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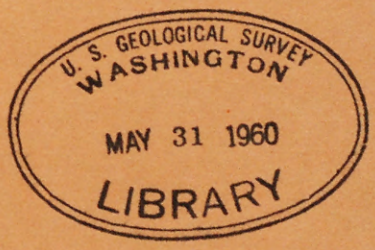
Naval Petroleum Reserve No. 4

Alaska



Preliminary Report No. 32

PRELIMINARY REPORT ON THE STRATIGRAPHY AND STRUCTURE OF THE UPPER COLVILLE, KURUPA, AND ETIVLUK RIVERS AREA

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By

Robert M. Chapman, G. Donald Eberlein,

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November 1950

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INTRODUCTION

Party and logistics

U. S. Geological Survey Party 5 traversed the Southern Foothills province and parts of the north edge of the Brooks Range from the Killik River to the eastern forks of the Etivluk River between May 27 and July 31. The personnel consisted of Robert M. Chapman, geologist and chief of party until July 5; G. Donald Eberlein, geologist, who joined the party on June 24 and succeeded Chapman as chief of party; Charles D. Reynolds, geologist; William L. D'Olier and W. Douglas Carter, field assistants; Richard D. Olson, cook; and Max H. Davis, Arctic Contractors' weasel mechanic. The authors commend all of the temporary men as very capable field men and most agreeable companions throughout the season.

The party assembled at Umiat in mid-May and was transported by bush plane on May 23 to the Killik River at 68°31'N. and 154°03'W. where a ski landing was made on the large lake on the east side of the river. The party crossed the Killik River by boat and camped on the west side where three weasels had been cached earlier in May. From this point the party worked westward in the Southern Foothills province to the eastern forks of the Etivluk River and thence northward to the confluence of Kucher Creek and the Colville River. Thirteen camps were made during this time. Work in the area was terminated here, and the party moved eastward down the Colville River valley to begin work on the Aupuk anticline. The geology of the Aupuk anticline is described in another report.[1/] Food, supplies, gasoline, and oil were placed in five caches in the area, and mail and supplementary food were supplied by air drops.

On June 30, party 5 reached Kurupa Lake, one of the few places within the area where landings by large float planes can be made. Dr. Ralph Imlay visited the party here for 4 days, and he and Chapman left the party July 5 to return to other duties.

Work accomplished

During the season detailed geologic studies were made of the river-bluff exposures along most of the major and tributary drainages and of most of the exposures in the interstream areas. In addition traverses

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1/ Eberlein, G. D., Chapman, R. M., and Reynolds, C. D., Stratigraphy and structure of the Aupuk anticline: U. S. Geological Survey, Navy Oil Unit, Report No. 38, 1950.

were made southward along three major streams for about 5 miles into the Brooks Range. Barometer elevations were carried throughout the area. In so far as possible the geologic data has been extended on vertical aerial photos into areas that could not be visited in the field owing to lack of time.

Previous work in the area

Three Geological Survey field parties have worked parts of this area previously. Chapman and Thurrell covered part of the upper Oolamnagavik River area in 1946.[2] Stefansson, Mangus, Detterman, and Patton visited the Kurupa Lake area in 1948. In 1949 Mangus, Detterman, M. C. Lachenbruch, and A. H. Lachenbruch mapped the extreme southeastern portion of this area from a camp on the Killik River.[3] Practically none of this area was covered by P. S. Smith and J. B. Mertie, Jr., in their Killik River traverse. Parts of the data gathered by these parties have been incorporated in this report.

STRATIGRAPHY

Carboniferous

Mississippian

Noatak formation.--The Noatak formation in this area is composed of two distinct mappable units that have been informally designated until recently as Noatak formation above and Kanayut formation below. At the suggestion of J. T. Dutro, these units are here being treated as one formation and subdivided into an upper "shale member" and a lower "sandstone-conglomerate member."

The "sandstone-conglomerate member" forms a prominent east-west belt of rugged mountains in the Brooks Range. The northern edge of its belt of outcrop lies roughly 5 miles south of the front of the Range. The southern edge of its belt of outcrop was not reached by party 5. The thickness and stratigraphic relation of this unit were not determined, but it appears to be at least 2,000 feet thick, and seems to be conformable with the overlying "shale member." Near the Killik River the "sandstone-conglomerate member" is reported to be at least 3,500 feet thick.

The member was examined at four localities: (a) Kurupa River 5 miles south of Kurupa Lake, (b) West fork of Kurupa River, (c) Two miles east of east fork Etivluk River, and (d) One mile west of east fork Etivluk River.

The "sandstone-conglomerate member" consists of siliceous sandstone to quartzite, highly colored chert granule-small pebble conglomerate to

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2/ Chapman, R. M., and Thurrell, R. F., Jr., Report No. 5, Stratigraphy and structure of the area of the Kurupa, Oolamnagavik, Killik, and Colville Rivers, April 1947.

3/ Mangus, M. D., Detterman, R. L., Lachenbruch, A. H., and Lachenbruch, M. C., Preliminary report No. 26, Preliminary report on the stratigraphy and structure of the Etivluk, Nigu, and Kuna Rivers area, Alaska, November 1949.

conglomerate, and well indurated silt shale. The over-all color of the unit is medium red to brownish-red, but this is largely due to surface staining from weathering of parts of the shale. The sandstone is chiefly light gray, with some light red phases, fine to very fine grained, and very well indurated to quartzitic. The conglomerate matrix is similar to the sandstone, and the pebbles are red, green, gray, and black cherts and milky quartz, subround, and predominantly 1/8 -3/4 inch in diameter. The shales are medium gray, light to dark red, and green, sandy in parts, fissile, and moderately to well indurated. No fossils were found.

The "shale member" is less resistant than the "sandstone-conglomerate member" and is found in an east-west belt of lower relief that varies from 1/2 to 3 1/2 miles in width. Between the Kurupa and Killik Rivers this belt lies 1/2 to 1 1/2 miles south of the mountain front, but in the eastern Etivluk area the front of the Brooks Range is formed by this unit. The "shale member," which was examined at five localities between the Kurupa and Etivluk Rivers, is believed to be about 840 feet thick.

The lithology checks closely with the Noatak formation of the Kanayut Lake area as described by Bowsher and Dutro. It is chiefly silt shale, dark gray to black, highly micaceous in parts, well indurated, platy to fissile, with thin siltstone and sandy interbeds and ironstone concretions. No microfossils were present in samples of this shale. Minor amounts of dark gray to black clay shale, very fine-grained sandstone, and reddish brown coquina and hydroclastic limestone also occur. Fossils collected from the coquina zone on theKurupa River have been tentatively identified by Bowsher to be the same as found in his red limestone in the Kanayut Lake area. A reddish-brown weathering color is prominent in parts of the section.

Lisburne limestone.--The Lisburne limestone is composed predominantly of limestone and forms the outstanding light gray ridges at the north front of the Brooks Range between the Killik River and Kurupa-Etivluk Rivers divide. At the western end these beds are terminated abruptly by a transverse fault and are absent in the front of the Range in the eastern Etivluk River area. A prominent series of ridges and several small patches of Lisburne lie 9 to 15 miles north of the Range in the Southern Foothills province.

A detailed zonal breakdown of the Lisburne was not attempted due to lack of time in the field. Sections were examined at six localities and the over-all thicknesses and lithology were determined. Near the Killik River 700 feet of section was measured and at least 400 feet more is believed to be present.4/ Between the Killik and Oolamnagavik Rivers about 2,300 feet appears to be present. At the southeast end of Kurupa Lake a total thickness of 2,600 feet is well exposed.5/ A section 800 feet thick crops out in the Lisburne ridges lying 9 to 10 miles north of the mountain front on the east fork of the Etivluk River.

4/ Mangus, M. D., Detterman, R. L., Lachenbruch, A. H., and Lachenbruch, M. C., Op. cit.

5/ Brosge, W. P., and Reiser, H. N., Preliminary report No. 31, Preliminary report on selected sections of Lisburne limestone, Brooks Range, Alaska, November 1950, plate 3.

The lithology of the Lisburne in the Killik, Colamnagavik, and Kurupa Rivers area is predominantly light to medium gray, massive, fossiliferous limestone and cherty limestone with common hydroclastic and crinoidal facies. A petroliferous odor is characteristic of most of the limestone. Medium gray to black bedded chert and dark gray to black clay shale and limy shale make up a minor part of the section. Zones of siliceous, dolomitic limestone are rare. The 800-foot section in the outlier ridges in the Etivluk River area differs from this in that the upper one-third is siliceous, dolomitic, sugary textured, and slightly vuggy. Locally it has a strong petroliferous odor. The lower two-thirds is composed of heavy bedded black chert, limestone, and cherty limestone, with no shale. Triassic rocks lie above and below the section.

One small isolated outcrop of coarsely clastic, partly crinoidal, arenaceous limestone or limy quartzose sandstone is present on the Colamnagavik River about 15 miles north of the mountain front within the belt of predominantly Triassic rocks. Gastropods, tentatively identified by Bowsher as Tropidostrophia punctata of the Alapah member, are abundant in this crop. Also four poorly preserved spiriferoid-type brachiopods were found. Two other isolated outcrops of pale yellow limy, unfossiliferous quartz granule to small pebble conglomerate and finely crystalline sandy limestone were found on the Colamnagavik River 9 miles north of the Brooks Range and 2 miles north of the mountain front at the head of the westernmost Kurupa River drainage. All of these outcrops are believed to be from approximately the same zone, namely, the upper half of the Alapah member and probably the upper few hundred feet.

Carboniferous (Pennsylvanian)-Permian (?)

Siksikpuk group

Rocks of the Siksikpuk group were recognized at one locality on the east fork of the Etivluk River at camp 10. This section, identified on the basis of an arenaceous red stained microfauna, consists of red and green silt and clay shale that is complexly folded with greenish gray chert and chertlike siltstone. Samples taken from gray shale sections three-fourths mile north of camp 5 and a half mile north of camp 6 yielded specimens that appear to belong to this fauna also. It is likely that after further study of the field data other rocks of this group may be recognized in the Kurupa-Colamnagavik area.

Triassic

Shublik formation

Due to the structural complexity in this area and to the lack of exposures showing identifiable contact zones between the Triassic and Cretaceous units, the Shublik formation cannot be delineated exactly. General belts of identifiable Triassic rocks and of Shublik-Okpikruak formations undifferentiated are outlined on the map.

The Shublik formation consists of thin to thick bedded, light gray to light tan, sublithographic partly silty Monotis-bearing limestone, medium greenish gray to black bedded cherts that exhibit bright varicolored weathered surfaces, medium gray to black silt and clay shales, and brownish to black oil shale. Possibly a few thin beds of hard, light gray to tan, very fine grained, micaceous sandstone are included in this unit. The thickness of this formation is believed to be 500 to 650 feet, although this is necessarily a rough estimate because of the structural complexity.

Monotis subcircularis and Halobia have been identified in numerous samples collected in the area. Some microfossils characteristic of uppermost Shublik formation were found, but most of the samples of probable Shublik age are barren.

Lower Cretaceous

Okpikruak formation

The Okpikruak formation, which for the most part is mapped with the Triassic as an undifferentiated unit, crops out in the southern half of the Southern Foothills in a complexly folded and faulted belt. The same difficulties involved in delineating the Shublik formation are true of this formation, plus the fact that faunal control is limited to a few occurrences of fragmental and poorly preserved macrofossils. It does not appear feasible to make correlations, except in very general terms, between this area and the Chandler-Siksikpuk Rivers area to the east where much better control can be obtained.

Thickness estimates for the Okpikruak formation in this area are virtually meaningless, at least on the basis of present analysis of the field data, because the lithologic succession within theformation and its relation to the underlying Triassic beds have not been adequately seen. It is believed on the basis of evidence in this and other areas that the thickness varies considerably. In places it is probably absent and elsewhere it probably totals several thousand feet. It was possible to measure partial sections of Okpikruak beds at only a few places within the area. At Kurupa Lake 600 feet of Okpikruak was measured, overlying 520 feet of chert section of indeterminate age; at least 525 of Okpikruak was noted about 3 to 4 miles northwest of Kurupa Lake.

The rock types consist of: medium to dark yellowish-green and greenish-gray, dirty, granule, pebble and cobble conglomerates, in which the granules, pebbles, and cobbles consist of black, green, and gray chert, white quartz, some sandstone, shale, granite, mafic rocks, Monotis-bearing limestone, and Lisburne limestone; coarse to very fine grained, medium gray and greenish gray, dirty, micaceous low porosity graywacke and conglomeratic graywacke with carbonaceous and shell fragments; siltstone that is similar in appearance to the graywacke; medium to dark gray silt and clay shales that hielded no microfossils; and possibly some medium to dark gray bedded chert with thin interbeds of siliceous fissile shale. The weathering color of the clastic rocks is usually a dull rusty brown. Flow casts, plant remains, worm trains, ferruginous concretions and local development of cyclic bedding were also noted.

Torok formation

The Torok formation forms nearly all of the outcrops in the northern half of this area. Its belt of outcrop is an area of low hills and broad featureless lowlands, marked by a few groups of conspicuously high hills that trend northeast. The outcrops are discontinuous and most of them show the Torok beds to be complexly folded and faulted.

Two gross lithologic types are distinguishable within the Torok, and these permit the recognition of subdivisions of the Torok in this area. The first type is a monotonous sequence of medium to dark gray, poor to moderately indurated clay and silt shale with a small percentage of thin, medium gray, hard, slabby, sometimes lenticular siltstone. The second lithologic type in the Torok contains a conspicuous amount of siltstone, sandstone, and conglomerate of graywacke type in addition to clay and silt shale. The conglomeratic constituents, ranging from granules to cobbles, are dominantly gray, greenish, and black chert (approximately 70 percent), with lesser amounts of light gray limestone, light colored chert, white quartz, mafic and granitic igneous rocks, and a few angular siltstone and shale fragments. One oil shale cobble was noted. The fine-grained matrix of the graywacke sandstone and conglomerate is dirty, low in porosity, and has a distinct green-gray color. Dull cream colored, noncalcareous, porcelainlike, angular grains are present in these rocks but were not noted in the Okpikruak graywackes. The weathering color seems to be generally a lighter reddish to yellowish brown than is found in the Okpikruak, although this distinction alone cannot be used to differentiate these two very similar rock units.

Only one fossil collection was made from this formation. The fossils which appeared to be brachiopods and one ammonite were found in calcareous concretions on Kucher Creek. They are so poorly preserved that identification is doubtful. A diligent search in this area this season and in 1946 yielded no other macrofossils. A number of shale samples, chiefly from the western part of the area, produced some microfossils that are diagnostic or suggestive of the Torok. Many of the shale samples, however, proved to be barren.

Because of the complexity of structure and the uniformity of the lithology, repetition of section is usually impossible to detect, and also thick sections of continuous exposure are rare. Thus section measurements of this formation are subject to considerable error. A section, believed to be reliable, of 4,950 feet was measured on the east fork of the Etivluk River. The basal 1,800 feet, the lower contact of which was not seen, consists roughly of 65 percent shale and 35 percent siltstone, sandy siltstone, and sandstone. A middle unit, 740 feet thick, is composed chiefly of siltstone, graywacke sandstone, and graywacke conglomerate, with very little shale. The upper 2,410 feet is mainly interbedded silt and clay shale and siltstone with 30 percent or less of graywacke.

The relationship of the clastic rock units forming the prominent groups of hills, to the shale units and to the 740 feet of coarse clastic section mentioned above are not clear. It is certain that the hill forming

conglomeratic units overlie an indeterminate thickness of shale and that at least a small thickness of shale overlies them. At present it is not possible to say whether or not the 740 feet of clastics is equivalent to the hill forming units. A tentative correlation of the group of high hills between the Killik and Oolamnagavik Rivers and the prominent Torok formation mountains in the Chandler River area has been suggested, but the evidence is still inconclusive.

The bluffs on lower Kucher Creek expose shales and siltstones that are probably upper Torok, zone A. This section shows an upward gradation into the bluff-forming zone B, Tuktu sandstone sequence. Several thin coal beds occur in this gradational zone.

Igneous rocks

Two large areas of fine-grained crystalline mafic igneous rocks form prominent hills in the upper Oolamnagavik River area, and numerous small igneous outcrops are scattered throughout this area. A few isolated igneous crops occur on the east fork of the Etivluk River. These igneous bodies all lie within the belts of Shublik and Okpikruak formations, and no others are known in the area.

Most of these rocks appear to be sills intruding the Shublik formation. At a locality about 2 miles south of camp 2 between the Killik and Oolamnagavik Rivers a sill lies in apparently conformable contact on one side with a sequence of Okpikruak formation graywacke and conglomerate. Except in one of the large igneous areas, contact effects seem to be negligible. No mineralization of the adjacent rock was seen. An alteration zone showing all gradations, in talus only, between true crystalline igneous rock and slightly altered graywacke is developed in the area 2 1/2 to 3 miles south of camp 2.

No field evidence was seen that indicated anything but a conformable relationship of the igneous bodies to the enclosing rock. The possibility that they formed as flows was considered, but no evidence to support a flow origin was seen.

The northernmost group of igneous bodies mapped on the east fork of the Etivluk River are apparently intrusive into sandstones, conglomerates and cherty siltstones of the Okpikruak formation. Phases of these igneous rocks possess a good diabasic texture, and at one locality appeared to show the effects of autobrecciation. Angular fragments of diabase, ranging in size from a fraction of an inch to several feet, were observed to be enclosed in a mesostasis of finer grained mafic igneous rock.

STRUCTURE

Brooks Range province

Within the north front of the Brooks Range excellent sections showing structures are exposed along most of the north-flowing streams. Only a short time was available to party 5 for examination of this belt of

rocks, and inasmuch as the structures are complicated, not enough data are available to make as good an interpretation as would be possible with further field work.

In general the beds dip south at angles of 20° to 80° and range northward from oldest to youngest. Thus the major part of the Noatak formation and Lisburne limestone is apparently overturned toward the north. The Lisburne beds at the north front of the Range are in general nearly vertical to slightly overturned. Several areas near the Killik River and Kurupa Lake particularly are considerably deformed and small units of Shublik and Okpikruak formations are infolded and faulted (?). However, in general the Lisburne acts as a very competent unit and minor complex folding within it is not common.

At least two northwest trending faults transect the Lisburne limestone. The one at Kurupa Lake offsets the mountain front about 1 mile, and the other abruptly terminates the belt of Lisburne outcrops at the Etivluk-Kurupa Rivers divide.

The "shale member" of the Noatak formation that lies just south of the Lisburne belt is a relatively incompetent unit, and the shales have been greatly deformed and sheared by folding and faulting. Overturned and recumbent folds caused by thrusting from the south are common.

Structures are well exposed throughout the "sandstone-conglomerate member" of the Noatak. Overturned and recumbent folds, many of which are broken by thrust faults, are preserved by the competent coarse clastic beds.

The mountain front contact of Lisburne limestone with the Triassic-Okpikruak belt was not actually exposed, although it can be approximated within a few hundred yards. It is believed to be a high-angle reverse fault, although the possibilities of a disconformable contact on the north limb of an overturned fold or a "rootless" block of pre-Triassic rocks thrust northward over the belt of the Triassic-Okpikruak rocks are also possible.

In the western part of the area where the Lisburne limestone is absent, the contact between the "shale member" of the Noatak formation and the Triassic is also not exposed but the contact zone is characterized by severely crumpled and broken rocks. The contact is believed to be a thrust fault. The overturned portion of the Noatak formation ends somewhere between Kurupa Lake and the Etivluk River divide, and the beds in the Etivluk area seem to lie in normal succession.

Southern Foothills province

The Triassic and Okpikruak formations together with the scattered igneous masses and rare occurrences of rocks of the Siksikpuk group and of the Lisburne limestone are intricately infolded and faulted throughout the structurally complex southern half of the Southern Foothills province. Sufficient time has not been available yet to fully evaluate all of the

structural field data. In addition accurate interpretation of the smaller structures is difficult because lithologic differentiations which would aid materially in extrapolation of the disconnected structure readings cannot be made.

In general the structure in this belt of rocks is a large synclinorium with numerous smaller complex folds and faults. In the center of the synclinorium Okpikruak rocks crop out, but on the limbs of the synclinorium Okpikruak and Shublik formations are so intermixed that identification of units is difficult or impossible. Also in many localities the structures are so small that it is not possible to map them on a scale of 1:96,000.

The outlier ridges of Lisburne limestone are near the northern edge of this structural belt. The limestone beds dip south and are bounded on the north apparently by a thrust fault. This also appears to explain the relationship of the small Lisburne outlier on the Oolamnagavik River. It is postulated that this ridge-forming section is a part of a wedge-shaped block that is bounded on the south by a reverse fault that brings the Lisburne in contact with the Okpikruak. The relationship that exists between the outlier ridge of Lisburne and the disappearance of the Lisburne at the mountain front directly to the south has not been established.

The northern part of the Southern Foothills province is a structurally complex belt composed of rocks of the Torok formation, except for one small hill of Triassic rocks on the Oolamnagavik River near camp 3. It is impossible to get more than a general impression of the structures in the shaly sections of the Torok, and only a little more information can be gathered from the exposures in the coarse clastic sections.

The structure of the Torok belt seems to tie in with the broad east-west trending anticlinorium that is believed to be present in the areas to the east and west. A zone of crumpling and complex faulting is apparent in the central part of the belt, and in the EtivlukRiver-Kucher Creek area the regional dips indicate that this zone is approximately coincident with the axial plane of the anticlinorium. Several synclines and anticlines are mapped along the northern and southern edges of the belt in the western part of this area, but very few of these structures are visible in the Kurupa-Killik Rivers area where a narrowing of the Torok belt occurs. A transverse regional "high" is one possible explanation for this narrowing of the belt as well as for the localization along a zone of weakness of the igneous intrusives in the vicinity of the Oolamnagavik River.

OIL POSSIBILITIES

1. No structures favorable for oil accumulation were noted in this area.

2. Faults are believed to be common throughout the area and might cause traps favorable for oil accumulation. However, sufficient surface evidence cannot be obtained to delineate them.

3. Thicknesses of rock units and regional structural conditions are so hypothetical in this area that a reasonable guess as to the subsurface conditions in the Torok formation anticlinorial belt cannot be made. This would seem therefore to exclude this area from any play to reach the Lisburne limestone at drillable depth.

4. The lithology of the Lisburne limestone in its northernmost exposure on the east fork of the Etivluk and the Oolamnagavik Rivers is more dolomitic, vuggy, and clastic than it is to the south. This suggests that the Lisburne would have more attractive porosity to the north of the Range. Only a few thin zones of the Lisburne exposed at Kurupa Lake showed any indication of porosity, but this may not be a fair sampling as an intensive study of the Lisburne frontal ridge was not made by party 5. The sandstones, graywackes, and conglomerates in this area show extremely low porosity.

SUMMARY

Most of the Southern Foothills province and parts of the northern edge of the Brooks Range between the Killik River and east fork of the Etivluk River were covered by weaselborne party 5 during the 1950 field season. This work has been supplemented by some data gathered by previous parties in parts of this area.

Rocks of Mississippian through Lower Cretaceous ages were mapped. The Mississippian Noatak formation, consisting of a lower, quartzitic sandstone-conglomerate member and an upper shale member lie within the north edge of the Brooks Range. The Lisburne limestone, a predominantly limestone and chert unit, forms the front of the Range except in the western part of the area where it is faulted out. The maximum thickness of this formation appears to be 2,600 feet. One prominent outlier and several small patches of dolomitic, hydroclastic, and coarsely clastic quartzose Lisburne are present in isolated localities 9 to 15 miles north of the Range. Possible Carboniferous-Permian (?) shales (Siksikpuk group) are present in several isolated localities.

The Triassic Shublik formation, consisting of chert, limestone, shale, and oil shale, is believed to be 500 to 650 feet thick. These rocks form prominent ridges and, over large areas, are infolded and infaulted with Lower Cretaceous rocks of the Okpikruak formation so that it is difficult to differentiate them. The Okpikruak is composed of graywacke, conglomerate, siltstone, silt and clay shale, and possibly chert. Estimates of thickness are doubtful, as there is probably considerable variation within the area. Numerous mafic igneous sills intrude the Triassic and possibly the Okpikruak rocks.

The Torok formation, also of Lower Cretaceous age, lies in the northern half of the area. It is believed to be at least 4,950 feet thick, and consists of shale, siltstone, graywacke, sandstone, and conglomerate. It appears to grade upward into the zone B Tuktu sandstone.

The entire area is structurally complex and structural interpretation is difficult because of poor exposures in the critical zones. Thrust faults and overturned folds are common in the front of the Range. Isoclinal folding and faults are characteristic of the Southern Foothills province. An east-west anticlinorial zone in the Torok belt is suggested, but the evidence is meager.

The area shows no attractive petroleum possibilities on the basis of surface field evidence.