(4)

Jurassic Stratigraphy of Alaska and Petroleum Exploration in Northwest America

by

Lewis B. Kellum
University of Michigan

Reprint from Transactions of the New York Academy of Sciences. Ser. II, Vol. 7, No. 8, June, 1945.

TRANSACTIONS
of
THE NEW YORK ACADEMY OF SCIENCES

SER. II, VOL. 7 JUNE, 1945 No. 8

SECTION OF GEOLOGY AND MINERALOGY*

MAY 7, 1945

DOCTOR LEWIS B. KELLUM, Director, Museum of Paleontology, University of Michigan, Ann Arbor, Michigan: *Jurassic Stratigraphy of Alaska and Petroleum Exploration in Northwest America.* (This lecture was illustrated with lantern slides.)

The bearing of the Jurassic stratigraphy of southwestern Alaska on the petroleum possibilities of northwestern America stems from the events of geologic history recorded in the rocks. The faunal zones recognized in stratigraphic sections of near shore marine deposits dates the orogenic, physiographic and climatic changes taking place on nearby lands and in the neritic belt. Source and reservoir rocks in the sections can be projected into the subsurface of nearby areas where the cover is sufficient to permit accumulation of hydrocarbons. Precise age determination of the rock units within the formations permits the recognition of structural features which may influence the migration of hydrocarbons. The accurate correlation of strata in southwestern Alaska with those of the Pacific coast and Rocky Mountain region of Canada and the western United States by means of the faunas, integrates the geologic events throughout northwestern America, highlights the oil producing horizons of one area for intensive study in distant

* No meeting of the Section of Anthropology was held in May.

TRANSACTIONS of the New York Academy of Sciences, Series II, Volume 7, No. 8, June, 1945.
This publication is distributed to Members and is published monthly from November to June, inclusive, at 109 West Chestnut Street, Lancaster, Pa., by The New York Academy of Sciences, Seventy-ninth Street and Central Park West, New York City.
Editor: Roy Waldo Miner.
Executive Secretary: Eunice Thomas Miner.
Entered as second-class matter December 2, 1938, at the post office at Lancaster, Pa., under the act of August 24, 1912.

TABLE 1

TENTATIVE COMPOSITE TRIASSIC AND JURASSIC STRATIGRAPHIC SUCCESSION IN SOUTHWESTREN ALASKA

Period	Formation	Lithology	Faunas
Upper Jurassic	Naknek 5000′	White or light-colored, hard arkosic sandstone, andesitic tuff, coarse and fine sandstone, shale and conglomerate. Thin sills of quartz diorite are intruded into the sedimentary beds. 3000+ feet.	*Aucella*
		Gray shale with dark arkosic beds. At the base is fine conglomerate or grit with thin sandy beds scattered through it, equivalent to the Chisik Conglomerate. 1645 feet.	*Cardioceras*
		Chisik Conglomerate: Locally developed; 290′–400′. Boulders of granite or diorite and other igneous rocks embedded in tuffaceous andesitic matrix.	
	Shelikof 8000′	Massive black shale with some limestone lenses and nodules. 700–1000 feet.	
		Massive brown to gray sandstone with minor amounts of shale and conglomerate. 4000–4700 feet.	*Astarte* sp. E
		Gray sandy shale. 200 to 1200 feet.	
		Chinitna shale member: Gray shale with stringers of fine and coarse sandstone and buff-weathering limestone; large limestone concretions weathered ashy gray at one horizon carry fossils. A thin porphyry sill intrudes this section at Wide Bay. 400–1300 feet.	*Cadoceras*
		Well-stratified gray shale interbedded with thin lenticular layers of limestone and thin beds of soft gray sandstone weathered yellow; limestone concretions varying from 1 to 10 feet in longest dimension contain wood fragments and a large flat *Inoceramus*. Several diabase sills intrude these strata at Wide Bay. 950 feet.	
		Interbedded sandy shale and fine to medium grained silty sandstone containing gray limestone concretions. 100 ± feet.	*Seymourites*

TABLE 1 (Continued)
TENTATIVE COMPOSITE TRIASSIC AND JURASSIC STRATIGRAPHIC SUCCESSION IN SOUTHWESTERN ALASKA

Period	Formation	Lithology	Faunas
Upper Jurassic	Tuxedni 4000′	Tonnie sandstone member: a series of alternating sandstones, shales and coarse conglomerates with numerous fossil bearing horizons. 1200 feet.	*Miccocephalites*
Middle Jurassic		Sandy shale with stringers of shaly sandstone; near the middle are coarse sandstones grading into conglomerates with cobbles of volcanic rock; small calcareous concretions in the shale near the base are fossiliferous. 950 feet.	*Oppelia* sp. C
		Cynthia Falls member: Medium-grained gray sandstone grading horizontally into alternating sandstone and conglomerate. 800 feet.	
		Sandy shale with numerous stringers of shaly sandstone and with concretionary masses in the upper half; fossils present at many horizons. 1250 feet.	*Defonticeras* sp. B *Zemistephanus*
Lower Jurassic	Kialagvik 1600′	Kolosh member: (a) Platy to massive medium-grained to conglomeratic greenish-gray sandstone containing wood fragments and *Inoceramus*. 200 feet.	*Inoceramus* sp. C
		(b) Interbedded sandstone and shale becoming predominantly sandstone at the top. 300 feet.	*Dactylioceras*
		Aleuts member: (a) Interbedded sandstone, shale and conglomerate, increasing in coarseness upward with several beds of conglomerate in the upper 200 feet. 450 feet.	*Hammatoceras? kialagvikense*
		(b) Dark gray to black shale grading upward into gray shaly sandstone. 650 feet.	"*Hammatoceras*" *howelli*
	Bidarka 2300′	Dark gray-black shale with occasional thin beds of light colored, coarse-grained, well-indurated sandstone. 1300 feet.	*Arieticeras?*
		Massive to thin-bedded tuffaceous sandstone and interbedded calcareous shale and limestone. 1000 feet.	*Astarte* sp. D
Upper Triassic	Kamishak 1400′	Thin-bedded, dense, organic limestone interbedded with shale and sandstone; intruded by dikes and sills.	*Pseudomonotis subcircularis*

potentially productive areas, and shows the extent and distribution of synchronous seas, the position of their shorelines, their hinge lines of subsidence and their basins.

The sequence of Jurassic and Triassic formations in southwestern Alaska is shown in TABLE 1.

The Kamishak formation exposed at Cold Bay is dominantly limestones and may be considered favorable source rocks for petroleum. Their apparent organic character is also encouraging. The limestones are not greatly metamorphosed and the few igneous dikes and sills which penetrate them have produced only narrow zones of alteration. These intrusions are thought to be of pre-Jurassic age, since they are confined to the Triassic rocks. The overlying Jurassic strata are free from intrusives in the Cold Bay section. The gradational and apparently conformable contact between the Triassic and Jurassic systems in this section indicates that there was no period of folding, uplift and erosion after the Triassic limestones and associated sandstone had been deposited. Such an unconformity, if present, might have afforded the opportunity for escape of liquid hydrocarbons which had accumulated in the Triassic rocks before Jurassic time. On the other hand, many if not most large accumulations of oil throughout the world are associated with unconformable contacts. Tuffaceous sandstones in the upper part of the Triassic section furnish possible reservoirs for the accumulation of oil formed in the limestone and shale source rocks. The objective of any deep well drilled in the Alaska Peninsula should be to penetrate the Triassic rocks from top to bottom. It is perhaps significant, however, that the Triassic throughout the world has produced less oil than any other post-Cambrian system. This is explained by the fact that it was a time of restricted seas and expanded deposition of continental and volcanic deposits. These presumably lacked the kind and quantity of organic material to yield the hydrocarbons necessary to form commercial quantities of petroleum in the areas of the present land masses. The neritic belt in which the proper balance of highly organic marine sediments interfingered with coarse clastics to produce both source and reservoir rocks was, for the most part, during Triassic time, outside the margins of the present continents. Nevertheless, Triassic or Permo-Triassic strata have produced small quantities of oil in the Rocky Mountain region of the United States (Moenkopi and Chugwater formations), in the Mendoza Province of Argentina and the Emba district of the U. S. S. R.

Another factor bearing on the presence of commercial oil in Triassic rocks in southwestern Alaska is the igneous activity associated with them. In the Cold Bay section, the amount of igneous rock penetrating the limestones of the Kamishak formation is unimportant, but at Ursus Cove, 180 miles to the northeast, considerably more intrusive rock is present. Possibly, the igneous activity of early Mesozoic time on the Alaska Peninsula may have been decreasing in intensity to the southwest.

The Jurassic section at Cold Bay consists of 2600 feet of dark colored shales and tuffaceous sandstones. They are considered to be a favorable association of possible source and reservoir rocks. Shales predominate near the top of the formation and would serve as a cap rock for the more porous sandstones. The absence of limestones as a potential source rock in the Jurassic is to be noted, but this deficiency may be, in part, offset by their presence in the underlying Triassic, separated only by a gradational contact.

All of the sediments referred to the Jurassic in the Cold Bay section are assigned to the Lower Jurassic and are overlain disconformably by the basal conglomerate of the Upper Jurassic Shelikof formation. There is no positive evidence that the Kialagvik formation or equivalent strata are present in the Cold Bay section, although the upper 1300 feet of the Bidarka formation did not yield any fossils. The stratigraphic interval between the Kialagvik formation cropping out on the Wide Bay anticline and the Lower Jurassic Bidarka formation cannot be estimated. The absence of igneous rocks in the Jurassic at Cold Bay is favorable. The succession of fine and coarse grained sediments in the Triassic and Jurassic section implies an oscillating sea without important mountain building nearby.

There are several factors in the stratigraphic section exposed at Wide Bay which seem to have a bearing on the oil possibilities of the Alaska Peninsula. A careful comparison of the lithologic variations vertically within each faunal zone and subzone brings out the cyclic nature of the sedimentation. Within each time interval, the sediments laid down grade from finer or coarser-grained clastics. If this persists in the subsurface section, it would provide an alternation of potential source and reservoir rocks. The coarsest sdiments in the Kialagvik formation are the conglomerates interbedded with sandstones in the upper part of the Aleuts member. The member has an exposed thickness of 1150 feet and grades upward from shales in the lowest outcrops to conglomerates at the top. At Fossil Bluffs on Wide Bay, there is a thin zone of limestone 575 feet above the base. This sequence of lithologic units interpreted in terms of shoreline development implies a regressing sea. As the shoreline moved closer to the Wide Bay area, coarser clastics were deposited. Conversely, during an earlier stage of the regression, the area was further off-shore where clearer waters prevailed, and the deposition of calcium carbonate would not have been masked to such an extent by the influx of clastics. Hence, limestones might be expected to comprise a larger percentage of the subsurface section than is present in the exposed part of the Kialagvik formation. This is supported by the repeated record of stringers of impure limestone in calcareous shale throughout the lower half of the log of Standard Grammar Well No. 1, in strata included in the Kialagvik by the Company's geologists. This well was located in the Kanatak District, 30 miles northeast of the sections measured at Wide Bay.

The Kialagvik formation on the Iniskin-Chinitna peninsula increases in coarseness from the base upward. The lower 1600 feet is chiefly sandy shale and siltstone with some sandstone stringers. The upper 900 feet consists of sandstones with numerous thick beds of cobble conglomerates derived largely from volcanic rocks. The sequence here confirms the evidence of a regressing sea and the approach of the shoreline. The coarse conglomerates suggest that this regression was accompanied by orogenic disturbances nearby, but there is no evidence of angular unconformity between the Kialagvik and the overlying Tuxedni sandstone.

The Tuxedni standstone is a series of alternating sandstones and sandy shales. The sandstones become thicker and coarser in the upper part of the section and there are several thick beds of boulder conglomerates present. The boulders in some of these are coarse granites evidently derived from the erosion of an intrusive mass brought to the surface by uplift and degradation. The beginning of Tuxedni deposition records a new transgression of the sea in Middle Jurassic time, followed by oscillations of the shoreline as deposition and erosion contended for the littoral zone. Following the initial invasion, the record is one of halting withdrawal throughout the remainder of Middle Jurassic time. The thickness of the Tuxedni sandstone indicates a subsidence of over 4000 feet in the Iniskin Chinitna Peninsula area, but the deposition of clastics kept pace with it and the sea remained shallow throughout the period. When subsidence ceased, permanent deposition came to an end.

At Wide Bay, the Middle Jurassic Tuxedni sandstone is not present and the Upper Jurassic Shelikof formation rests on the Lower Jurassic Kialagvik without apparent unconformity. Evidently, there was little or no subsidence in the Wide Bay area during Middle Jurassic time. It began again in early Upper Jurassic time and the Shelikof sea transgressed a long distance west of the Wide Bay area where fine clays and limes were deposited. The influx of clastics from a rising land area on the northwest soon pushed the shoreline eastward in spite of several thousand feet of subsidence during the early Upper Jurassic time. The middle part of the Shelikof formation consists of sandstones and siltstones.

The Chinitna shale, which overlies the Tuxedni sandstone on the Iniskin-Chinitna Peninsula, is in part equivalent to the lower shales of the Shelikof formation and, like it, records a period of marine transgression. The overlying Naknek sandstone shows another influx of great quantities of sands, from the adjacent land-mass. These accumulated as rapidly as the subsiding sea bottom permitted their permanent deposition. The thick bed of coarse conglomerate widely present at its base records the sudden uplift which accompanied the withdrawal of the sea after the Chinitna-Lower Shelikof transgression.

The depositional record of Jurassic time in southwestern Alaska is one of great subsidence in the neritic belt, accompanied by oscillation of the shoreline. The subsidence here was balanced by uplift of the land area to the northwest contributing coarse clastics to the eastward flowing streams. Igneous activity accompanying this orogeny is reflected in the Arkosic sandstones throughout the section and the cobbles and boulders of volcanic and intrusive rocks at many horizons. The correlation of Jurassic formations and faunas of southwestern Alaska with those of Canada and the western United States is shown in TABLE 2.

TABLE 2
CORRELATION CHART OF JURASSIC FORMATIONS AND

<table>
<tr><th>PERIOD</th><th>EUROPEAN STAGE</th><th>AGE IN BUCKMAN'S CLASSIFICATION (AFTER McLEARN)</th><th>WIDE BAY AND COLD BAY ALASKA</th><th>FAUNAS OF SOUTH-WESTERN ALASKA</th></tr>
<tr><td rowspan="8">UPPER JURASSIC</td><td></td><td rowspan="5"></td><td rowspan="2">Naknek SS</td><td>Aucella</td></tr>
<tr><td>Argovian</td><td>Cardioceras</td></tr>
<tr><td rowspan="3"></td><td rowspan="4">Shelikof Fm.</td><td></td></tr>
<tr><td>Astarte sp. E</td></tr>
<tr><td></td></tr>
<tr><td rowspan="3">Callovian</td><td rowspan="2">Propanulitan</td><td rowspan="2">Cadoceras
Seymourites
Miccocephalites</td></tr>
<tr><td rowspan="9">HIATUS</td></tr>
<tr><td>Macrocephalitan</td><td rowspan="3"></td></tr>
<tr><td rowspan="6">MIDDLE JURASSIC</td><td rowspan="8"></td><td></td></tr>
<tr><td>Stephanoceras</td></tr>
<tr><td rowspan="4">Sonninian</td><td>Oppelia sp. C</td></tr>
<tr><td>Defonticeras sp. B</td></tr>
<tr><td>Zemistephanus</td></tr>
<tr><td rowspan="2"></td></tr>
<tr><td rowspan="5">LOWER JURASSIC</td><td></td></tr>
<tr><td>Hildoceratan</td><td rowspan="2">Kialagvik Fm.</td><td>Dactylioceras</td></tr>
<tr><td>Toarcian</td><td rowspan="3"></td><td>"Hammatoceras"</td></tr>
<tr><td></td><td rowspan="2">Bidarka Fm.
?</td><td rowspan="2">Arieticeras ?
?</td></tr>
<tr><td>Sinemurian</td></tr>
</table>

Faunas in Southwestern Alaska, Canada and Oregon

INISKIN-CHINITNA PENINSULA	FAUNAS OF PACIFIC COAST OF CANADA		FAUNAS OF FERNIE FORMATION OF CANADA	OREGON
Naknek SS.				?
			Cardioceras canadense	Lonesome Fm.
			Peltoceras occidentale	
				?
Chinitna Sh.				
	Yakounites		Seymourites	Trowbridge Group
		Y	Corbula munda	
	Toricelliceras	A		
		K	Chlamys mcconnelli	
	Teloceras	O		
Tuxedni SS.		U	Teloceras, Stemmatoceras, Defonticeras, Saxitoniceras, Zemistephanus	Izee Group
	Defonticeras	N		
	Zemistephanus; Kanastephanus			
			Sonninia	Colpitts Group
?				
Kialagvik Fm.	"Dactylioceras"	M		
		A	Dactylioceras; Hammatoceras	
		U	Grammoceras	Mowich Group
	"Sequinziceras"	D		
	"Oxynoticeras"	E		Donovan Group
			Eparnioceras	