NOTE:

The analysis of geologic data collected in 1947 has resulted in some revision in the stratigraphic picture of the Upper Cretaceous and early-Tertiary sequences of rocks. In connection with this revision it has become advisable to drop the use of the term "formation" as the time-rock unit designations A through I and instead to use the term "zone." Use of the term "formation" will be more appropriate in a more detailed tongue-member classification of the Upper Cretaceous rocks.

In these 1947 preliminary reports the time-rock units formerly called Formations E, F, G, H, and I are now called Zones E, F, G, H, and I. However, some changes in vertical limits have been made. These are discussed in the reports concerned.

As the term is used in the October 1947 reports, Zone A is, in general, the sequence of rocks formerly called Formation A. Exceptions are on the Oolamnagavik and Kurupa Rivers where Zone A is equivalent to Formations A, B, and C. Zone A is dominantly a marine section of thick sandstone members separated by siltstone and shale. The thickness is fairly consistent, ranging from about 2,000 feet to about 2,500 feet as measured along streams from the Sagavanirktok to the Utukok Rivers. Zone A has proved to be a very persistent unit laterally. It has been recognized in the field on the Utukok, Colville, Kurupa, Oolamnagavik, Killik, Chandler, Anaktuvuk, Nanushuk, and Sagavanirktok Rivers.

All rocks between the top of Zone A and the bottom of Zone E are now classified as Zone D. This sequence of rocks thickens from east to west ranging from about 2,500 feet on the Nanushuk to about 5,000 feet on the Utukok River. On the Nanushuk River it is mainly a marine shale section which becomes sandy and contains some coal near the top. Although marine tongues are present in the sections that have been studied to the west, deltaic-coastal, and terrestrial facies form a large part of the section. The units into which Zone D can be divided differ from river to river and are called d-1, d-2, etc. These divisions apply only to a particular river or area and are not to be considered correlative.

U.S. Geological Survey.

PRELIMINARY REPORT ON THE STRATIGRAPHY AND STRUCTURE OF THE AREA OF THE COLVILLE RIVER FROM THE IPNAVIK TO KURUPA RIVERS, ALASKA

By

R. F. Thurrell, Jr.

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The area covered in this report extends along the Colville R. from the mouth of the Ipnavik R. (Long. 156-30 W.) to the mouth of the Kurupa R. (Long 154-50 W.). On the east it adjoins the area treated in Report No. 5*. It is bounded on the north by the area worked this year by the Awuna-Kigalik party**. On the morning of August 8, 1947, one plane load of supplies and equipment was flown to a gravel bar at the mouth of the Ipnavik R. That afternoon the remaining equipment and field party were flown to the landing bar. The plane "overshot" the landing bar. It nearly hurdled the Ipnavik R. crashing in shallow water at the east bank.

There was little damage to the load of equipment and no serious injury to the passengers, although the plane was damaged. Salvage became hopeless two days later when the river rose about 3 feet moving the plane downstream 1/4 mile into a deep channel of the Colville. R.

From the mouth of the Ipnavik R. the party moved downriver in 18-foot collapsible canvas boats. Camp sites were located from 8 to 10 miles apart. Field work was completed on August 31 at the confluence of the Kurupa and Colville Rivers, whence the party floated downstream to Umiat.

Base maps at 1:48,000, compiled from Tri-Metro on aerial photography, were used. Outcrops and sample localities were located on the aerial photography, carried in the field. Later they were relocated on the base maps. The present aerial photographic coverage is good in the western part of the area, but in the eastern part, particularly along the Colville R. from the Awuna R. to the Kurupa R., the coverage is poor. The resultant accuracy of the base map is parallel.

Altitudes were computed from closed traverses with altimeters reliable to about 10 feet. Two of these were used. The discrepancy between them was usually less than 5 feet. No barometric observations were taken during the time of the traverses. Morning and evening readings in camp, and differences in recordings at closure points were used to adjust the relative elevations obtained at each camp site. The difference in elevation between camp sites was computed from an assumed river gradient. No surveying was undertaken.

* Chapman, R. M., and Thurrell, R. F., Stratigraphy and structure of the area of the Kurupa, Oolamnagavik, Killik, and Colville Rivers, 1947.

** Whittington, C. L., and Troyer, M. L., Preliminary report on the stratigraphy and structure of the area of Kigalik and Awuna Rivers, Alaska.

The Colville R. flows through Lower Cretaceous rocks west of the area covered in this report, and first impinges against Upper Cretaceous rocks near its confluence with the Etivluk R. East of the Etivluk R. it passes through Upper Cretaceous rocks only. On the south side of the river valley the terrain is low ranging from 50 to 150 feet above river level, and is generally capped by terrace gravels averaging 30 feet thick. The gravel is predominantly quartz and dark chert, as much as 2 inches in diameter. In Lower Cretaceous rocks the terrain north of the river valley is very similar to that on the south.

The basal section of the Upper Cretaceous rocks forms a frontal bluff, in places 500 feet high. This bluff trends approximately N. 70°W. It passes from the north to south side of the Colville R. two miles east of the Etivluk R. North of the Colville R. from the bluff to the Awuna R., bedding traces* are prominent. They form an important link in the correlation of the outcrops along the river, and in the computation of stratigraphic thicknesses. Many of these traces are not present on the south side of the Colville.

From the Etivluk R. to the Awuna R. the Colville R. is cutting across the stratigraphic section in a series of broad bends. The present river gradient is believed to be about 4 feet per mile, similar to that east of the junction of the Kurupa R. with the Colville R. This gradient is characterized by rapid descents separated by long stretches of slow deep water. The mouth of the Kurupa R. is estimated as 790 feet above sea level**. Thus 50 river miles west, at the mouth of the Ipnavik R., the elevation is approximately 1,000 feet above sea level.

## STRATIGRAPHY

### Lower Cretaceous

The Lower Cretaceous strata are exposed along the north side of the Colville R. in scattered outcrops. These outcrops occur westward from a point three miles west of the mouth of the Etivluk R. Correlation of the sections exposed at different localities is not reasonable on the basis of field observations. The dips of beds are steep. Tight folds exist. The magnitude of faults observed cannot be satisfactorily ascertained. Rock exposures are small.

The strata are composed of clayshale in 1 to 3 inch beds. It is fissile, fairly hard, with interbeds of siltstone and sandstone. The sandstone is very fine grained. It is dark gray-green to gray, in 1 to 4 inch layers and is cross-bedded. It contains a large amount of interstitial clay and silt. The porosity is very low. The surfaces of many

* Surface expression of underlying rocks in the form of banks of talus, frost boils, or marked changes in vegetation.

** Op. cit., (Report No. 5) Fig. 1.

layers show irregular current ripple marks, swirls, lumping, and have a "ropy" appearance. The sandstone was observed also in beds 2 to 4 feet thick.

Beds are crumpled near the axes of tight folds. Slickensides and calcite mineralization occur near the axes of the folds. Jointing is well developed in two planes at right angles to each other and approximately perpendicular to the bedding plane. This produces thin "bricks" and rectangular to square-ended "rods." They appear both in place and in the talus, giving a very distinctive appearance to talus slopes of Lower Cretaceous rocks.

Samples of clayshale and siltshale collected for microfossil determination have been processed and classified as barren.

## Upper Cretaceous

A total thickness of about 7,500 feet of Upper Cretaceous shale is believed to be present in this area. This thickness has been computed from a series of distances between distinct bedding traces, using altimeter elevations and field three-pointing. V's in bedding traces gave reliable strikes and dips. The distances were measured on the 1:48,000 base maps. The thickness of the upper part of the section is less accurate than the lower part, as measurements were taken from the poorer part of the map. Also, the exposures downriver from Section No. 5 were small and nearly along the strike. Values for strike and dip are less certain there.

The lithology of outcrops along the river is correlated with the computed stratigraphic thickness by the position of the bedding traces in the exposed sections. This information is supplemented by the character of talus, frost boils, and rubble horizons located between the main structure traces. In case of variation in thickness along the strike between the same beds, error could arise from such correlation. In the few places where the stratigraphic distance between two beds could be computed in localities serveral miles aprart, no change in thickness was discovered.

The contact between the Upper and Lower Cretaceous rocks is not exposed in this area. If the structural evidence, very steep versus gentle dipping strata, is accepted, the contact can be limited in position by outcrops 3 miles apart on the Etivluk and Colville Rivers. In the stratigraphic columns the thickness of Upper Cretaceous rocks has been computed from the base of the lowest observed sandstone (120 feet thick), which forms a bedding trace. Beneath the sandstone are strata indicated by talus and poor exposures as primarily clayshale and siltshale. This shale section could be up to 1,000 feet thick and remain conformable with the sandstone above it. Preliminary examination of heavy mineral concentrates of sandstones collected from Lower and Upper Cretaceous strata in this vicinity shows no criterion for placing the contact. It is believed that the shale section may be in part Upper Cretaceous.

The Upper Cretaceous strata exposed in this area have been divided into three zones, A, D. and E. Zone A is the basal section, with marine depositional environment. Zone D is the coal bearing section, with littoral, lagoonal, or terrestrial depositional environment. Zone E is very limited, and questionable, containing the only bentonite in the series of beds.

For purposes of correlation with the strata along the Kurupa R.* it is considered advisable to state here the relationship of the zones to formations on the Kurupa R. The sequence of rocks through Formations A, B, and C, on the Kurupa R. are correlated with Zone A on the Colville R. Formations D and E are the same as Zones D and E, respectively.

Zone A.

Zone A is about 2,480 feet thick. The strata are predominantly sandstone, and siltstone, with lesser amounts of siltshale and clayshale, and a minor amount of ironstone. The sandstones vary from fine to very fine grained. A few are medium grained. They are well stratified. They are primarily dark greenish-gray, and they weather a blackish hue. Finely divided flecks of carbonaceous material are concentrated in laminae in some of the sandstones. These sandstones weather in 1 to 3 inch plates and break readily along the bedding planes. Talus, after long exposure, tends to become stained uniformly to dark yellowish green-gray. Oscillation ripple marks, fairly uniform in wave length and amplitude, appear on some of the beds of platy sandstone. Worm tracks (or tubes) are abundant. Some sandstone beds are very hard. Of these many are high in calcareous cement. A minor amount of granule conglomerate occurs at the top of the zone in lenses and concretions.

The lowest member of Zone A is a sandstone 120 feet thick. It is poorly exposed, though talus is abundant. The first main ridge (Trace No.1) of the frontal bluff is 100 feet of sandstone (At 960)**. It is more massive than the other sandstones characteristic of this zone. It weathers into irregular slabs. Field examination indicated nearly uniform porosity throughout Trace No. 1. Laboratory tests on 4 samples show an average of 12.9 percent (10.9-15.9). 470 feet higher in the section is Trace No. 2, a sandstone 150 feet thick (1525-1675). For a short distance it forms the top of the frontal bluff, and can be followed as a bedding trace for serveral miles. On the north side of the Colville R. the sandstone is poorly exposed, though broad bands of talus exist. The same member was found on the south side of the river where it formed a good outcrop. Porosity samples showed 14.7 and 14.8 percent. The sandstone is poorly stratified, fine grained, and light to medium gray. It weathers pale yellow-red. Fossil wood fragments are plentiful. The sandstone also has scattered thin lenses of carbonized wood. Trace No. 2 locally has a sharp division in the middle, forming two distinct traces. The traces are separted

* Op. cit.

** Indicates number of feet above the base of Zone A.

by approximately 15 feet of siltshale.

Trace No. 3 is sandstone approximately 40 feet thick (2400-2440). The lower 20 feet is well exposed in a bluff where the trace crosses the north side of the Colville R. The sandstone is fine to coarse grained, in layers 1 to 3 inches thick, and contains conglomeratic lenses several inches thick. It is medium green to green-gray. Carbonized plant fragments are present. One sample from the lower half of Trace No. 3, where it is exposed in the bluff, showed a porosity of 17.4 percent, which is believed to be about the average. Round concretions up to 2 feet in diameter are in the talus. They are sandstone, similar to that in the trace. They are very platy, and break up as flat discs. Fossil fragments are in some of the concretions.

A number of other sandstone beds, from 5 to 25 feet thick, are scattered throughout Zone A.

The siltstone and siltshale in Zone A are greenish-gray to medium neutral. They contain a large amount of carbonaceous material. Most of the plant remains found were preserved in the siltstones and siltshales. Crossbedding is common within thin layers, 1/2 to 1 inch thick. Though poorly exposed, from lack of steep bluffs, the abundance of siltstone and siltshale in talus slopes shows that they form a high percentage of the less resistant strata between the sandstone members. As seen in outcrops, small amounts of clayshale, ironstone, and limestone are present.

Fossils are scarce in Zone A. Poorly preserved pelecypod casts were observed in the sandstone of Trace No. 1 and other sandstones in the lower part of the zone. An unidentified pelecypod, very thick-shelled, was found in a conglomerate layer in Trace No. 3. Dentalium was indentified in two sandstone beds, shown at 735 feet and 830 feet on the columnar chart.

Zone D.

Zone D is about 9,345 feet thick. It may be thicker, as a covered interval exists above the top exposure of the zone. This zone has been subdivided into two units, d-1 and d-2.

Unit d-1: Unit d-1 is about 1,585 feet thick (2480-4065). There are two distinct lithologic groups in the unit. The first group is composed of sandstone, siltstone and siltshale with the same characteristics as Zone A. This group contains marine fossils and is indicated as marine tongues.

The second group is predominantly sandstone and siltshale, with some siltstone, clayshale, ironstone and coal. The coal is good-grade bituminous in beds 2 to 8 feet thick and contains little or no bone and clay. Many of the non-marine sandstones are crossbedded. Their grain size is fine to coarse (medium to coarse predominant). Granule conglomerate layers and lenses are numerous.

The sandstones of the second group are light to medium gray and weather pale to bright yellow-red. On a new fracture surface the weathering seems spotty, like specking between the grains, rather than a uniform color as noted in Zone A. Ironstone lenses, layers, and concretions are numerous. They vary from 1 inch to 2 feet thick. Limestone is also present. The similarity of occurrence and appearance causes difficulty in distinguishing it from ironstone (on a fresh surface ironstone appears browner, limestone blacker, and the latter usually has higher carbonaceous content). The siderite-calcite proportion in the concretions seems variable over a wide range. Fossilized tree trunks have been found standing upright in the strata in several exposures. One exposure showed differential compaction in the sediments surrounding the tree. The presence of these trees indicates non-marine deposition.

Unit d-1 contains one 40-foot conglomerate (3095-3135). It is massive with thin interbeds of coarse sandstone. White quartz and dark chert are the chief constituents. The quartz is granule to small pebble size, sub-round to round. Large pebble size predominates in the chert, which is sub-angular. The matrix is coarse grained, very tightly cemented.

Porosity is poor in Unit d-1 sandstones. The marine beds have much fine interstitial material. In a few porosity may reach 10 percent. The non-marine beds have a coarser texture but are too well cemented.

Siltstone and siltshale are medium to dark neutral. They are usually cross-bedded within layers. Their fossil plant and wood content is high. Clayshale is more abundant than in Zone A.

The division between Zone A and Unit d-1 is placed below the lowest coal bed (just above Trace No. 3). The sandstone mentioned in Zone A at 1,585-1,735 feet above the Lower Cretaceous has the characteristics of the non-marine sandstones of Zone D. However, the intervening 750 feet contains no other such beds and is placed in Zone A.

Unit d-2: Unit d-2 is composed of non-marine sandstones, siltstones and siltshales, and clayshale as described in Unit d-1. Also, it is the main coal-bearing section. The division between Unit d-1 and Unit d-2 is placed above the highest fossiliferous sandstone (middle of Trace No. 6). The unit has a minimum thickness of 2,815 feet (4065-6880). Above 6880 there is a large covered interval.

Sandstone comprises most of the bottom 1,000 feet, in beds 25 to 100 feet thick. A 100-foot bed is at the base, overlying the fossiliferous sandstone at the top of Unit d-1. The beds are well cemented. Porosity is generally low. Samples tested in the laboratory vary from 4.5-11.0 percent. The bed between Trace No. 6 and Trace No. 7 shows 9.7 percent porosity. Two samples from an 80-foot bed sandstone (4920-5000) shows 10.0 and 11.0 percent porosity. These figures are believed to be near the average porosity for the whole bed. Trace No. 8 is the lowest sampled, 4.5 and 4.9 percent. Many other sandstones have equally low porosity, but porosity samples were taken only from the sandstones appearing more porous. This was determined in the field by testing with a drop of water.

The top part of Unit d-2 contains at least 50 feet of coal. It is in beds varying ½ foot to 6 feet in thickness. The majority are 2 to 3 feet thick. They are distributed evenly throughout this part of the unit. The coal is good-grade bituminous with very little bone. 500 feet of section, well exposed (5900-6400), is very micaceous. A large amount of chlorite may be present. The sandstones display a high sheen, and are green-gray. The high micaceous, or cloritic content gives the siltshale surfaces a polished appearance. The strata weather light green-gray. The upper limit of the micaceous zone is indefinite because the strata are poorly exposed. The lower part of the unit contains a few scattered beds with high micaceous content. Division of this unit on the basis of coal or the micaceous zone would be possible.

Porosity is very low in the micaceous section, but two sandstone members below it, in the coal bearing section, were sampled. The lower is 50 feet thick, (5335-5385) varying fine to coarse grained, with extensive crossbedding. The fine layers showed only 7.9 percent. The coarse beds showed 13.5 percent porosity. 100 feet higher a 30 foot massive sandstone appeared very porous, but showed 8.4 percent. Surface leaching of cement probably caused this discrepancy.

Two conglomerates, 30 and 40 feet thick (Section 7), crop out 4 miles west of the Kurupa R. on the south side of the Colville R. The exposure is on the north limb of the Kurupa-Awuna syncline. The conglomerates are composed of sub-angular dark chert with minor quantities of sub-round white quartz, varying from granule to pebble size. The matrix is very-fine sandstone. Cross bedding is extensive.

The conglomerates cannot be correlated adequately with the sections exposed on the south limb of the structure. It does appear, however, that they may correlate with the conglomerate 5,950 feet above the base of Upper Cretaceous on the Kurupa River*.

Zone E (?).

The top of Zone D, as described, is on the south limb of the Awuna-Kurupa syncline, approximately 1¼ miles from the axis. The only exposure of Zone E (?) is about ½ mile from the axis. A river cut (Section No. 6) 75 feet high exposes 15 feet of bentonitic sandy clay, underlain by 20 feet of bentonitic sandstone. The latter is medium neutral, fine-grained and very friable. Below it is 15 feet massive fine-grained sandstone which is very hard and contains abundant fossil wood. Talus, which covers the base, contains some ironstone and limestone, and scattered coal.

The stratigraphic interval between this outcrop and Zone D is estimated as 400 feet. Thus Section No. 6 is placed at 7250-7370. An additional 100 to 200 feet of section stratigraphically higher is completely covered. The total section is estimated as 7,500 feet.

* Op. cit. Section No. 4.

Comparing the section in this area with the section exposed on the Kurupa R. there are two outstanding features. The dearth of fossils is pronounced. Many more fossils were found on the Kurupa and Oolamanagavik than were found here. Faunal Zone No. 2 Inoceramus was not found here similar to the situation on the other rivers. The Kurupa section contained less coal than is present here.

## STRUCTURE

### Lower Cretaceous

Lower Cretaceous rocks were examined to a limited extent along the Colville River near the Ipnavik River and in the northernmost outcrops of the Etivluk River. In each of the several outcrops the major trend was N. 70°W., dipping 55-65°S. Tight plunging folds were noted west of the Ipnavik R.

The outcrops on the Etivluk R. are approximately 3 miles from the frontal bluff of Upper Cretaceous rocks. In the intervening shale section a reading of N. 70°W. - 14°N. was obtained on the north side of the Colville R. about 3/4 mile south of the frontal bluff. It is believed this may mark the base of the Upper Cretaceous.

### Upper Cretaceous

The structure of the Upper Cretaceous strata is complicated by an anticline and a syncline which die out in this area. The area may best be considered as falling within two major boundaries. On the south is the frontal bluff, with strata dipping north in all places. On the north lies the Kurupa-Awuna syncline, crossing the Colville R. near the mouth of the Awuna R.

A cross-section north from the Etivluk River to the Awuna River discloses continuous north dips, 9 degrees in the frontal bluff decreasing slightly northward. Here the strata in the frontal bluff trend N. 25°W. Near the Awuna the strike is nearly E.-W.

A second cross-section passing south from the Awuna River shows the presence of an anticline and syncline between the two boundaries. The two axes continue east through the Kurupa and Oolamnagavik Rivers*.

The syncline, plunging slightly eastward, dies out about one mile east of the point where the Colville River cuts through the frontal bluff. East of here along the frontal bluff the attitude of the strata is N. 70-75°W., 10-12°N. As the beds bend around the end of the syncline the strike changes to N. 25°W., as previously noted, then gradually returns to N. 70°W. about 15 miles northwest of the mouth of the Etivluk R.

The Colville R. cuts across the anticline in two large north bends, exposing the structure very well. On the eastern cross-section the anticline is assymetric, with a steeply dipping north limb and gently

* Op. cit. fig. 1

dipping south limb. The axis trends N. 70°W. Farther westward, the south limb dips more gently, about 4 degrees South where it is first cut by the river. The north limb becomes steeper, dipping 45 degrees North near the axis. Then the south limb gradually becomes flat, forming a monocline for a very short distance. West of this point the south limb reverses and dips gently northward around the edge of the monocline. There are minor faults in the north limb near the axis. Away from the axis on this limb the strike of the strata is N. 55°W., gradually swinging to N. 80°W. much farther to the west.

In the N-S cross-section, (B-B'), and the cross-section A-B-C, shown to the west in the Kigalik-Awuna Report*, located 27 miles apart, the thickness of Upper Cretaceous strata differs. In the latter there is approximately 5,000 feet of section stratigraphically at the Kurupa-Awuna axis, while in the eastern section there is about 7,500 feet. The increase of 2,500 feet represents strata of higher zones not present in cross-section A-B-C. The average plunge for the 27 mile distance is 1½ degrees (to the east). This plunge is substantiated by the change in strike on the south limb of the syncline.

* Op. cit., (Kigalik-Awuna)