The Yakoun has not yet yielded the Oppelia fauna which characterizes the upper sandy shale member of the Tuxedni sandstone on the Iniskin-Chinitna Peninsula.

The Yakoun formation is composed largely of pyroclastic rocks, agglomerates and tuffs. Flows of andesite and basalt are included. In the lower part of the formation well-bedded tuffs and tuffaceous sandstones contain the marine fauna of early Middle Jurassic age. The Tuxedni sandstone consists of interbedded sandstones and shales with agglomerates locally developed in the Cynthia Falls member and in the Tonnie member. The agglomerates are made up of cobbles and boulders of volcanic rocks with some granites present.

Izee and Colpitts groups of central Oregon

A sequence of sediments of Middle Jurassic age in the vicinity of Snowy Mountain has been described by Lupher (1941). The faunas present in the Colpitts group and the overlying Izee group indicate an age corresponding to the upper Aalenian and lower Bajocian stages of Europe (Lupher: 1941, p. 236). There is no direct faunal evidence for the correlation of the Middle Jurassic sequence in central Oregon with the Tuxedni sandstone, although numerous species of Sphaeroceratidae and Stepheoceratidae have been correlated with the Middle Jurassic of Europe. These families are represented in the Tuxedni sandstone by Defonticeras, Zemistephanus and Kanastephanus, but none of these genera has been found in central Oregon. The occurrence of Bajocian deposits in Oregon and the presence in the Western Interior region of Middle Jurassic genera found in the contemporaneous faunas of Canada and southwestern Alaska suggest future discovery

of a similar fauna in the northwestern United States. Crickmay (1931, p. 34) also postulates a transgression of a Middle Jurassic sea which entered both the Pacific geosyncline and the Rocky Mountain geosyncline.

SYSTEMATIC DESCRIPTIONS

Family STEPHEOCERATIDAE S. Buckman

Genus Zemistephanus McLearn

Genotype: Ammonites richardsoni Whiteaves

1927. McLearn, Trans. Roy. Soc. Canada, 3rd ser., vol. 21, sec. IV, p. 72.

1929. McLearn, National Museum of Canada, Bull. 54, Geol. Ser. no. 49, p. 18.

Generic delineation:

"The inner whorls are cadiconic and latumbilicate. On ultimate whorl becoming serpenticonic, there being umbilical enlargement and whorl contraction, particularly in the proportional thickness of whorl. The primary ribs end in tubercles and are becoming less prominent on the ultimate whorl, but persist to the end. The suture line is moderately complex; ES is large and deeply divided, S1 is smaller than ES, and S2 is shallower than, and as broad as S1; L1 is somewhat longer than EL, L2 is much smaller than L1, is simple and cruciform, has a long, median lobule and is a little inclined; the auxiliary lobes are inclined. The tubercle is about on the border between L2 and S2.

"...There is some resemblance in shape, ribbing, and suture line to Teloceras, e.g. T. banksii (J. Sowerby), but the tubercle is more dorsal in position with respect to L2 of the suture line and there is falling offto serpenticone, which does not occur in Teloceras."

Zemistephanus moffiti K. and N. n. sp.

Plate 2, Figures 1 and 2.

1946. Zemistephanus sp. A. Kellum. U. S. Geol. Surv. MS.

Description: Moderately large, incomplete mold; inner whorls replaced by calcite; remnant of outer whorl is limestone.

Specimen thick, evolute; umbilicus wide and deep with sides sloping at an angle of about 45 degrees. Cross-section of outer whorl quadrate with broadly rounded venter and shorter broadly concave dorsal side, reaching its greatest width about at middle of whorl height forming a subangular ridge bearing coarse nodes which in side view rings the umbilical margin. The outer whorls embrace the inner whorls as far as this line of nodes; the line of contact bisects the nodes except in the last whorl where the contact line passes to the ventral side of the nodes as the whorl narrows. There are approximately 16 nodes on the largest complete whorl present.

Besides the spiral line of nodes around the umbilicus, the ornamentation consists of numerous, coarse, rounded ribs which cross the venter without interruption. Four ribs radiate from each node and a fifth of equal strength begins just above the line of nodes in the internodal area. One large rib extends dorsally from each node down the side of the umbilicus to the line of contact between whorls.

Suture and aperture unknown.

Dimensions:

Diameter of incomplete holotype	195 mm.
Umbilical width	100 mm.
Height of outer whorl	53 mm.
Thickness of outer whorl	110 mm.

Remarks: Zemistephanus moffiti differs from Z. richardsoni in having a greater whorl height, in being less inflated, and in having the umbilicus less deeply excavated. The umbilicus is shallower and more broadly conical in the early whorls, becoming steeper in the outer whorl. It differs from

Z. funteri in its greater umbilical width, and in having a smaller number of secondary ribs per umbilical node.

From Z. vancouveri it differs in its much greater umbilical width and much lower whorl height; the ventral area is not so highly arched. Z. moffiti has a larger number of secondary ribs radiating from each tubercle.

This species is named in honor of Dr. Fred H. Moffit, Geologist of the U. S. Geological Survey, who mapped the Iniskin-Chinitna Peninsula in 1921 and collected many fossils from the Tuxedni sandstone.

Holotype: 23764, Museum of Paleontology, University of Michigan.

Horizon: This species is the zone fossil for the lowest zone of the Tuxedni sandstone on the Iniskin-Chinitna Peninsula.

Localities: Z. moffiti has been identified with certainty at two localities, and specimens which probably belong to this species were found at two other localities.

19973 = 44AWwF40 On left side of Quincy Creek about 3000 feet upstream from mouth of South Fork and about 180 feet above stream level.

19942 = 44AWwF11 On right side of South Fork of Quincy Creek about 4500 feet upstream from confluence with Quincy Creek.

19976 = 44AWwF43 (?) On left side of Quincy Creek about 3000 feet upstream from mouth of South Fork and about 30 feet above stream level.

19979 = 44AWwF45a (?) On right side of Quincy Creek about 4300 feet upstream from mouth of South Fork and about 150 feet above stream level.

Family SPHAEROCERATIDAE S. Buckman

Genus Defonticeras McLearn

Genotype: Defonticeras defontii McLearn

1927. McLearn, Trans. Roy. Soc., Canada, 3rd ser., vol. 21, sec. IV, p. 72.

1929. McLearn, National Museum of Canada, Bull. 54, Geol. Ser. 49, p. 13.

Generic delineation:

> "Inner whorls and posterior part of ultimate whorl sphaeroconic, with very small umbilicus, followed by marked and abrupt umbilical enlargement on the anterior half of the ultimate whorl. Mouth border rather simple, having behind the lobe a well-defined sulcus and in some species a ridge of low relief. Living chamber is about three-fourths of a whorl or less. Primary ribs are fairly stout and slightly inclined, but not sloping well forwards at the anterior end of the ultimate whorl. The secondary ribs are straight across the ventral area. No tubercles. The suture line is complete with a wide L2 and very small S2 and auxiliaries. The point of furcation of the ribs is on the outer part of L2."

Defonticeras stantoni K. and N. n. sp.

Plate 3. Figures 5 and 6.

1946. Defonticeras sp. B. Kellum. U. S. Geol. Surv. MS.

Description: There are numerous specimens in our collection but none is complete. The holotype has one side and part of the venter preserved. Original shell material is present.

Shell inflated, ovoid or depressed sphaeroid; involute in the early whorls, with narrow deep umbilicus, becoming evolute with widening umbilicus in the last half of the ultimate whorl.

Wall of umbilicus nearly vertical; only one and three-quarter whorls visible in the umbilicus of the holotype; two whorls in a smaller paratype. Cross section of whorl lunate with breadly rounded venter and deeply embracing dorsal side.

Aperture broad, fairly well preserved, bordered by narrow flattened band or lip with faint lapets at the side; followed by a broad (8 mm.), pronounced sulcus with prominent ridge posterior to it. The anterior side of this ridge drops off abruptly into the sulcus but the posterior side slopes away gently as a smooth band to a faint depression marginal to the first rib.

Living chamber is approximately half of the outer whorl.

Shell ornamented with numerous primary and secondary ribs. The primary ribs begin near the top of the umbilical wall and increase rapidly in height and thickness to a maximum before reaching the middle of the flank where they divide into two secondary ribs. A third secondary begins on the flank between each two primaries at the line of virgation. The three secondary ribs are about equal, becoming wider spaced and less conspicuous toward the anterior part of the outer whorl. The primary ribs curve anteriorly on the flanks. The secondary ribs curve posteriorly from the point of furcation and pass almost directly across the ventor.

Dimensions:

Diameter of holotype	56 mm.
Height of whorl	7 mm.
Thickness of whorl	34 mm.
Width of umbilicus (near aperture)	14 mm.

Remarks: D. stantoni differs from all species previously referred to this genus by McLearn in having a much smaller height of whorl. It differs from all except D. oblatum in the inclination of the primary ribs on the flanks and slight posterior deflection of the secondary ribs. It differs also in the closer spacing of the primary ribs on the anterior part of the ultimate whorl.

This species is named in honor of Dr. T. W. Stanton who made preliminary identifications of most of the fossils collected during earlier studies of the Tuxedni sandstone.

Holotype: 23765, Museum of Paleontology, University of Michigan.

Horizon: Defonticeras stantoni is a zone fossil in the lower part of the Tuxedni sandstone. It occurs in strata 600 to 875 feet thick which overlie the zone of Zemistephanus moffiti and underlie the Cynthia Falls sandstone member.

Localities:

19981 = 44AWwF47 In small steep gully which enters the right side of Quincy creek about a mile and a half upstream from the junction of Quincy Creek canyon with the valley of Fitz Creek, and about 125 feet above the level of Quincy Creek.

20025 = 44AWwF49 On Quincy Creek about 400 feet downstream from Twin Falls, which flows over the Cynthia Falls Conglomerate at a point about 2¼ miles upstream from the junction of Quincy Creek and Fitz Creek.

19933 = 44AWwF2a On the south shore of Chinitna Bay about 5400 feet east of Fitz Creek Landing.

19940 = 44AWwF9 On the right side of Fitz Creek about 900 feet downstream from the mouth of Forky Creek.

19999 = 44AWwF66 On the right side of Tonnie Creek about 2200 feet upstream from the junction of its canyon with the valley of Fitz Creek.

20000 = 44AWwF67 On the left side of Tonnie Creek about 2500 feet upstream from the mouth of its canyon at Fitz Creek valley.

20002 = 44AWwF69 On the right side of Fitz Creek at the mouth of a small tributary about 400 feet southeast of the abandoned oil well IBA No. 1.

20003 = 44AWwF70 On the northwest slope of Havenstrite Ridge in small steep canyon about 2300 feet southeast of the abandoned oilwell IBA No. 1.

Genus Kanastephanus McLearn

Genotype: Kanastephanus crickmayi McLearn

1927. McLearn, Trans. Roy. Soc., Canada, 3rd ser., vol. 21, sec. IV, p. 73.

1929. McLearn, National Museum of Canada, Bull. 54, Geol. Ser. 49, pp. 21-22.

Generic delineation:

> "At stage of growth of inner whorls, cadiconic. At stage of penultimate whorl, cadiconic, with slightly contracting umbilicus, but whorl becoming relatively a little higher and, therefore, somewhat less depressed, as in K. altus. At stage of ultimate whorl there is umbilical enlargement and rounding and contracting of whorl, chiefly in thickness, i.e., a falling off to serpenticone. At all stages, however, whorls are thicker than high. The living chamber is nearly three-fourths of a whorl. There are lateral lappets. With the falling off to serpenticone at the stage of the ultimate whorl, there is also some simplification in ribbing. The primary ribs, however, increase in number, not only on the inner whorls, but also on the ultimate whorl where there is the greatest number per whorl. The simplification on the ultimate whorl is the decrease in number of secondary ribs, due to decrease in number of secondaries per each primary, and is carried to the stage of two per each primary, arising by bifurcation. The ribs are of considerable relief and in some species are slightly inclined on the sides, particularly near the anterior end, but in all are straight across the venter. There is a single row of lateral tubercles. Suture line fairly simple. L1 is rather broad stemmed, tripartite, with moderately long median lobule, and is about as long as E1. The small L2 is both narrow and short. The small aux. 1 is inclined and the miniute aux. 2 is a little inclined. ES is much broader and deeper than S1 and is unequally divided by a short lobule, the inner branch being the smaller. The S1 is smaller, but is similarly divided. S2 is smaller than S1 and divided by a short lobule. There are two minute auxiliary saddles. The position of the tubercle is about on the boundary between S1 and L2."

Kanastephanus tonniensis K. and N. n. sp.

Plate 3. Figures 7 and 8

1946. Kanastephanus sp. A Kellum. U. S. Geol. Surv. MS.

Description: The holotype is an internal mold with fragments of original black shell material adhering. The species is represented in our collection by a dozen specimens from four localities. None is complete and most are distorted.

A widely umbilicate, coarsely ribbed and rather thick, coiled ammonite of medium size. The whorl section is subquadrate, wider than high and reaching its greatest width near the middle; venter broadly rounded. Inner whorls embrace about half of each preceding whorl, overlapping as far as the line of lateral nodes; the outer whorl, near the anterior end embraces about a third of the penultimate whorl and the line of contact recedes from the line of nodes anteriorly.

Ornamentation on the outer whorl consists of 22 coarse primary ribs which begin at the line of contact with the preceding whorl and extend directly to a line of nodes at or near the middle of the flank where they bifurcate into secondary ribs which continue with full strength across the venter. Rarely an odd secondary rib, equal in size to the others, begins at the line of nodes in the interspace. The secondary ribs are moderately high and sharp, with broader interspaces between. On the inner whorls the primary ribs, seen in the umbilicus, are inclined forward. This becomes more pronounced on the smaller whorls. Aperture and suture line not preserved.

Dimensions:

Diameter of holotype	51.4 mm.
Umbilical width	27.0 mm.
Height of outer whorl	14.8 mm.
Thickness of outer whorl	23.2 mm.

Remarks: Kanastephanus tonniensis is closely related to K. mac-Kenzii McLearn from the lower part of the Yakoun formation on Maude Island, MacKenzie Bay. They may prove to be identical. The Alaskan species has a somewhat wider umbilicus and greater thickness of whorl, but since it has undergone some distortion, these minor differences may not be significant. In all other described species of Kanastephanus, there are three secondary ribs to each primary.

This species is named from Tonnie Creek where the holotype and best preserved specimens were found.

Holotype: 23766, Museum of Paleontology, University of Michigan.

Horizon: Kanastephanus tonniensis occurs in the zone of Zemistephanus moffiti in the lower part of the lower sandy shale member of the Tuxedni.

Localities:

19974 = 44AWwF41 On the left side of Quincy Creek about 3300 feet upstream from the mouth of South Fork.

19977 = 44AWwF44 On the left side of Quincy Creek about 3450 feet upstream from the mouth of South Fork; on the same bed as locality 19974.

19978 = 44AWwF45 On the right side of Quincy Creek about 3450 feet upstream from the mouth of South Fork; opposite locality 19977.

19997 = 44AWwF64 On the right side of Tonnie Creek about 1600 feet upstream from the junction of Tonnie canyon and the valley of Fitz Creek.

Family OPPELIIDAE H. Douville

Genus Oppelia Waagen 1869

Genotype: Ammonites subradiatus Sowerby

Generic delineation:

> Discoidal ammonites with narrow umbilicus, of which the greatest thickness is found near the umbilicus; the flanks lightly convex, thinning toward the external region which is rounded or sharp, but without distinct keel. The ornamentation consists of feeble ribs of sickle shape. Between these ribs may be intercalated some costae which are present only in the vicinity of the external region, but may be lacking.
>
> Suture always with numerous elements, at least five saddles. Ventral saddle massive, often as large at the base as S1 and S2, bordered by two lobules of which the divergence is variable. S1 always larger at the base than the other saddles; this character may diminish and even disappear with age. S1 is normally divided in half by an accessory lobule. S2 is generally higher and more slender than S1. Accessory saddles regularly decreasing as far as the umbilicus in such a way that their summits are always by degrees tangent to the straight line resting on the saddles S1 and S2. Lobes with uneven terminations. (Translation from Roman: 1938, p. 157).

Oppelia chinitnaensis K. and N. n. sp.

Plate 3. Figures 1 and 2.

1946 Oppelia sp. C. Kellum. U. S. Geol. Surv. MS.

Description: Numerous specimens with original shell material preserved were found in calcareous concretions above the Cynthia Falls sandstone on Tonnie Creek.

A compressed involute shell of medium size with sharp venter. Outer whorl wedge-shape and broadly convex in section, attaining greatest thickness near the center of the flank and thinning slightly toward the umbilicus; much higher than wide, embracing preceding whorl about five-sixths. Flanks broadly convex with a faint broad spiral depression between the midline and the umbilical margin which is slightly elevated. Umbilicus narrow exposing about half a turn of the penultimate whorl inside. Umbilical wall vertical; umbilical shoulder rounded.

Flanks ornamented with broad faint falciform ribs which begin at the umbilical margin, where they are barely visible, and increase in strength

toward the venter. From the umbilicus they incline slightly forward to the middle of the flank where they are angulated and incline backward with a scythe-like curve, resuming a forward inclination as they approach the venter and dying out at the venter; interspaces somewhat wider than the ribs; venter smooth.

Toward the anterior part of the outer whorl a secondary rib is rarely intercalated between the primary ribs, and of equal strength with them, beginning about the middle of the flank at the line of angulation. Numerous other very faint short ribs, inclining forward, are intercalated close to the ventral margin.

Dimensions:

Diameter of holotype	58. mm.
Height of whorl	33.6 mm.
Thickness of whorl	12.8 mm.
Width of umbilicus	5.3 mm.

Remarks: The genotype, Oppelia subradiata Sowerby, occurs in the Bajocian stage of the Middle Jurassic in Europe and is the oldest species in the genus which ranges into the Upper Jurassic Oxfordian stage (Roman: 1938, pp. 156-157). Few species in North America have been referred to this genus except in Mexico where Burckhardt (1906) described 12 species from the Oxfordian and Kimmeridgian of Mazapil. An ammonite from the Jurassic of Malone, Texas was identified by Cragin (1905, p. 101) as Oppelia? fallax (Castillo and Aguilera). Fragmentary specimens from several Jurassic localities in the Yellowstone National Park referred by Stanton (1899, p. 630) to Oppelia? are said by Imlay (1945, p. 1025) to belong mostly to the genus Arctocephalites Spath.

Holotype: 23767, Museum of Paleontology, University of Michigan.

Horizon: Oppelia chinitnaensis is a zone fossil occurring in the upper sandy shale member of the Tuxedni sandstone. It was found in the lower 100 feet of the sandy shale which occupies an interval of about 1000 feet between the Cynthia Falls sandstone and the Tonnie sandstone.

Localities:

19943 = 44AWwF12 Near the head of Cliff Creek about a mile and a quarter upstream from its junction with Fitz Creek.

20001 = 44AWwF68 On the left side of Tonnie Creek Canyon about 3500 feet upstream from its junction with the valley of Fitz Creek.

Family MACROCEPHALITIDAE S. Buckman

Genus Miccocephalites S. Buckman

Genotype: Miccocephalites miccus S. Buckman

1929. S. Buckman, National Museum of Canada, Bull. 58, Geol. Ser. 58, p. 14.

Generic delineation:

> "Platycone (ex sphaerocone) of Macrocephalitoid pattern, like dwarf 'macrocephali curvicostati' of Waagen. Costae laminate, flexed, especially primaries over umbilical edge, and secondaries towards edge of venter, carrying ribs over venter with a curve convex forward: lamination of costae well shown on a flatly arched venter. Suture-line obscurely shown, but it can be seen that it is simple with narrow lobes.
>
> "Miccocephalites differs from Macrocephalites and Paracephalites in its style and curve of ribbing, which has been described above, and in its simpler suture-line. It differs from Metacephalites in the character of laminate ribbing and in suture-line.
>
> "Distinction from Pseudocadoceras or like forms is to found in the venter flatly arched instead of fastigate (angulate), in the characters of the ribbing, and in the decrease instead of increase of stoutness with growth."

Miccocephalites sp. A. cf. M. concinnus S. Buckman

Plate 3. Figures 3 and 4.

1946 Miccocephalites sp. A. Kellum cf. M. concinnus Buckman. U. S. Geol. Surv. MS.

Description: A single fragment of an ammonite referred to the genus Miccocephalites was found in a coquina about 100 feet above the Tonnie conglomerate in the Tonnie Creek section. The original shell material is preserved and the delicate ribbing and cross-section of the whorl are clearly visible. The fragment, however, consists of less than a quarter of the complete outer whorl.

Although the umbilical margin is not present on the specimen, the primary ribs on the flanks end dorsally at a fracture plane which evidently cuts the specimen almost at the shoulder of the umbilicus. Five primary ribs reach this plane. From it they are inclined slightly backward on the flank, but within 2 mm. they curve abruptly forward and are inclined anteriorly on the flank. All except one of these five primary ribs divide on the lower part of the flank, giving rise to one, two, or three secondary ribs. The point of furcation is at a different height on each rib ranging between 2.7 mm. and 4.4 mm. from the fracture, i.e. on about the dorsal third of the flank. The primary ribs are narrow, sharply angulated at the crest, and separated by broader rounded interspaces. They attain their greatest strength both in height and width at the sharp curve from posterior to anterior inclination. From the point of furcation a secondary rib may begin in one of three distinct ways: (1) It may develop as a smaller rib on the flank of the primary, (2) the primary rib may divide into two equal secondaries, or (3) the secondary may begin independently in the middle of the interspace. In any case the secondaries attain equal strength close to

the point of origin and incline forward on the flank continuing without change across the venter. They are separated by more broadly rounded interspaces.

The venter is a broad to slightly flattened arch. The flank is more distinctly flattened.

Dimensions:

Height of whorl from venter to fracture near umbilicus ... 11.8 mm.

Thickness of whorl ..... 10.5 mm.

Remarks: The specimen is too fragmentary for specific identification. The ribs appear to be slightly less flexuose than in M. concinnus. The angle between the flank and the venter is more rounded than indicated by most of Buckman's figures.

Holotype: 23768, Museum of Paleontology, University of Michigan.

Horizon: This genus designates the highest zone recognized in the Tuxedni sandstone on Tonnie Creek. It was found only at one horizon in the Tonnie member about 100 feet above the Tonnie conglomerate which is 540 to 710 feet above the base of the member. Although here included tentatively in the Tuxedni sandstone the meager faunal evidence available suggests that the Tonnie member may be in part Upper Jurassic and correlated with a part of the Chinitna shale.

Locality:

20014 = 44AWwF81 Near the head of Tonnie Creek, in the streambed about a mile and a quarter upstream from the junction of Tonnie canyon and the valley of Fitz Creek.

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EXPLANATION OF PLATES

Plate 2

Middle Jurassic ammonites from Iniskin-Chinitna Peninsula

Figure

1, 2....*Zemistephanus moffiti* K. and N., n. sp.;
Lateral and apertural views of holotype;
U. M. 23764 (p. 17)

PLATE 2

2

1

Plate 3

Middle Jurassic ammonites from Iniskin-Chinitna Peninsula

Figure

1, 2 ... Oppelia chinitnaensis K. and N., n. sp.;
Lateral and apertural views of holotype;
U. M. 23767 (p. 25)

3, 4 ... Miccocephalites sp. A cf. M. concinnus S. Buckman;
Lateral and apertural views; U. M. 23768 (p. 28)

5, 6 ... Defonticeras stantoni K. and N., n. sp.;
Lateral and apertural views of holotype;
U. M. 23765 (p. 20)

7, 8 ... Kanastephanus tonniensis K. and N., n. sp.;
Lateral and apertural views of holotype;
U. M. 23766 (p. 23)

PLATE 3