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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

PAPER 59-14

UPPERMOST JURASSIC AND CRETACEOUS ROCKS, EAST FLANK OF RICHARDSON MOUNTAINS BETWEEN STONY CREEK AND LOWER DONNA RIVER, NORTHWEST TERRITORIES

106M and 107B, (Parts of)

J. A. Jeletzky

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INTRODUCTION AND ACKNOWLEDGMENTS

This report presents the principal results of work done in the area between June 16 and September 15 of the 1958 field season; it supplements the results of the 1955 field season, contained in G.S.C. Paper 58-2, and should therefore be used in conjunction with that publication.

Valuable help was given by Mr. H.J. Mitchell, former Subdistrict Administrator of the Department of Northern Affairs and National Resources for the Aklavik area, Mr. L.B. Post, his successor in July 1958, and other residents of Aklavik. The Shell Oil and Texaco Exploration Companies of Canada, and Sproule and Associates Consulting Services, Calgary, provided aircraft transportation and other help.

The writer was assisted in the field by A.K. Crank and T.C. Shearer.

PHYSICAL FEATURES

The area studied is roughly rectangular, 5 to 12 miles wide by about 60 miles long. Outside of it, several smaller areas were studied on lower Peel, Vittrekwa, and Road Rivers. Two smaller areas were studied west of the Richardson Mountains, one at the junction of the Porcupine and East Porcupine Rivers and the other on the Porcupine River between Bell and Driftwood Rivers.

In the northern part of the area the steep eastern escarpment of Aklavik Range and the range itself gradually lose their prominence between the top of Mount Gifford and the lower course of Donna River; about a mile south of Donna River they disappear beneath a rolling, tundra-covered, eastward-tilted plateau dotted by numerous lakes and swamps. In this part of the area, the lower Donna River runs mainly in a wide, canyon-like valley (the lower canyon of Donna River), 200 to 300 feet deep, which offers numerous and extensive sections of bedrock. Most confluents of the lower Donna River, and most of the independent streams north of it, follow meandering courses with low banks and few outcrops.

Similarly, south of Treeless Creek the steep eastern escarpment of Aklavik Range and the range itself gradually diminish and then disappear beneath the low, rolling plateau, much like that occurring north of Aklavik Range; this plateau begins on the north side of Longstick Creek. Only the larger creeks and rivers, such as Stony Creek, Rat River, and Barrier River, interrupt the monotony of this grass- or bush-covered plateau, which occupies all of the southern part of the area. Many of these creeks and rivers form deep but more or less mature valleys or wide canyons up to 400 feet deep, which afford the only extensive outcrops of bedrock.

The summer of 1958 was in every way the opposite of the summer of 1955 (Jeletzky, 1958a)[1]. It was unusually warm and dry and the temperatures mostly ranged between 50 and 80°F. Temperatures below 50°F were relatively rare even in June and September. In July and August there were several days with daytime temperatures between 75 and 90°F, and on a few days the mercury climbed to about 100°F. Only a few rainy or stormy days occurred throughout the season and the tundra was tinder-dry most of the time. No snow fell before the end of August and the first real blizzard was on September 15th.

Except for the easily navigable Husky Channel (see Jeletzky, 1958a, p. 2), only Rat River is navigable by freight canoe between its junction with Husky Channel and the Indian campsite called 'Destruction City', at the mouth of Longstick Creek.

A Beaver plane was used extensively to land party members and equipment on various small lakes within the area, and on Porcupine River, and to return them to base camps on Husky Channel. Otherwise, travel was on foot and in canoes, except for the occasional use of helicopter provided by organizations mentioned previously.

STRATIGRAPHY AND AGE

The predominantly marine Uppermost Jurassic and Cretaceous sequence of the eastern slope of northern Richardson Mountains is even more complete than it was previously thought.

The late Upper Cretaceous is now the only major part of the sequence still unknown in the area.

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[1] Names and dates in parentheses refer to publications listed in the References at the end of this report.

TABLE OF FORMATIONS

Cretaceous or Tertiary	Piercement(?) breccia
Upper Cretaceous (Cenomanian-Turonian and? later)	Upper Cretaceous shale division
Late Lower Cretaceous	Albian shale-siltstone division
Mid-Lower Cretaceous	Upper sandstone division Upper shale-siltstone division
Upper Jurassic and early Lower Cretaceous	Coal-bearing division Lower sandstone division Lower shale-siltstone division

UPPER JURASSIC AND EARLY LOWER CRETACEOUS

Lower Shale-siltstone Division

The faunal evidence presented below indicates that 580 to 610 feet of the lower member of the lower shale-siltstone division belongs in the Upper Tithonian stage of the Jurassic system,180 to 185 feet more than was previously thought (Jeletzky, 1958a, pp. 4, 19, 29). The Jurassic-Cretaceous boundary should, accordingly, be placed some 50 feet below the top of the lower member of the division. Only the top 180 to 190 feet of the division are, therefore, in the lowermost Cretaceous (Berriasian).

Stratigraphy

Additional extensive but incomplete sections of the lower shale-siltstone division were measured at the southeastern end of Mount Gifford massif and along its eastern escarpment, in the upper part of Treeless Creek, at the northern end of Mount Goodenough massif, on Upper Rat River, and on Mount Toughenough. Except for the Mt. Toughenough section,these sections do not differ materially from those described previously.

Beds 22 to 25 of section 1 and beds 2 to 7 of section 2 of the lower shale-siltstone division (Jeletzky, 1958a, pp. 19, 29) are now assigned to the Jurassic system. The redefined Jurassic-Cretaceous boundary coincides with a persistent and marked lithological change within the lower member of the division. Just below this boundary is a succession of sandy siltstone, silty sandstone, and calcareous sandstone beds, 50 to 70 feet thick, intercalated with minor beds of pebbly and gritty sandstone and pebble-conglomerate. Several beds of greenish grey to blackish green, moderately to strongly glauconitic sandstone and siltstone 1 foot to 1 1/2 feet thick occur in the upper part of this succession. A few feet above the Jurassic-Cretaceous boundary, these variegated rocks are replaced by 50 to 55 feet of mostly pure, light grey, commonly strongly calcareous shales distinguished by their intensive rusty weathering and the alternation of brown, grey, and light grey lamellae. Bed 1 of section 2 is typical of these shales.

The erosional break within the lower member of the lower shale-siltstone division, mentioned in Paper 58-2, was not found in most of the sections studied in 1958. Whether or not this erosional interval has any regional significance, it does not coincide with the Jurassic-Cretaceous boundary but occurs within the uppermost Tithonian variegated rocks.

Age and Correlation

The uppermost Tithonian Buchia fischeri-B. trigonoides fauna has been found throughout a zone 260 to 280 feet thick in the middle and upper (but not the uppermost) part of the lower member of the lower shale-siltstone division. As already mentioned, this zone includes 180 to 185 feet of beds with occasional Buchia cf. okensis (Pavlow) and Buchia okensis var. elliptica (Pavlow) that previously were tentatively included in the overlying basal Cretaceous Buchia okensis zone.

The Buchia fischeri-B. trigonoides zone ends a few feet below the light grey shales mentioned above, to which the Buchia okensis zone is now restricted.

These shales form the top part of the lower member and are characterized by the predominance of large, rugose, commonly thick shells of Buchia okensis (Pavlow) f. typ. and P. okensis var. canadiana (Crickmay). Craspedites (Subcraspedites) cf. suprasubditus (Bogoslowsky) appears to be diagnostic of the lowermost 10 to 12 feet of the restricted Buchia okensis zone. The Buchia okensis zone is of earliest Cretaceous (early Berriasian) age (Jeletzky, 1958a, p. 5).

The quartzitic sandstones with Buchia mosquensis var. concentrica on Porcupine River described by McConnell (1891, p. 124D) were found to form the top rather than the base of the local succession; they are actually equivalent to McConnell's upper sandstone division. The same, poorly preserved Portlandian or Upper Tithonian Buchia fauna was found in both divisions, and indicates the equivalence of these rocks with the Jurassic part of the lower shale-siltstone division (see Correlation Chart, in pocket).

Glauconitic sandstones and conglomerates with the upper Tithonian and early Berriasian Buchia and belemnites occur south and west of Stony Creek basin. These arenaceous equivalents of the lower shale-siltstone division were seen on Vittrekwa, Road, and Rock Rivers. This 500- to 600-foot sandstone division was previously placed in the base of the late lower Cretaceous (Albian) Sans Sault group (Hume, 1954, pp. 52-53) and correlated with lithologically similar sandstones occurring at the base of the Sans Sault group elsewhere in Mackenzie River basin. The westward and southward change of the predominantly shaly rocks of the lower shale-siltstone division to the above-described, more shallow-water rocks takes place in the headwaters of Stony Creek. There the sections of the lower shale-siltstone division exposed on the southern slope of Mount Toughenough and south of the headwaters of Stony Creek are lithologically transitional. They include numerous interbeds and several 50- to 200-foot-thick members of hard quartzites, as well as some beds of pebble-conglomerate. This section contrasts strongly with the lithologically typical Rat River sections of the lower shale-siltstone division. The Mount Toughenough equivalents of the lower shale-siltstone division have been previously considered Devonian or older on the basis of their distinctive lithology (Foley, 1944, pp. 9-10).

These facies changes of the lower shale-siltstone division are interesting and confirm Frebold's (1957, p. 44, fig. 5) palaeogeographical conclusions.

Lower Sandstone Division

The lower sandstone division, as originally defined (Jeletzky 1958a, pp. 6-7), is subdivisible into two lithologically distinct map-units and is redefined to embrace only the lower of these. It is now restricted to the buff sandstone member and to the lower 150 to 170 feet of the white sandstone member. The upper part of that member is now considered a separate division, the coal-bearing division.

Stratigraphy

Numerous excellent sections of the redefined lower sandstone division were measured on the eastern flank of Mount Gifford massif and at the northern end of Mount Goodenough massif. These agree in all details with those previously described.

Farther south, along the eastern side of Mount Goodenough massif and at the lower end of Goodenough Creek canyon, only the lowermos part of the buff sandstone member is preserved here and there underneath the transgressively overlapping basal beds of the upper shale-siltstone division.

On upper Treeless Creek only 20 to 25 feet of white- to buff-weathering, medium- to coarse-grained, commonly gritty and pebbly sandstone with carbonaceous inclusions and films occur between the uppermost beds of the lower shale-siltstone division and the lowermost beds of the upper shale-siltstone division. These sandstones are interbedded with pebble-conglomerates and are lithologically similar to rocks of the white sandstone member of the division. This thin wedge of the lower sandstone division occurs throughout the upper course of Treeless Creek and is an excellent horizon marker.

Typical rocks of the buff sandstone member reappear in headwaters of Stony Creek (see below). It seems probable therefore, that the absence of this member in the upper Treeless Creek sections is due to a change of facies caused by the proximity of the southeastern shore of the early Lower Cretaceous sea. It is not clear, however, whether the insignificant thickness of the lower sandstone division in the Treeless Creek sections is due to its pronounced thinning toward the east, or to deep erosion prior to mid-Lower Cretaceous transgression.

South of Treeless Creek some 200 to 250 feet of typical, fossiliferous sandstones of the buff sandstone member of the division occur on the southern slope of the 5,500-foot-high Teeweechee Mountain some 13 miles southwest of Mount Toughenough. These sandstones overlie conformably the fossiliferous arenaceous equivalents of the lower shale-siltstone division. The apparent total absence of rocks of the lower sandstone division between upper Treeless Creek and Teeweechee Mountain must, therefore, be due to their erosion prior to the deposition of the upper shale-siltstone division.

Age and Correlation

The uppermost beds of the buff sandstone member and the lowermost beds of the white sandstone member have yielded a Buchia crassa (Pavlow) and Buchia n. sp. aff. crassa (Pavlow) fauna (Jeletzky, 1960). This fauna occurs in the Beattie Peaks and (?) Monach formations of the marine Bullhead group on one hand, and in the upper part of the Deer Bay shale and the basal beds of the Isachsen sandstone of the Queen Elizabeth Islands on the other. This confirms the early Valanginian age of the upper part of the buff sandstone member (Jeletzky, 1958a, p. 6). This Buchia fauna is, however, of late rather than early lower Valanginian age (Jeletzky, 1960). The Valanginian sea must thus have left northern Richardson Mountains somewhat later than previously thought (Jeletzky, 1958a, p. 16) and at about the same time as it left the Peace River region and the Queen Elizabeth Archipelago.

No early Lower Cretaceous rocks equivalent to the lower sandstone division were found in McConnell's (1891, p. 124D) Porcupine River section. The thick, apparently unfossiliferous, conglomerates overlying its late Jurassic part, may, however, be of that age (Correlation Chart).

Coal-bearing Division

The coal-bearing division consists of about 520 feet of irregularly interbedded sandstone, siltstone, shale, and coal seams. The coal seams are restricted to the lower part.

Stratigraphy

The following description of the coal-bearing division is based principally on the detailed study of excellent sections in the southern and northern walls of the lower canyon of Donna River. In these sections the complete sequence of the division and both contacts are exposed.

Incomplete, structurally complex, and poorly exposed sections occur in the southern walls of Fault Creek canyon above its forks, half-way between Fault Creek and Bug Creek on the eastern slope of Aklavik Range, and on top of the plateau in the upper course of Bug Creek. So far as is known these sections agree with those on the lower Donna River in most of their essential features. However, no coal seams comparable with those of the lower Donna River sections were observed in them, except for a few layers of impure coal an inch or 2 inches thick.

What appear to be the lowermost beds of the coal-bearing division outcrop in the lower part of Jimmy Creek's canyon at the northern end of Mount Goodenough massif. Farther south the division disappears on the geographical unconformity between the older Lower Cretaceous and mid-Lower Cretaceous rocks (Jeletzky, 1958a, p. 10).

The lower member of the coal-bearing division is about 240 feet thick on lower Donna River. It consists of irregularly interbedded, friable to hard, light to dark grey, often whitish weathered, commonly carbonaceous to coaly sandstones with dark grey to bluish grey, mostly carbonaceous to coaly siltstones and shales. Fine-grained, commonly silty sandstones predominate and medium- to coarse-grained varieties are rare or absent. This is in contrast to the underlying white sandstone member of the lower sandstone division.

Several seams of coal occur in the lower member. In most of the sections studied there are three or four such seams ranging from 1 foot to 5 feet in thickness. These seams are accompanied by a variable number of irregularly scattered non-persistent thin beds, layers, and inclusions of impure coal. All beds, and particularly all coal seams, are pronouncedly lenticular; their thickness varies greatly within an extremely short distance. Similarly the lithological composition of the whole member varies greatly along strike.

The lower member is obviously non-marine and grades upwards into the upper member and downwards into the white sandstone member of the lower sandstone division.

The upper member of the coal-bearing division is about 280 feet thick in the lower Donna River section. It consists predominantly of buff- to rusty-weathering, grey, quartzose, fine- to medium-grained sandstones that are often markedly crossbedded and ripple-marked. Many layers of dark grey, fine-grained, silty sandstones and sandy shales are interbedded with these generally hard, resistant sandstones. The upper member only rarely contains thin layers and small nests of carbonaceous to coaly sandstone or shale. It appears to be predominantly marine, as marine pelecypods and belemnites were found in many beds.

A 70- to 80-foot unit of dark grey shale and siltstone with various numbers of interbeds and concretions of clay ironstone occur in the middle part of the upper member. Intertongues of sandstone with these shales or lateral changes of shale to sandstone within very short distances were noted in the lower part of the shale unit.

The contact of the upper member with an overlying thick shale sequence appears to be gradational. The contact was, however, only seen in one somewhat imperfect outcrop that was difficult to reach. The overlying thick shale sequence is tentatively correlated with the lower member of the upper shale-siltstone division on the basis of lithology and some poor fossils. The latter include Acroteuthis n. sp.?, Pecten (Entolium) sp. ind., and Pleuromya sp. ind., which are apparently conspecific with unnamed forms from the upper shale-siltstone division.

Age and Correlation

The lower member of the coal-bearing division did not yield any marine fossils. A few poor, indeterminate plant remains were, however, found in the coal seams and the coaly shales associated with them.

The dark grey shale unit of the upper member has yielded Acroteuthis cf. conoides Swinnerton and allied belemnite forms. Acroteuthis conoides is a middle Hauterivian fossil in England (see Jeletzky, 1960). The upper and lower sandstones of this member have yielded Inoceramus sp. ind., Pecten (Entolium) sp. ind., Pleuromya sp. ind., and Acroteuthis sp. ind., that are apparently conspecific with some unnamed forms in the overlying upper shale-siltstone division.

The upper member of the coal-bearing division appears, therefore, to mark the beginning in the northern part of the area of the widespread mid-Lower Cretaceous transgression. This transgression spread rapidly into the southern part of the area and beyond it at the beginning of the time during which the upper shale-siltstone division was formed.

The dating of the upper member of the division as middle Hauterivian, indicates that the lower, coal-bearing member is of early Hauterivian and possibly latest Valanginian age. This dating is in agreement with the middle to late Valanginian dating of the non-marine white sandstone member that apparently underlies it gradationally (Jeletzky, 1958a, p. 8; 1960). The continental or fresh-water episode of the lower Cretaceous history of northeastern Richardson Mountains thus lasted from middle Valanginian through early Hauterivian times.

The coal-bearing division is lithologically similar to the coal-bearing beds outcropping along the west shore of Coal Lake on Moose Channel. These coal-bearing beds seem, however, more comparable with the thick lowermost Jurassic or (?) uppermost Triassic coal-bearing beds and conglomerates outcropping in headwaters of Blow River some 7 miles north of Bonny Lake, because of their occurrence in close proximity with Palaeozoic rocks, which they appear to overlie unconformably.

The non-marine Isachsen sandstone of Queen Elizabeth Islands is at least partly correlative with the coal-bearing division of Aklavik Range, because of its similar stratigraphic position. The lower part of the Isachsen sandstone immediately overlying its basal marine beds must also include equivalents of the white sandstone member of the Aklavik Range (see Correlation Chart).

The non-marine Bullhead group of the Peace River foothills and plains is also known to include equivalents of the coal-bearing division and of the white sandstone member of the lower sandstone division.

The available palaeontological evidence indicates that the regression of the early Lower Cretaceous sea occurred at about the same time throughout the western interior of Canada and the Queen Elizabeth Archipelago. Even more remarkable is the approximate geological contemporaneity of this regression with the even more widespread regression that occurred at that time all over the European Arctic (Frebold, 1951, pp. 134-135, and earlier works).

MID-LOWER CRETACEOUS

The strata of the lower shale-siltstone and lower sandstone divisions are unconformably overlapped by a thick succession of mid-Lower Cretaceous marine shales, siltstones, and sandstones throughout the southern part of Aklavik Range. The same relationships were observed in the Rat River and Stony Creek parts of the area.

Between Bug Creek and lower Donna River, and apparently all the way north from there to the Arctic coast, the rocks of the coal-bearing division appear to completely fill the erosional gap between the mid-Lower Cretaceous and older rocks present to the north.

The mid-Lower Cretaceous succession consists of 1,500 to 3,000+ feet of shale and siltstone, the upper shale-siltstone division, overlain conformably by some 250 to 900 feet of buff-weathering sandstone with intercalated siltstone and shale units, the upper sandstone division.

Upper Shale-siltstone Division

Stratigraphy

The study of numerous additional sections of the upper shale-siltstone division on Treeless Creek, on Rat River below its confluence with Barrier River, at the northern end of Mount Goodenough massif, west of Mount Gifford massif (west of the Donna River fault), and at the lower end of the lower canyon of Donna River, has led to no modification of the lithology, stratigraphy, and thickness as already published (Jeletzky, 1958a, pp. 10, 54-79). South of Rat River, however, the upper shale-siltstone division thickens and its facies changes. This appears to be caused by the proximity of the southern shore of the mid-Lower Cretaceous sea. Sandstones increase markedly in the upper and lower parts of the division on Barrier River, in headwaters of Stony Creek between Mount Toughenough and Barrier Ridge, and on upper Vittrekwa River. The rocks of the division become, furthermore, much more indurated throughout this part of the area. Its sandstones are largely quartzite-like or true quartzites. This southern facies of the upper shale-siltstone division is lithologically indistinguishable from the Imperial (Bosworth) and Fort Creek formations of the Upper Devonian series, with which it was mostly confused in the past (Foley, 1944, pp. 10-11; Hume, 1954). Rocks of the upper shale-siltstone division were not seen south of Vittrekwa River basin, on lower Peel River, and east of the point 2 miles above the mouth of Stony Creek.

The upper shale-siltstone division appears to be more than 3,000 feet thick everywhere south of Rat River. This estimate is based on the somewhat arbitrary piecing together of several incomplete sections measured on Barrier River and in headwaters of Stony Creek.

The southward facies changes of the upper shale-siltstone division parallel those of the lower shale-siltstone division. Rocks of both divisions are lithologically indistinguishable on Barrier River and in headwaters of Stony Creek. They become lithologically distinguishable again, however, on upper Vittrekwa River where the lower shale-siltstone division is laterally replaced by glauconitic sandstones and pebble-conglomerates.

The southern facies of the upper shale-siltstone division was subdivided lithologically into three instead of two members distinguishable farther northward. The lower member is characterized by irregular interbedding of hard to soft shales and siltstones with quartzite-like, hard sandstones and true quartzites. Some pebble-conglomerate interbeds also occur in its sequence. Sandstones and conglomerates occur in heavy beds and in 50- to 200-foot-thick, markedly lenticular units, so that the ratio of shaly and arenaceous rocks within the member varies markedly within the shortest distances along strike. The lower member appears to be at least 1,000 feet thick; it is conformably overlain by the middle member, which consists of at least 1,500 feet of soft to hard, grey shales and siltstones with numerous bands and concretions of clay ironstone. The upper member is lithologically similar to the lower, but no pebble-conglomerates were noted in the upper member and its sandstones are commonly less indurated than those of the lower member. The upper member is at least 500 feet thick. It grades upward in the upper sandstone division but its contact with the middle member was not seen.

The extent of the transgressive overlap of older rocks by the upper shale-siltstone division is greater than previously recognized; no less than 1,020 to 1,040 feet of rocks of the lower sandstone and coal-bearing divisions are absent in the southern part of the area.

Even if some unrecognized hiatus should occur between the coal-bearing and the upper shale-siltstone divisions on lower Donna River, there seems to be no gap in the fossil record. This is in marked contrast with the southern part of the area where the late Berriasian, all of the Valanginian, and early to middle Hauterivian parts of the record are missing.

The uplift of the northern Richardson Mountains during middle Valanginian to middle Hauterivian time was thus largely limited to the southern part of the area. Farther north, between Bug Creek and lower Donna River and possibly all the way north to the Arctic coast, deposition continued without interruption or almost so throughout this time interval. The episode, is however, reflected even there by the presence of the non-marine components of the white sandstone member of the lower sandstone division and the lower member of the coal-bearing division.

The influence of a major uplift to the south accompanied by deep erosion and the action of rapid streams is clearly reflected in the coarse grain and arkosic composition of the rocks and the extensive crossbedding in the rocks of the white sandstone member. This was not the case during the time of the lower member of the coal-bearing division, whose rocks reflect swampy lowlands conditions and were, perhaps, deposited on the coastal plain fringing the early Hauterivian landmass from the north. This coastal plain extended perhaps as far north as the present Arctic coast, with the Hauterivian sea lingering in proximity to the latter.

Age and Correlation

The lower 30 to 40 feet of the upper shale-siltstone division of Aklavik Range (Jimmy Creek) has yielded large Simbirskites (Simbirskites) cf. kleini Neumayr and Uhlig, Acroteuthis cf. conoides Swinnerton, and Oxyteuthis sp. indet. and is therefore of late Hauterivian age. These fossils are near the top of the west European Subsaynella sayni zone and probably correspond to its Simbirskites (Simbirskites) progredicus subzone (see Jeletzky, 1960). There is thus no palaeontologically measurable time interval between these beds and the underlying middle Hauterivian rocks of the upper member of the coal-bearing division. This agrees with the tentative conclusion already stated that the contact between the two divisions on the lower Donna River is gradational.

The late Hauterivian age of the basal beds of the upper shale-siltstone division means that some 750 feet of its lower member can now be placed with confidence in the early Barremian. The higher beds of the lower member and the basal beds of the upper member are also of early Barremian age. This is indicated by the occurrence of Crioceras (Crioceras) cf. latum (Gabb) and Crioceras (Shasticrioceras?) sp. indet. in these beds. These fossils suggest the equivalence of these beds with the Crioceras raricinctum to Crioceras denckmanni subzones of the international standard (Jeletzky, 1960). The bulk of the upper member is of late Barremian age but apparently does not include the uppermost part of this stage.

No equivalents of the upper shale-siltstone division were found near the junction of Porcupine and East Porcupine Rivers nor on Porcupine River between Bell and Driftwood Rivers; the dark shales with interbeds of clay ironstone at the latter place, so like them lithologically (McConnell, 1891, pp. 123D-125D), were shown to be Jurassic and Permian in age by fossils determined by H. Frebold and P. Harker.

Upper Sandstone Division

Stratigraphy

The upper sandstone division consists predominantly of buff, rusty, or light grey sandstone which is mostly fine to medium grained, well sorted, quartzose, and micaceous. It forms several members from 90 to 150 feet thick interbedded with units of darker-coloured, fine-grained, commonly clayey and shale-like, soft sandstone, sandy siltstone, shale, and clay ironstone of the same thickness or somewhat thinner. Some pebbly sandstone and pebble-conglomerate interbeds appear near the base of the division on Rat

River and on lower Stony Creek. In places these are accompanied by beds of strongly glauconitic sandstone. Considerable interbeds of pebble-conglomerate and grit appear in the lower 300 to 350 feet of the upper sandstone division on upper Vittrekwa River. There its sandstones are, furthermore, mostly coarse, gritty, and pebbly throughout this part of the sequence. An erosional interval and an angular unconformity of 5 to 10 degrees was noted between this conglomeratic member of the division and its overlying grey, sandy siltstone member in several sections on upper Vittrekwa River.

In the mouth of Vittrekwa River and on Lower Peel River between Vittrekwa and Road Rivers (see Correlation Chart) 250 feet or more of the grey sandy siltstones and sandstones of the upper sandstone division overlap transgressively heavy pebble- to cobble-conglomerates believed to be late Devonian or Mississippian in age. The underlying sandstone-conglomerate member of the division apparently wedges out between upper Vittrekwa River and its mouth.

These facies changes of the lower part of the upper sandstone division towards the south and southeast appear to have been caused by the proximity of the southern and southeastern shores of the mid-Lower Cretaceous sea during early Aptian and early Upper Aptian times. The predominantly silty lithology of the grey sandy siltstone member of the division on Stony Creek and on Vittrekwa River, the appearance of an angular unconformity between the conglomeratic and grey sandy siltstone members of the division on upper Vittrekwa River, and the apparent overlap of the Palaeozoic rocks by those of the grey sandy siltstone member on Lower Peel River reflect, however, further advance of the mid-Lower Cretaceous sea during late Upper Aptian time (time of the grey sandy siltstone member).

Although the sandstones of the upper sandstone division vary widely in the degree of consolidation and in places grade into sands, the division as a whole is cliff-forming; ridges and escarpments formed from it can be followed for miles through binoculars or on air-photographs. The rocks of the upper sandstone division are lithologically indistinguishable from those of the lower sandstone division.

The upper sandstone division is estimated to be between 800 and 900 feet thick between Treeless Creek and Donna River. There, however, only its lower and middle beds were observed in good, measurable sections. The best of these sections are 500 to 550 feet thick and occur in the eastern slope of the Mount Goodenough massif and in deep ravines 1 mile to 1 1/2 miles west of the Mount Gifford massif. Some 300 to 350 feet of very poorly exposed strata of the division occur, however, above the highest measured bed on the plateau of the Mount Goodenough massif.

On Rat River between 'Destruction City' and the mouth of Barrier River the total estimated thickness of the upper sandstone division decreases to some 510 to 520 feet. These sections include 300 to 350 feet at the top apparently corresponding to the poorly exposed upper beds of the division on the Mount Goodenough plateau.

At Stony Creek the total measured thickness of the division further decreases to about 410 feet. This includes about 40 feet of grey sandy siltstones, the grey siltstone member, that are younger than any beds of the division seen farther north. Stony Creek sections expose the only known contact with the overlying rocks of the Albian shale-siltstone division.

On upper Vittrekwa River the total thickness of the upper sandstone division is assumed to be some 550 to 600 feet. This increase in thickness is due to the thickening to at least 250 feet of the grey sandy siltstone member of Stony Creek sections. The contact of the division with the overlying rocks of the Albian shale-siltstone division was not seen anywhere on upper Vittrekwa River.

At the mouth of Vittrekwa River, and on Lower Peel River between Vittrekwa and Road Rivers, only 250 feet of siltstones and sandstones of the grey sandy siltstone member have been observed. All of the older part of the upper sandstone division is assumed to wedge out between upper Vittrekwa River and its mouth.

Rocks of the upper sandstone division were not seen anywhere on Road River or on Lower Peel River beyond the point about 13 miles upstream from the mouth of Vittrekwa River. However, only its grey sandy siltstone member is likely to extend that far south and southeast.

The contact with the underlying upper shale-siltstone division is mostly gradational (Jeletzky, 1958a, p. 10) and there is no indication of an erosional contact, even in the few sections where the contact appears to be fairly abrupt.

The contact with the overlying rocks, be they those of the Upper Cretaceous shale division or those of the Albian shale-siltstone division, is everywhere sharp and uneven, and a pebble-conglomerate of varying thickness mostly fills the depressions in the surface of the division. The presence of only 40 feet of grey sandy siltstones in Stony Creek sections, as compared with the presence of at least 250 feet of these siltstones on Vittrekwa and Lower Peel Rivers indicates that this contact is not only erosional but also cuts across the beds in a regional unconformity. The known magnitude of the transgressive overlap involved is, however, small as compared with the magnitudes of the overlaps of the upper shale-siltstone and Upper Cretaceous shale divisions (see Correlation Chart).

Age and Correlation

The lowermost 120 to 130 feet of the upper sandstone division is of the latest Barremian age as its fauna includes numerous representatives of the genus Acroteuthis Stolley, 1911, which is not known to range above Upper Barremian rocks (see Jeletzky, 1958a, p. 13). These lower beds of the division appear, therefore, to be equivalent to the European Costidiscus recticostatum zone. Their fauna includes Acroteuthis cf. pseudopanderi Sintsov, Acroteuthis resembling A. kernensis Anderson and A. mitchelli Anderson, Hibolithes n. sp.?, Aucellina aptiensis (d'Orbigny) Pompeckj, A. caucasica (Buch), other non-diagnostic pelecypods listed in Jeletzky (1958a, p. 15), and a species of starfish. The overlying 100 to 400 feet of the division must be of early Aptian (Bedoulian) age because of its stratigraphic position between uppermost Barremian and early upper Aptian rocks (see Correlation Chart). Of the remaining 200 to 620 feet of the division, the lower 200 to 340 feet contains Tropaeum australe (Moore) emend. Whitehouse 1926, T. undatum Whitehouse, Aucellina aptiensis (d'Orbigny) Pompeckj, and A. caucasica (Buch), and is of the early upper Aptian (early Gargasian) age. The uppermost 40 to 250 feet (the grey sandy siltstone member) has only yielded Aucellina aptiensis (d'Orbigny) Pompeckj, Aucellina caucasica (Buch), and other non-diagnostic pelecypods. The occurrence of A. aptiensis indicates that the grey sandy siltstone member is still of late Aptian age in spite of its locally unconformable contact with the older beds of the division and its transgressive overlap of Palaeozoic rocks on the east flank of the basin. The grey sandy siltstone member is assumed to correspond with the lower part of the late upper Aptian stage above the Tropaeum bowerbankii subzone of the European standard (see Jeletzky, 1960).

The magnitude of the erosional interval separating the rocks of the upper sandstone division from those of the Albian shale-siltstone division is somewhat uncertain, as it is still doubtful whether the Lemuroceras or Beudanticeras affine zone is of middle Albian or late lower Albian age (Jeletzky, 1960). Most probably it embraces latest Albian as well as part or all of early Albian time.

The magnitude of the erosional interval separating the rocks of the upper sandstone division from those of the Upper Cretaceous shale division in the Rat River and Treeless Creek sections is naturally much greater, and also embraces latest Aptian time, as Tropaeum australe ranges to the very top of the upper sandstone division in both sections. The oldest diagnostic fauna of the Upper Cretaceous shale division is late Cenomanian in age, but lies some 200 feet or more above the base. Assuming that the unfossiliferous interval at the base of the Upper Cretaceous shale division does not include any late Lower Cretaceous rocks, the erosional interval would embrace all of the Albian in addition to the latest Aptian.

The concretionary shales and siltstones that outcrop east of the Mackenzie delta, on the shores of Darnley Bay and farther inland, are probably equivalent to the upper part of the upper sandstone division (Jeletzky, 1960), but the only known ammonoid fragment is so poorly preserved that it could also be a Hauterivian or Barremian uncoiled form.

No rocks equivalent to any part of the upper sandstone division were found in McConnell's sections on Porcupine River. The lithologically similar upper sandstones of McConnell (1891,pp. 123D-125D) were found to be of late Upper Jurassic age (see above) and equivalent to the lower shale-siltstone division.

The correlation (Jeletzky, 1958a, p. 15, correlation chart) of the upper sandstone division with the upper beds of the Isachsen sandstone of the Queen Elizabeth Archipelago should perhaps be revised. Marine fossils of possible Aptian age were identified by the writer in collections made by E. T. Tozer and R. Thorsteinsson from the lower part of the Christopher shale, which overlies the Isachsen sandstone, on Mackenzie King Island. If this is confirmed by better fossils, it will indicate that the Aptian transgression also covered part or all of the Queen Elizabeth Archipelago during Aptian time and that a direct marine connection existed then between the subsiding trough of northeastern Richardson Mountains and Sverdrup basin.

The apparent reappearance of rocks of the upper sandstone division in the Darnley Bay area suggests that they underlie the Mackenzie delta and occur in the Horton and Anderson river basins farther east.

LATE LOWER CRETACEOUS

Albian Shale-siltstone Division

The rocks of the Albian shale-siltstone division are widespread on Lower Peel River above the mouth of Vittrekwa River and throughout the lower courses of Vittrekwa and Road Rivers. There they fill out a broad and shallow basin, which extends northward into the Stony Creek area. On Stony Creek the rocks of the Albian shale-siltstone division were observed only between Mount Toughenough and a point about 3 miles below the upper forks of Stony Creek. They appear, however, to underlie a triangular-shaped strip of low plateau for a distance of up to 4 miles north of the upper forks of Stony Creek (see map). The Albian shale-siltstone division was not found on lower Stony Creek or anywhere in the more northerly parts of the area, presumably because it was all eroded away before the sediments of the Upper Cretaceous shale division were deposited.

Stratigraphy

The Albian shale-siltstone division consists of greenish grey to black, mostly hard shales and siltstones with many interbeds of clay ironstone and rows of clay ironstone concretions. Thin layers and lamellae of shale and siltstone commonly alternate. Much of the siltstone is more or less sandy; some beds of very sandy siltstone and silty, clayey, shale-like sandstone occur in the lower part of the succession. A bed 4 or 5 feet thick of pebbly shale interbedded with pebbly grit occurs at the base of the division.

Only 315 feet of these shales and siltstones were measured on Stony Creek but the division is probably at least 800 to 1,000 feet thick on Road and Vittrekwa Rivers and south of the mouth of Vittrekwa River, on Peel River. Farther south Foley (1944) and Hume (1954, pp. 52-53) have measured from 800 to 2,000 feet of shales and siltstones equivalent to those of the Albian shale-siltstone division on Upper Peel River and along its western confluents, such as Trail and Caribou Rivers.

Age and Correlation

The lower 200 to 250 feet of the Albian shale-siltstone division has yielded Beudanticeras affine (Whiteaves), Lemuroceras(?) sp. indet., and Cleoniceras(?) sp. indet., and is therefore of early middle Albian or possibly of late lower Albian age, in terms of the international standard stages, and represents some part of the Beudanticeras affine and Lemuroceras zone of the western interior of Canada (Jeletzky, 1960). Higher beds of the division are assumed to include younger Albian zones, as Gastroplites spp. indet. were previously identified from equivalent shales on Peel River and elsewhere in Mackenzie basin (Warren, 1947; Hume, 1954, p. 51).

The occurrence of the late Cenomanian Inoceramus crippsi s. lato fauna well up in the overlying Upper Cretaceous shale division and the presence of an erosional interval and a regional unconformity between the Albian shale-siltstone and Upper Cretaceous shale divisions, indicate that the Albian shale-siltstone division does not include any Upper Cretaceous rocks.

About 100 feet of grey sandstones and siltstones with Lemuroceras sp. indet. and Cleoniceras? sp. indet. outcrops just above the junction of East Porcupine and Porcupine Rivers. These equivalents of the Albian shale-siltstone division are overlain by 70 to 80 feet of non-fossiliferous, dark grey, soft shales. The shales dip underneath a sequence, 1,200 to 1,400 feet thick, of unfossiliferous, dark grey, siliceous, hard shales with buff sandstone members in the upper part. The siliceous shales appear, thus, to be younger, although their contact with known Albian rocks is nowhere exposed and faults are numerous in the area. The whole sequence is tentatively considered to be equivalent to the Albian shale-siltstone division of the eastern flank of Richardson Mountains.

Rocks equivalent to the Albian shale-siltstone division must be present underneath the Mackenzie delta and in the basins of Horton and Anderson Rivers to the east, as Beudanticeras sp. indet. was collected near Toker Point on the Arctic shore.

South and southeast of the surveyed area, shales and some sandstones equivalent to the Albian shale-siltstone division are widespread in the basins of Peel, Arctic Red, and Mackenzie Rivers (Hume, 1954,pp. 51-53).

Rocks equivalent to the Albian shale-siltstone division are also widespread in northern Alaska, where they are represented by the Torok formation, 6,000 to 10,500 feet thick, and by the lower part of the Nanushuk group (Gryc, Patton, and Payne, 1951, p. 160; Imlay and Reeside, 1954, p. 241, correlation chart).

In the Queen Elizabeth Archipelago, the upper part of the Christopher shale is equivalent to the Albian shale-siltstone division (Heywood, 1957, p. 12). The Hassel formation of the same region probably also includes equivalent rocks, as late Cenomanian fossils were found in rocks tentatively correlated with the lower part of the next younger Kanguk formation.

UPPER CRETACEOUS

Upper Cretaceous Shale Division

Stratigraphy

Only two remnants of the Upper Cretaceous shale division are known within the area. Both occupy the downfaulted parts of synclinal structures. The larger body occupies the eastern slope of Aklavik range between Goodenough Creek and a point about 1 1/2 miles north of Longstick Creek and the smaller occurs on the northeastern side of Rat River. Only the lowermost 10 to 15 feet of the division is exposed at the latter, and the northerly extension is assumed to be cut off by a northwesterly trending fault.

The Upper Cretaceous shale division is the youngest Cretaceous formation known in the area. It consists of dark to light grey, soft shales that are in places scarcely consolidated. Many are laminated or thinly bedded. The shales have a bluish tinge and, in the upper two thirds of the division have a pronounced blue-grey weathering. Numerous concretions of various shapes and sizes composed of hard, dark to blackish grey shale abound in many beds of the division. Many of these are septaria-like and contain geodes of carbonate or silica minerals. The concretions mostly weather whitish grey or yellowish grey. The absence of rusty-weathering bands and concretions is a notable feature of the division.

The exposed part of the division in the larger body is estimated to be 900 to 1,000 feet thick; its top was nowhere observed. Most of the accessible sections are obscured or completely destroyed by slumping, and it is difficult to work out the sequence of beds or to make more than a rough estimate of its visible thickness.

The Upper Cretaceous shale division was subdivided lithologically into three members. The dark grey shale member at the base is predominantly composed of dark grey, soft, massive to fissile shales that weather ash-grey rather than bluish grey in most beds. The dark grey shale member is estimated to be 350 to 400 feet thick, but, as no complete section of this member was anywhere observed, this estimate is based on the somewhat arbitrary piecing together of several sections.

The dark grey shale member is followed by the orange-weathering shale member. The latter consists of dark grey, orange- to yellow-weathering, laminated shale, whose upper part is strongly sulphurous and ferruginous. Silty and sandy shales commonly occur in the orange-weathering member, but are mostly restricted to rows of large, thin-bedded, loaf-like, fossiliferous concretions. The orange-weathering member is about 60 to 65 feet thick and persists all through exposures in the Treeless Creek area, always in the same stratigraphic position; it is an important horizon marker. The contacts with the lower and upper members appear to be gradational.

The orange-weathering member is followed by the bluish weathering member, which consists of light to ash-grey, bluish tinged shales, with numerous, large, septaria-like concretions of whitish weathering, hard shale. The shale of this member is distinctly blue-grey when weathered. As most outcrops of the division are slumped, the bluish weathered shales commonly cover them from top to bottom, causing the characteristic blue-grey colour of the outcrops. The visible thickness of the bluish weathering member is estimated to be 500 to 550 feet; its top was nowhere observed.

A 7- to 8-foot bed of pebble-conglomerate with interbeds of peculiar, speckled olive-green to meat-red, glauconitic grit and blackish grey, pebbly shale occurs at the base of the division on Treeless Creek. This basal conglomerate rests with an uneven and sharp boundary on the rocks of the upper sandstone division. No similar basal conglomerate was observed in the Rat River area where the shales overlie the rusty-weathering sandstones of the upper sandstone division with a sharp and uneven contact.

The presence of the Albian shale-siltstone division above the upper sandstone division in the Stony Creek sections and its absence between the upper sandstone and Upper Cretaceous shale divisions on Rat River and Treeless Creek indicate that the contact of the Upper Cretaceous shale division with the upper sandstone division is not only erosional but is also regionally unconformable. The minimum figure for the transgressive overlap is 315 feet, the thickness of the shales missing from the Albian shale-siltstone division between Stony Creek and Rat River. The overlap is however, greater than this, for the Albian shale-siltstone division is at least 800 to 1,000 feet thick on Vittrekwa and Road Rivers and on the nearby parts of Peel River. The Upper Cretaceous transgressive overlap is, therefore, comparable in size with the mid-Lower Cretaceous overlap.

Age and Correlation

Only non-diagnostic marine pelecypods and fossil wood were found in the basal beds of the Upper Cretaceous shale division. The late Cenomanian Inoceramus crippsi Mantell s. lato et var. fauna occurs, however, about 200 feet above the base in the middle part of the dark grey shale member. This and the presence of the regional unconformity between the Upper Cretaceous shale and the Albian shale-siltstone divisions favours an earliest Upper Cretaceous age of the basal beds of the former.

The lower part of the orange-weathering member of the division locally carries a poorly preserved Turonian fauna, including Scaphites cf. delicatulus Warren, Borissjakoceras, sp. indet., Watinoceras or Prionocyclus (Collignoniceras), Inoceramus ex gr. lamarcki Parkinson, and Inoceramus cf. labiatus (Schloth.). This fauna almost certainly represents the lower Turonian zone of Watinoceras and Inoceramus labiatus (Jeletzky, 1960).

A single imprint of Scaphites cf. preventricosus Cobban was found in the bluish weathering shale member, about 300 feet above the base. Although imperfect, this specimen is sufficient to permit the beds concerned to be assigned to the uppermost Turonian of the international standard (Jeletzky, 1960).

No diagnostic fossils were found in upper beds of the bluish weathering member, but as they overlie gradationally the uppermost Turonian rocks, they are presumably of Coniacian age. Santonian and Campanian rocks may, however, also be present.

The lower Turonian Little Bear formation of the Mackenzie River basin (Hume, 1954, pp. 8, 51) is partly equivalent to the orange-weathering member of the Upper Cretaceous shale division, and equivalents of the division may also be present in the Slater River and East Fork formations (Hume, 1954, pp. 8, 47-48).

In northern Alaska, the upper part of the Nanushuk group and the greater part of the Colville group (Gryc, Patton, and Payne, 1951; Imlay and Reeside, 1954, pp. 242-243, correlation chart) are equivalent to the Upper Cretaceous shale division. The Colville group includes, however, Santonian and Lower Campanian rocks, which are younger than any fossiliferous rocks in the Upper Cretaceous shale division.

On Porcupine River, in the area of its confluence with East Porcupine River, the known and presumed Albian rocks are overlain by a sequence some 4,000 feet thick, of medium- to coarse-grained, pepper and salt, quartzose sandstones, which cap all hills east and west of the river. Only a single, poorly preserved fragment of a macruran crustacean was found in these sandstones, and their contact with the older Cretaceous rocks was not observed. These rocks are considered to be Upper Cretaceous in age because of their superposition on fossiliferous Albian rocks.

The Upper Cretaceous rocks of the Porcupine River, are believed to include marginal, shallow-water and/or continental facies of the Upper Cretaceous shale division (see Correlation Chart).

Only Santonian to lower Campanian rocks, which are younger than any fossiliferous beds in the Upper Cretaceous shale division, are known to occur east of Mackenzie delta (Jeletzky, 1960). It is probable, however, that older Upper Cretaceous rocks equivalent to the Upper Cretaceous shale division also occur there.

In Queen Elizabeth Archipelago, the marine equivalents of the Upper Cretaceous shale division were found by H.R. Greiner at one locality on Graham Island. Upper Cenomanian Inoceramus cf. pictus Sowerby was identified by F.H. McLearn from these rocks, which were tentatively placed into the Kanguk formation.

Only Santonian to lower Campanian index fossils, identified by the writer, were found elsewhere in the Kanguk formation and equivalent rocks. These beds are, therefore, roughly contemporaneous with the Santonian to lower Campanian sandstones and shales east of Mackenzie delta.

It is presumed (Jeletzky, 1950, pp. 22-23) that the Kanguk formation and equivalent rocks of the Sverdrup basin range from late Cenomanian to early Campanian in age, and thus appear to be partly equivalent to the Upper Cretaceous shale division.

CRETACEOUS OR TERTIARY

Piercement(?) Breccia

Lithology, etc.

A peculiar breccia outcrops in cliffs 50 to 100 feet high for about 1/4 mile along the southern shore of Donna River between the upper end of its lower canyon and the Donna River fault.

A probable outcrop of the same breccia, 40 by 60 feet, occurs about 1/2 mile west of the southwestern end of the above and about 1/4 mile west of the Donna River fault. This outcrop is on the bottom of Donna River valley, south of the stream's bed and is completely surrounded by the recent alluvial deposits. It is, however, on strike with relatively undisturbed and only slightly tilted rocks of the upper shale-siltstone division that border the valley of Donna River in this vicinity. The occurrence looks like a large block that has fallen into the river bottom from above, but no outcrops of the breccia were observed anywhere in the vicinity, either on the slope or on the plateau above.

The breccia consists of various sedimentary rocks in fragments and blocks up to 40 feet long and 15 feet thick and of fragments and blocks of diabase up to several feet in diameter. The fragments are all sharply angular and are embedded in an abundant dirty white to light blue matrix of finely to coarsely crystalline, commonly cavernous gypsum and(?) anhydrite. Most of the sedimentary fragments and blocks are lithologically comparable with Palaeozoic and Mesozoic rock types observed in the area. Coal-bearing shales and sandstones, apparently derived from the Lower Cretaceous coal-bearing division, were the youngest sedimentary rocks identified; rose-coloured flinty shales, apparently derived from the Ordovician to Carboniferous, possibly Devonian, rocks of Aklavik Range (Jeletzky, 1958b, p. 1593), were the oldest. At least two varieties of diabase of unknown age were recognized. No stratification was observed within the breccia.

The breccia outcrops are mostly separated by more or less wide covered intervals from nearby outcrops of Lower Cretaceous rocks. On the southeastern side, however, near the top of the cliffs, the breccia is overlain by sheared and jointed, dark grey shales with an uncertain attitude. These shales are unfossiliferous, but are lithologically similar to the dark grey shales of the upper member of the coal-bearing division which outcrops not more than 1/4 mile to the east. The contact seems to be normal but is sharp and uneven and no conglomerate was observed at the base of the shales. It is, however, only exposed over a length of 200 to 250 feet at the northeast end of the breccia outcrops. Farther southwest the breccia outcrops right to the rim of the tundra-covered plateau overlooking Donna River valley from the southeast and there are no outcrops within 1/2 mile on the plateau.

Origin and Age

The principal outcrops of breccia are believed to form part of a largely covered piercement dome or diapir fold. This is believed to be a piercement breccia for the following reasons:

(1) In spite of its close proximity to the Donna River fault, the breccia cannot be interpreted as a post-Lower Cretaceous tectonic breccia. Such an assumption would be incompatible with the presence in the breccia of numerous sedimentary and intrusive fragments and blocks of many different lithological types which apparently are derived from several nearby Palaeozoic and Mesozoic formations. The high content of gypsum and(?) anhydrite in the matrix is equally incompatible with this interpretation.

Only the intrusion of the gypsum and(?) anhydrite core into the overlying Palaeozoic and Mesozoic rocks could cause the agglomeration of rocks of the different types mentioned above in the gypsum and(?) anhydrite matrix.

(2) The lithological features of the breccia agree well with those of the post-Cretaceous piercement domes and diapir folds discovered recently in the Sverdrup basin of Queen Elizabeth Archipelago (Heywood, 1955; 1957, pp. 24-25; Fortier, 1957, p. 413).

(3) The apparent lack of the characteristic outline of a piercement dome or diapir fold is easily explained by the almost complete absence of outcrops around the breccia exposures. Distortion of the original piercement structure by the Donna River fault and its subsidiary faults, which pass closely to the west and to the east of the principal breccia outcrops, may also account for this.

The breccia includes fragments and blocks of coal-bearing rocks, apparently derived from the lower member of the coal-bearing division. Moreover it seems to be overlain by dark grey shales, comparable with those of the shale unit of the upper member of the coal-bearing division. If correct, this would indicate that the breccia was emplaced after the deposition of the lower member of the coal-bearing division but before the deposition of the shale unit of its upper member. On the other hand the apparent absence of a basal conglomerate and the sharp and abrupt nature of the contact, conflict with this interpretation. Moreover there is no indication of any unconformity, or even an erosional break, between the lower and upper members of the coal-bearing division. It is more probable, therefore, that the shale outcrop is either a small exposed segment of the outer rim of the piercement structure or a part of a large block engulfed by the intruding breccia. If so, the breccia is younger than any part of the coal-bearing division and was emplaced between the mid-Lower Cretaceous and Recent time. This seems to the author the most probable date.

STRUCTURAL GEOLOGY

The structure of the area is dominated by many major faults, which split it up into several fault blocks. The folds are either strongly disrupted by these faults or subordinated to and directly caused by them. Characteristic features of the folds are their generally small dimensions, irregular pattern, and commonly dome-like character.

The constant involvement of the mid-Upper Cretaceous rocks in the major plicative and disjunctive dislocations and the apparent absence of any older Cretaceous structures within the area indicate that the present-day structures were caused largely or entirely by the post mid-Upper Cretaceous orogenic movements. These movements were probably of the early Tertiary age (Alpine orogeny). More than one post mid-Upper Cretaceous orogenic phase is suggested by the structural relationships observed in the area.

The structure of the area contrasts strongly with that of the central parts of Richardson Mountains, which are dominated by symmetrical, large-scale, mostly open folds rather than by faults (Goodman, 1954, p. 348; Gabrielse, 1957, p. 10, and personal observations).

The part of the eastern flank of the Richardson Mountains investigated appears, therefore, to form a structural zone of its own within the Richardson Mountains. This zone of intense faulting and small, predominantly dome-like folds appears to fringe the more regularly folded central parts of the Richardson Mountains from the east and to separate them from the essentially stable belt situated farther east.

The structural complexity of the Cretaceous and uppermost Jurassic rocks varies widely within the area. Some parts are underlain by horizontal to only slightly folded rocks, rarely affected by minor faults; other parts are underlain by tightly folded, steeply dipping to overturned rocks, crisscrossed by closely spaced major faults and thrusts with various trends. Domes, recumbent parallel-sided folds, and low-angle overthrusts were observed locally within the latter parts of the area. Yet other parts of the area are intermediate between these extremes in the intensity and complexity of their structures.

ECONOMIC GEOLOGY

PETROLEUM AND NATURAL GAS

The predominantly marine Uppermost Jurassic and Cretaceous rocks of the area appear to be promising as potential source rocks and reservoirs of petroleum and natural gas. The occurrence of several thick sandstone formations and members overlain and underlain by thick shale formations and members is, in itself, favourable.

The minor sandstones occurring within the lower shale-siltstone division are mostly silty and argillaceous and probably not as porous as the younger sandstones. Similarly the sandstone interbeds and members of the upper shale-siltstone division are mostly silty and argillaceous and are probably unfavourable.

Sandstone interbeds and members of the lower and upper shale-siltstone divisions thicken markedly in the southwestern part of the area south of Rat River. These heavy sandstones are, however, largely quartzite-like or true quartzites with little or no visible porosity. They appear, therefore, to be unfavourable as potential reservoir rocks.

Glauconitic sandstones and pebble-conglomerates laterally replacing the predominantly shaly rocks of the lower shale-siltstone division on upper Vittrekwa and Rock Rivers are fairly friable and appear to be porous; they deserve, therefore, further attention as potential reservoir rocks.

The sandstones of the lower sandstone, coal-bearing, and upper sandstone divisions appear to be mostly clean and some of them well-sorted, apparently porous, marine sandstones. They are, moreover, thicker and more widely distributed than the sandstone beds of the lower and upper shale-siltstone divisions.

Some of the sandstones of the upper sandstone division are poorly cemented, and in Rat River basin many beds and members are of almost unconsolidated sand.

The presence of several transgressive overlaps is favourable for the accumulation of oil and gas in stratigraphic traps. This condition exists beneath the regional unconformity at the base of the upper shale-siltstone division, and beneath that at the base of the Upper Cretaceous shale division, and probably also at the base of the Albian shale-siltstone division.

The smaller, doubly plunging anticlines and domes within the area are also favourable features, even though most of them are disrupted by faults. The presence of a possible piercement dome or diapir fold on the lower Donna River also deserves mention.

In spite of the abundance of potential reservoir rocks and favourable structures, no active oil or gas seepages were observed in the area, nor did the writer hear of any such seepages having been observed by the local residents.

Small lumps of hard, brownish black, asphaltum-like bitumen were observed scattered in the rock and as fillings of Dentalium and gastropod shells in a 2- or 3-foot bed of sandy siltstone in the upper shale-siltstone division. No connection with a fault or with shear planes was observed. The bitumen-bearing bed occurs at the base of an outcrop on the right shore of Rat River about 1 mile downstream from the mouth of Barrier River. It lies some 60 feet below the contact of the upper shale-siltstone and upper sandstone divisions.

W.J. Montgomery of the Fuels Division, Mines Branch, reports as follows:

"According to Abraham's classification the bituminous material submitted would be classified as follows:

Genus, Bitumen, Species, Asphaltite and Member Gilsonite.

The solubility of this gilsonite was determined in benzene, and 93% was found to be soluble in this solvent. The infra red spectrum agreed most closely with that of gilsonite. The C = O absorption band was almost non-existent which suggests that this is not a weathered sample. It is very doubtful that this bituminous material is directly related to petroleum, that is to say that petroleum seeped upward through the underlying formations and collected in the vugs provided by the fossils. The absence of a carbonyl absorption band would suggest that this is not a weathered petroleum from which the volatile components have been distilled and the residue polymerized by the action of oxygen from the air."

The occurrence, nevertheless, suggests that these shales are a possible source of hydrocarbons.

A specimen of oil shale was collected at Darnley Bay, which gave on distillation 94 gallons of petroleum to the short ton (Fortier, McNair, and Thorsteinsson, 1954, p. 2101). This sample was probably collected from rocks equivalent to the mid-Lower Cretaceous rocks of the present area, which are known to occur in that part of Darnley Bay.

COAL

Coal seams 1 foot to 5 feet thick were noted in several sections of the lower member of the coal-bearing division. All of these are within the lower canyon of Donna River; elsewhere only thin layers of impure coal or coaly shale were seen. None of the seams was investigated in detail and no samples were analyzed, but some seams appear to be sufficiently thick and persistent to be of commercial interest. Indeed coal from these seams was reportedly mined and hauled to Aklavik in the winter by dog sled and tractor train.[1] Traces of the winter road connecting the shore of Husky Channel with the mouth of the lower canyon of Donna River are still clearly visible from the air, and a cabin still stands near the reported site of the coal mine. The coal seems to be of the bituminous or sub-bituminous type, and of sufficiently high quality to justify further investigation.

REFERENCES

Foley, E.J.
1944: Final Geological Report on "The Lower Peel River Area"; Imperial Oil Ltd., Canol Project, Assignment No. 23a, (an unpublished report on file with Geol. Surv., Canada).

Fortier, Y.O.
1957: The Arctic Archipelago; in Geology and Economic Minerals of Canada (Fourth Ed.); Geol. Surv., Canada, Econ. Geol. Ser. No. 1, pp. 393-442, figs. 79, 80, plates XXXVII-XLII, Table XXV.

Fortier, Y.O., McNair, A.N., and Thorsteinsson, R.
1954: Geology and Petroleum Possibilities in Canadian Arctic Islands; Bull. Am. Assoc. Petrol. Geol., vol. 38 (10), pp. 2075-2109, 7 figs.

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[1] H. Hoidahl, Aklavik, personal communication.

Frebold, Hans
1951: Geologie des Barentsschelfes; Abhandl. deut. Akad. Wiss. Berlin, Kl. Math. u. allgem. Naturw., Jahrb. 1950, No. 5, Abhandl. zur Geotektonik Nr. 4.

1957: The Jurassic Fernie Group in the Canadian Rocky Mountains and Foothills; Geol. Surv., Canada, Mem. 287.

Gabrielse, H.
1957: Geological Reconnaissance in the Northern Richardson Mountains, Yukon and Northwest Territories; Geol. Surv., Canada, Paper 56-6.

Goodman, A. J.
1954: Tectonics of East Side of Cordillera in Western Canada; Western Canada Sedimentary Basin (symposium); Am. Assoc. Petrol. Geol., pp. 341-354, 6 figs. (Originally publ. in Bull. Am. Assoc. Petrol. Geol., vol. 35, No. 4, pp. 783-796, 1951.)

Gryc, G., Patton, W.W., and Payne, T.G.
1951: Present Cretaceous Stratigraphic Nomenclature of Northern Alaska; J. Wash. Acad. Sci., vol. 41, (5), pp. 159-167, 3 figs.

Heywood, W.W.
1955: Arctic Piercement Domes; Bull. Can. Inst. Min. Met., vol. 48 (No. 514), pp. 59-64, 9 figs.

1957: Isachsen Area, Ellef Ringnes Island, District of Franklin, Northwest Territories; Geol. Surv., Canada, Paper 56-8.

Hume, G.S.
1954: The Lower Mackenzie River Area, Northwest Territories and Yukon; Geol. Surv., Canada, Mem. 273.

Imlay, R.W., and Reeside, John B. Jr.
1954: Correlation of the Cretaceous Formations of Greenland and Alaska; Bull. Geol. Soc. Amer., vol. 65, pp. 223-246, 1 correl. table, 1 fig.

Jeletzky, J.A.
1950: Actinocamax from the Upper Cretaceous of Manitoba; Geol. Surv., Canada, Bull. 15, pp. 1-28, 3 plates, 2 figs.

1958a: Uppermost Jurassic and Cretaceous Rocks of Aklavik Range, Northeastern Richardson Mountains, Northwest Territories; Geol. Surv., Canada, Paper 58-2.

1958b: Geological History of Aklavik Range, Northeastern Richardson Mountains, N.W.T.; Bull. Geol. Soc. Amer., vol. 69, No. 12, pt. 2, p. 1593, (Abstract only).

1960: Marine Cretaceous Macrofossil Zones of the Western Interior of Canada and Their Correlation with the European and United States Western Interior Zones and Stages; XX Intern. Geol. Congr., Mexico City, Cretaceous symposium (in press).

McConnell, R.G.
1891: Report on an Exploration of the Yukon and Mackenzie Basins, N.W.T.; Geol. Surv., Canada, Ann. Rept. (new ser.), vol. IV, pp. 6D-163D, 2 maps.

Warren, P.S.
1947: Cretaceous Fossil Horizons in the Mackenzie River Valley; J. Pal., vol. 21 (2), pp. 118-123, pl.