STRATIGRAPHY, FACIES AND PALAEOGEOGRAPHY OF JURASSIC AND CRETACEOUS ROCKS OF NORTH YUKON AND MACKENZIE DISTRICT, NWT (NTS 116I, 116J, 116L, 116O, 116P, 117A)

Project 550004

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In June and July 1973, about five weeks were spent in a stratigraphical-palaeontological study of the Jurassic and Cretaceous (mainly Berriasian to Aptian) rocks of the ~~Nork~~ Yukon and the Mackenzie District, N.W.T. and in supporting the field work of D.K. Norris (Project 690005) and F.G. Young (Project 700068) in these and adjacent areas.

The approximate boundaries of the principal areas surveyed in 1973 are indicated in Figure 1 where they are numbered consecutively 1 to 9. These areas are numbered and discussed in the same order in the following text for the convenience of the reader.

1. Headwaters of Bluefish River and Lord Creek

D.K. Norris led the writer to the Jurassic part of Mountjoy's (in Frebold et al, 1967, p. 7) main section 230MJ in the eastern Keele Range. The study of this section (see below) invalidates the writer's (Jeletzky, 1972b) previously expressed doubts about the correctness of Mountjoy's (ibid) interpretation of this part of the section and particularly his suggestion concerning the provenance of the Upper Jurassic Buchias collected there by Mountjoy (in Frebold et al, 1967, p.7).

The Jurassic to mid-Hauterivian sequence of the area as now known includes (ascending order):

1. Kingak Formation (restricted) represented by at least 500 feet (base cut off by a strong northeast-trending ?normal fault) of poorly exposed and strongly disturbed bluish-grey, partly sandy, so far unfossiliferous siltstone. The

Kingak silstone is overlain conformably and apparently gradationally by;

2. Unnamed Upper Jurassic sandstone represented exclusively by littoral to neritic rocks containing a rich pelecypod fauna of *Buchia mosquensis* (s. lato) zone at several levels. The about 400 feet thick unit includes about 125 feet of sandy to pure, mostly unfossiliferous ~~sandy to pure~~ siltstone in the middle. This strongly attenuated offshore facies of the unnamed Upper Jurassic sandstone is overlain conformably and apparently gradationally by;

3. Husky Formation represented by some 1,400 feet (approx.) of mostly very poorly exposed, so far unfossiliferous, dark grey siltstone (mostly pure) and shale. Grades upwards through a 300 to 400 feet thick member of dull to dark grey, sandy to very sandy, micaceous, hard to moderately hard, massive-looking locally carbonaceous siltstone with some interbeds of superficially similar, very fine grained, silty sandstone into;

4. ?Uppermost Jurassic to early Berriasian sandstone division consisting of 500 to 550 feet of light to dark grey or dull yellow, mostly fine to very fine grained, hard to very hard often quartzite-like sandstone with minor interbeds and some up to 50 feet thick members of dark grey, moderately hard, sandy to very sandy siltstone in the basal and topmost part. This weathering-resistant, ridge-forming division is largely built of quartzose to orthoquartzitic sandstones but includes interbeds of polymictic sandstone containing up to 15 per cent (est.) of grains of ?kaolinized feldspar (?or white chert) and the same amount (est.) of dark mineral (? chert) grains. The sandstone is noncarbonaceous to slightly carbonaceous, feebly to slightly glauconitic, and well to moderately rounded and sorted in the upper 300 to 350 feet. This predominantly massive to heavily and indistinctly bedded sandstone, contains ~~are~~ some non-diagnostic marine pelecypods and is believed to be a lagoonal to outer barrier deposit. The

200 to 250 feet thick lower part consists predominatnly of thinly bedded to laminated, commonly cross-bedded and ripple marked, carbonaceous or coaly sandstones characterized by alternation of dark to light grey laminae; sorting and rounding of grains is poor for the most part, glauconite grains are notably absent while subvertical coaly rootlets, specks and inclusions of coaly matter, laminae and 1-3" pods of impure coal are common. This locally wood- and plant-bearing sandstone did not yield any marine fossils and is believed to be of an alluvial to deltaic origin. The division appears to be a western shoreline to nonmarine facies of the Husky shale of other areas of North Yukon. It grades upward into;

5. Lower sandstone division equivalent consisting of at least 300 feet (rough estimate only because of poor exposures and apparently tectonically disturbed state of rocks) of siltstone, light grey to whitish grey, weathering same or dirty white with orange to rust-coloured specks; mostly sandy to very sandy and grades locally into superficially similar, very silty and very fine grained sandstone; hard and dense, more or less strongly silicified throughout and apparently non-porous; micaceous and feebly to moderately glauconitic; thinly and mostly evenly bedded; considerable interbeds of similarly hard and silicified, mottled dark- to light grey, strongly bioturbated pure to feebly sandy siltstone rich in worm burrows; Buchia volgensis Jeletzky 1964 (non Lahusen 1888), Arctotis aff. anabarensis Bodylevsky 1960, variegated long-ranging pelecypods, Cylindroteuthis (Communicobelus) sp. indet. and Pentacrinus sp. indet. occur in the uppermost 100 to 150' exposed; all pelecyods are preserved as single, commonly fragmentary and abraded valves oriented along bedding planes; combined with the presence of belemnites and Pentacrinus this indicates deposition in an open marine (normal salinity) relatively high energy (inner neritic to lower littoral) environment; top is faulted in all

sections studied. Because of its late Berriasian age (*Buchia volgensis* zone) the unit 5 must underlie the basal sandstone unit of the mid- to late Valanginian (*Buchia* n. sp. aff. *inflata* zone) siltstone-sandstone division and younger Lower Cretaceous units previously described by Jeletzky (1972b), from several faulted sections situated closely eastward and northward of the here described section. The lithology and thickness of the faulted out early Valanginian rocks (*Buchia keyserlingi* zone) separating the unit 5 from the mid- to late Valanginian rocks is unknown. The lithology of unit 5 and that of the Mid- to late Valanginian siltstone-sandstone division matches closely that of western marginal facies of the Blue-grey shale division observed in the headwaters of Berry Creek (Jeletzky, 1972b). However, the known, incomplete thickness (at least 2,500 feet) of these two equivalents of the Blue-grey shale division greatly exceeds that of any known section of its marginal or offshore facies in the more northerly areas of the Porcupine Plateau-Richardson Mountain Trough (Jeletzky, 1972b; 1961b, pp. 12-13).

The presence of the high marine Kingak and Husky Formations and of the attenuated marine facies of the Unnamed Upper Jurassic sandstone in the eastern Keele Range necessitates a re-interpretation of the Jurassic palaeogeography of the area. The earlier idea (Jeletzky, 1972b, Fig. 1; 1972a; p. 212, Fig. 1) that the Valanginian to mid-Lower Cretaceous marine rocks outcropping in the headwaters of Bluefish River and Lord Creek apparently resulted from an eastward onlap of a shallow sea originating in the marine basin of Central Alaska appears to be improbable as no Upper Jurassic to early Valanginian marine rocks are known to be present in the latter area. It is suggested instead that the Jurassic to mid-Lower Cretaceous rocks outcropping in the headwaters of Bluefish River and Lord Creek were deposited in a narrow but deep embayment of the Porcupine Plateau-Richardson Mountain Trough which separated two eastward protruding peninsulas of the Keele-Old Crow Landmass. This embayment apparently ended blindly within the western part of Keele Range somewhere east of the Yukon-Alaska boundary as exemplified by the palaeogeographic map of the Upper Jurassic time included in Figure 1.

2. Middle Course of Lord Creek

Mid- to Late Valanginian siltstone-sandstone division originally described in the headwaters of Bluefish River and Lord Creek (see Jeletzky, 1972b, pp. 63-65 and in Section 1 of this report) outcrops on the hillsides immediately west of the upper forks of Dave Lord Creek (approx. at 67° 10' 30" N. Lat. and 139° 36' 30" W Long.). Up to 150 feet of dull grey to light brownish grey, buff to dull brown weathering, mostly fine grained sandstone is estimated to outcrops in these folded and faulted, invariably frostheaved and debris-covered exposures. The covered intervals are probably underlain by friable siltstone. The mostly polymictic (subgreywacke-like), non-carbonaceous sandstone is estimated to include 70 to 80 per cent of quartz grains; 10 to 15 per cent of white Kaolinized (NC 2) feldspar (? and/or white chert) grains, and a comparable percentage of dark mineral (mainly black chert) grains. The grains are mostly moderately to poorly rounded (subrounded to subangular) and moderately well sorted as to the size. This moderately hard to fairly friable, medium to heavily and indistinctly bedded, moderately porous sandstone is fossiliferous at a number of levels and includes some ½ to 4 inch interbeds of coquinoid sandstone. The diversified, exclusively marine fauna (GSC #88693) includes: Acroteuthis? (a new genus?) n. sp. A of Jeletzky (1964, p. 48, pl. X, figs. 1A-1B), Arctotis cf. anabarensis Petrova, 1953, Pecten (Entolium) orbicularis d'Orbigny, ? Buchia sublaevis (Keyserling 1845) (a poorly preserved, single left valve), Oxytoma sp. indet., Arctica sp. indet., various long-ranging pelecypods and Ditrupa cornu Imlay 1960. The sandstone was apparently deposited in a stenohaline, fairly high energy outer littoral environment (an open shelf sea). The latest Valanginian age is assigned tentatively to this indubitably early to mid-Lower Cretaceous (Berriasian to Hauterivian) fauna. The sandstone unit concerned appears to be correlative with the Buchia sublaevis-bearing topmost sandstone unit of the Mid- to late Valanginian siltstone-sandstone division of the headwaters of Bluefish River and Lord Creek, the topmost part of the Blue-grey shale division of northwestern Richardson Mountains (Jeletzky, 1961b, pp. 13-14; 1972b, p. 43) and the uppermost part of the offshore facies of White sandstone member of Eastern Richardson Mountains (Jeletzky, 1972b, pp. 22-23). This sandstone unit appears to be widespread in the part of northeastern Keele Range confined between the headwaters of Bluefish River and the Lone Mountain judging by distant observations and an airphoto analysis. However, there was no opportunity to land on any of its assumed exposures.

?Mid-Lower Cretaceous siltstone-sandstone division. There was no opportunity to study on the ground the exposures of rocks apparently stratigraphically intermediate between the Mid- to late Valanginian siltstone-sandstone division and the Eagle Plain Formation and presumably corresponding to the Mid-Lower Cretaceous siltstone-sandstone division exposed in the headwaters of the Bluefish River and Lord Creek (Jeletzky 1972b, pp. 63-66).

Eagle Plain Formation. The Cretaceous rocks exposed in the right (E) bank of an unnamed right confluent of Lord Creek at about 67°13'10"N. lat. and 139°01'30" W. long. (appr. 1 1/3 mi. above the confluent's mouth) consist of some 250 feet of dull greenish-grey weathering dark grey to dull borwn lithic sandstone (greywacke) rich in black chert grains and poor in those of quartz. This fine to very fine grained, moderately to poorly rounded and sorted greywacke is indistinctly but medium to thinly bedded, hard and dense but not quartzite-like. Three dimensional or flattened 1/8" to 1" clay balls, variously shaped worm burrows and subvertical, rounded burrows of a ghost-shrimp (?Calianassa) are common at a number of levels; no distinct crossbedding or ripple marks noted and most fossils are preserved in a life-position with valves closed or only slightly gaping.

This suggests a deposition in a generally low energy lagoonal or estuarine environment. A rich marine pelecypod fauna collected in the basal 20 feet exposed (base covered), is nondiagnostic. However, that collected 60 to 70 feet stratigraphically higher (GSC loc. 88702) is rich in small *Inoceramus* ex aff. *cordiformis* Sowerby and includes some *Inoceramus* ex gr. *deformis* Meek. This fauna is assigned a latest Turonian to Coniacian age and suggests the correlation of the greywacke unit concerned with uppermost beds of the *high marine* (flyschoid) Turonian shale unit outcropping in the banks of Porcupine River between Driftwood and Old Crow Rivers (Jeletzky, 1972b, pp. 46-48).

The Lord Creek greywacke section forms part of the almost unfossiliferous Eagle Plain Formation (Mountjoy, 1967, pp. 5-7) and indicates its being a predominantly nonmarine facies of the unnamed Early to mid-Upper Cretaceous marine sequence outcropping farther north between Driftwood and Old Crow Rivers (Jeletzky, 1972b, pp. 46-53).

3. Porcupine River Canyon

Additional study of and collecting from the well exposed, unusually fossiliferous siltstone-silty sandstone section situated in the western bank of Porcupine River at the point 10½ mi downstream from the mouth of Bell River (Jeletzky in Frebold, 1961, p. 2, footnote) confirmed its shallow water (inner neritic) facies and confirmed the previously suggested existence of a sequence of several largely endemic belemnite faunas in the middle Bajocian to early Callovian rocks of Arctic Canada. This sequence begins with the *Pachyteuthis* (?new subgenus) n. sp. A fauna ranging from middle Bajocian (*Cranocephalites borealis* zone) to ?basal Bathonian, continues with the *Pachyteuthis* (?*Pachyteuthis*) n. sp. B and ?*Cylindroteuthis* (new subgenus) n. sp. A fauna ranging from lower to middle Bathonian and ends with the fauna consisting of: ?*Cylindroteuthis* (new subgenus) n. sp. B, *Cylindroteuthis* (*Communicobelus*) aff. *subextensa* (Nikitin), *Hastites* n. sp. A, and a new genus of ?megateuthidine belemnites apparently allied to *Paramegateuthis* Gustomessov 1960. This fauna ranges through the upper Bathonian (beginning with the *Arcticoceras kochi* zone) and the ?lower Callovian. The overlying Jurassic beds only yielded rare poorly preserved *Cylindroteuthis* (*Cylindroteuthis*) sp. and *Cylindroteuthis* (*Communicobelus*) sp. of ?North Siberian affinities.

4. Southern Richardson Mountains

West and southwest of the area surveyed in 1971 (Jeletzky, 1972b, pp. 2-9, Fig. 1) the pre-Albian Mesozoic rocks were found to be widespread to a north-south-trending line situated two to four miles east of the Rock River. No outcrops of the pre-Albian Mesozoics were seen either farther west or south of the latitude 66°50′ (appr.).

The most extensive section of Bug Creek and Husky (arenaceous facies) Formations was studied about 10 to 12 miles WSW of the 3956' summit of the ridge across which the principal Mesozoic section was measured in 1971 (Jeletzky, 1972b, pp. 3-9, Fig. 1). The former section was measured from east to west atop of the plateau between approximate longitudes 136°29'30"N. and 136°32'30"W. and 2 to 3 miles S of the bed of that nameless eastern confluent of Rock River falling into the latter at about 66°51'15"N. and 136°40'W. This synclinal outlier is surrounded by the Upper Devonian to ?Lower Mississippian flyschoid turbidites on all sides and exposes the following upward sequence on the eastern flank:

1. Bug Creek Formation consisting of the same two members as in the 1971 sections (Jeletzky, 1972b, p. 3). However, the at least (base covered) 140 to 150 feet thick Lower Member consists predominantly of fine grained, orthoquartzitic, non-carbonaceous to feebly carbonaceous, moderately well sorted and rounded sandstone. Interbeds of lithologically similar but strongly carbonaceous sandstone and dark grey, friable coaly siltstone containing poor plant remains and fossil wood are rare and do not exceed 3 feet in thickness. Interbeds of medium to coarse grained, locally gritty and fine pebbly sandstone are also rare and thin (from 2 inch to very rarely 3-foot). Only a few 1-4 inch thick, lenticular interbeds of fine to medium pebble conglomerate were seen.

This commonly intensively cross-bedded and ripple marked sandstone appears to be an alluvial to deltaic facies deposited seaward of the predominantly piedmont facies of the Lower Member characterizing its principal 1971 section (see Jeletzky, 1972b, p. 3).

The about 160 feet thick sandstone of the Upper Member differs from that of the principal 1971 section in being feebly to moderately (5-?15%, est.) glauconitic. It is rich in 2-6 inch bands of orange- to wine-red coloured, strongly ferruginous, often sideroliticaliy weathering, very fine grained sandstone and sandy siltstone ("clay ironstone") and appears to grade (contact covered) into the overlying Husky shale through a 50-60 feet (est.) zone where the sandstone is interbedded with several 2-5 foot beds of dark grey, non-carbonaceous siltstone. Some long ranging marine pelecypods (no Buchia seen) occur locally. The member appears to be of a beach to inner littoral origin in contrast to its nonmarine facies in the principal 1971 section.

2. Husky Formation begins with a very poorly exposed, about 300 feet thick (est.) Shale Member consisting of dull to dark grey, friable, flaky to powdery-weathering apparently unfossiliferous shale with some 3-6" clay ironstone concretions. This is overlain (contact covered) by an about 750 to 800 feet (est.) Sandstone Member consisting of orthoquartzitic feebly to moderately glauconitic sandstone lithologically similar to that of the Upper Member of the Bug Creek Formation but containing 3-6 inch thick pods and interbeds of medium to coarse grained sandstone and fine to coarse, pebbly grit consisting mainly of quartz clasts in the basal 100 feet. The sandstone is mostly laminated to thinly but often indistinctly and corrugatedly bedded, and commonly crossbedded to ripple marked; it contains a rich fauna of littoral marine pelecypods of

Buchia mosquensis (s. lato) zone at many levels, including the basal and topmost beds exposed, and must have been deposited in a fairly high energy, intertidal open sea environment. The Sandstone Member is overlain by an extremely poorly exposed apparently synclinally bent Shale-siltstone member with the estimated visible thickness of some 250 to 300 feet (top not reached). This Shale-siltstone member did not yield any fauna. Like the underlying Bug Creek Formation the Husky Formation of the here described section is a fined out and shaled out, basinward facies of the arenaceous facies of Husky Formation exposed in the principal 1971 section 10 to 12 miles to the east-northeast (see Jeletzky, 1972b, p. 4). Three to six miles north of the bed of the previously mentioned major eastern confluent of the Rock River occur several Mesozoic outliers where the above described basinward facies of the Bug and Husky Formations are overlain by the Lower sandstone, the Coal-bearing, the Upper shale-siltstone and the Upper sandstone divisions striking north-south and dipping moderately to gently westward. All these units are lithologically similar to those of the principal 1971 section (see Jeletzky, 1972b, pp. 5-8) measured 10 to 13 miles east-southeastward therefrom on the eastern limb of a major anticline.

Palaeogeographical and structural setting of pre-Albian Mesozoic rocks.

The pre-Albian Mesozoic rocks of above described outliers are gently to moderately folded along north-south-trending axes. The underlying late Devonian to early Mississippian flyschoid turbidites of the "Imperial Formation" are, in contrast, folded (somewhat more steeply) along west-trending axes. Both groups of rocks are moderately to strongly disturbed by north- to norheast-trending normal and ?strike-slip faults. The pre-Albian Mesozoic rocks are therefore only preserved as erosional outliers underlying the topographically higher parts of the divide-areas and isolated mesa-like hills separated from each other by larger areas of lower ground underlain by the "Imperial Formation".

The erosional remnants of the pre-Albian Mesozoic clastics rapidly thin out and then wedge out southward within the report-area, the oldest formation extending farthest southward. None were observed south of the Bug-Creek-Husky outlier described in this report and another Bug Creek-Husky outlier situated 1½ miles east of it (centered around a high mesa-like hill situated at 66°53'N and 136°28'W.). The complete absence of any shoreward facies changes toward the south combined with the presence of pronounced basinward facies changes of all pre-Albian Mesozoic formations towards the west (Jeletzky, 1972b, pp. 9a-9a and in the previous para.) indicates that their southern zero edge is an erosional feature only. The Southern Richardson Mountains and Eagle Plain apparently experienced a much stronger uplift during and immediately after the late Aptian orogeny than the more northerly areas of northern Yukon (Jeletzky, 1972a, pp. 539-540) which resulted in the apparently complete destruction of their pre-Albian Mesozoic cover south of latitude 66°50'N (except for the Upper Peel River outlier; see Jeletzky, 1972b, pp. 1-2, Fig. 1).

5. Upper Vittrekwa River

~~Abundant and~~ A well preserved fauna of *Buchia okensis* (Pavlow) s. str., including the giant forms of *B. o.* var. *canadiana* (Crickmay 1930), was found in place in a 8-9 inch thick lenticular clay ironstone band 17 to 17½ feet below top (a disconformity with the Glauconitic sandstone member) of the rust-weathering shale bed 37 of the type section of the North Branch Formation (see Jeletzky, 1967, p. 133). This bed is thus equivalent to the Red-weathering shale member of the Husky Formation of more northerly and westerly areas of northern Yukon (compare Jeletzky, 1961b, p. 30; 1967, pp. 30-31) and denotes the same earliest Cretaceous peak of the Husky time transgression (Jeletzky, 1963, pp. 81-82; 1967, p. 44).

The discovery of Buchia okensis fauna in the topmost part of the Sandstone-conglomerate member indicates that the Glauconitic sandstone member of the North Branch Formation is younger than any part of the Husky Formation and probably corresponds to the Buff sandstone member of the Lower sandstone division. However, only a few long ranging marine pelecypods have been found in the Glauconitic sandstone member in 1973.

NC6

Contrary to the previous ideas of the writer (Jeletzky, 1961a, pp. 539-540), the: "angular discordance of from 5 to 10 degrees between the Conglomeratic and the Grey Sandy Siltstone members of the Upper Sandstone division...." observed in several sections on upper Vittrekwa River below its confluence with the North Branch Creek actually occurs between the Upper Devonian to early Mississippian and latest Aptian rocks. The basal 300 feet (est.) of the outcrop in the about 450 feet high triangular-shaped bluff of the right (SE) bank of Vittrekwa River opposite to the mouth of the North Branch Creek was found to be built of rhytmically alternating, medium to thick bedded (6 inch to 2 foot) argillite, greywacke and pebble conglomerate. All rock varieties including the conglomerate are graded. The basal contacts of greywacke beds are sharp, uneven and exhibit numerous load casts, flute casts and scratch marks diagnostic of their deposition by turbidity currents. Some Sigillaria- or Lepidodendron-like plant remains (field identifications of the writer) of the early Mississippian age have been found in the fresh, locally derived float at bluff's base. The Grey sandy silstone member and the Albian shale-siltstone division overlies these turbidites unconformably in this section and for several miles farther downstream in the banks of Vittrekwa River until the latter plunge beneath the water's level. The true Conglomeratic member of the Upper sandstone division exposed south and west of the here discussed section in the banks of North Branch Creek and the upper Vittrekwa River proper is absent in these downstream sections either by non-deposition or by a late upper Aptian erosion. The juxtaposition of this Conglomeratic member with the lithologically similar Early Mississippian turbidites is caused by a previously unrecognized principal (in the sense of Jeletzky, 1961a, p. 545) north-northwest trending ?normal or ?strike-slip fault with the relatively downthrown western side. This fault underlies the bed of the straight, north-northwest-trending bend of Vittrekwa River immediately upstream of its confluence with the North Branch Creek.

6. Northern part of Bell Basin

The previously little known Jurassic to Aptian rocks of that part of Bell Basin confined between the Waters River in the west, 67°35' latitude in the south, longitude 136°30' in the east, and 67°50' latitude in the north were studied in considerable detail to elucidate their stratigraphy, facies pattern and depositional tectonics within this key area.

Kingak shale was only observed in a few discontinuous poorly exposed sections in the headwaters of Waters River and in those of its left confluents west of longitude 137°05'. So far as it is possible to judge, the lithology and thickness of Kingak shale of this part of the area is similar to that of the sections situated farther west in the headwaters of Berry Creek (Jeletzky, 1972b, pp. 37-38). No Kingak shale sections transitional to those of the silty mid-basin facies of Bug Creek Formation observed between Summit Lake and the confluence of Bell and Little Bell Rivers (see below) were found in the intervening part of the area and the detailed facies and age relationships of the two require additional study.

Bug Creek Formation of the area confined between Summit Lake and the mouth of Little Bell River is represented by a mid-basin facies which differs from that characteristic of the Horn Lake-McDougall Pass and eastern White Mountains areas (Jeletzky, 1967 , pp. 24-25) in a greater thickness (at least 2,000 feet), prevalence of argillaceous rocks and restriction of arenaceous rocks to the relatively thin basal and topmost beds. The most complete, typical section studied is situated 2½ to 3 miles south of the western end of Summit Lake (at approx. 67°30'N Lat.; and 136°30'W. Long.) and consists of (descending sequence):

Upper sandstone member consisting of 300 to 350 feet (appr.) of light grey to light brownish grey, very fine grained to fine grained, moderately well rounded (subrounded to subangular grains prevail) and sorted, quartzose to orthoquartzitic, mostly non-carbonaceous to slightly carbonaceous sandstone with little or no interbeds and pods of ferruginous sandstone. This hard, ridge-forming sandstone is hard and commonly quartzite-like to true quartzite, massive to heavily bedded and forms sheer bluffs 150 to 180 feet high; several 5-15 foot-thick interbeds of thinly to medium but indistinctly and corrugatedly-bedded, partly ferruginous, carbonaceous to coaly, very fine grained sandstone rich in 1-3 inch long and 1/4 - 1/2 inch thick irregularly bent coaly inclusions some of which are subvertical and resemble rootlets of plants occur at irregular intervals including the basal 5 to 6 feet exposed; crossbedding and ripple marks were but rarely seen; very rare generically indeterminate ?cadoceratid ammonites and Inoceramus fragments (field identifications of the writer) occur in on the scree of the lower 60-70 feet of the unit and suggests its Bathonian or Callovian age; grades upwards into the Basal tongue of Husky Formation; lower contact covered or very poorly exposed but is believed to be abrupt and uneven (?erosional) because of the presence of fine scattered chert pebbles in the uppermost exposed beds of the Intermediate siltstone member.

The Upper sandstone member appears to correspond to the Upper sandstone member of eastern Richardson Mountains (Jeletzky, 1967 , p. 14) and to represent the ~~time~~ "moment" of the maximum regression of the Bug Creek time when the littoral to lagoonal regime briefly extended into the mid-basin zone including the Summit Lake-Little Bell area and that of the eastern flank of White Mountains.

Intermediate siltstone member consisting of siltstone dark grey, dull to ash-grey, fine rubbly to flaky and recessively weathering, friable; the siltstone is micaceous and varies from fairly sandy (mostly in basal 100 and uppermost 700 feet) to almost pure; it contains some rows of 3-10 inch rounded to angular concretions of very hard, blue-grey, bright orange to wine-red weathering, ferruginous siltstone ("clay ironstone"); sandy varieties are commonly bioturbated, with rare to common worm burrows; they may be locally crossbedded on a small scale; lower contact covered but believed to be gradational; no fossils seen; thickness 1400' (appr.).

Lower sandstone member consisting of quartzose sandstones similar to those of the Upper sandstone member but containing up to 10 per cent of limonite grains and the same amount of dark mineral (?chert) grains, numerous 4-10 inch bands and rows of 1/2 - 4-foot thick and up to 15-foot-long pods and lenses of hard to very hard, dull grey, intensively orange to wine-red weathering ferruginous sandstone and sandy siltstone ("clay ironstone"); no carbonaceous to coaly interbeds seen; Inoceramus (Retroceramus) cf. menneri Koshelkina, very rare and poorly preserved fragments of ?Cranocephalites-like cadoceratid ammonites and various long-ranging pelecypods (field identifications of the writer) occur in the lowermost 60 feet exposed; base covered and the unit appears to be faulted against the Upper tongue of Husky Formation; visible 270 feet but other short and poorly exposed sections suggest that the complete thickness of the unit is about 300 feet and that it overlies paraconformably the lithologically similar Permian sandstones. The Lower sandstone unit of the report-area appears to be equivalent to the Intermediate sandstone member of the eastern Richardson Mountains (Jeletzky, 1967 , pp. 15, 25, Figs. 1-2) and to be a deposit of an early Middle Jurassic (?mid-Bajocian) transgression on the crest of the Aklavik Arch following a late Lower to earliest Middle Jurassic phase of its flexing, uplift and erosion.

Unnamed Upper Jurassic sandstone exhibits pronounced eastward shaling and thinning out consistent with its inferred derivation from a western source area (Jeletzky, 1972b, pp. 9a-9c; 1971 , pp. 205, 211-213, Fig. 2).

In the westernmost section studied situated on the crest and southwestern shoulder of the 4,409' summit of 1:250,000 topo map (appr. 137°06' - 137°07' W. Long. and 67°38'30" to 67°30'45" N. Lat.) the thickness of the unit is about 1,635 feet and only includes rocks of the ?mid-Callovian to late Kimmeridgian or lower Portlandian (*Buchia mosquensis* s. lato zone) age. In contrast, the Unnamed Upper Jurassic sandstone is 2,000+ to ?4,000 feet thick (top not reached) and includes beds of ?early Callovian to at least early upper Tithonian (*Buchia fischeriana* zone) age westward and southwestward of this section (see Jeletzky, 1972b, pp. 39-41; 1971 , pp. 211, 213, Figs. 2, 3). The post-lower Portlandian beds of these Porcupine River and Berry Creek sections are replaced laterally by the predominantly argillaceous rocks of the Husky Formation in the here discussed northern part of Bell Basin (see below).

The section measured on the 4,409' summit is divisible into an about 650 feet thick ?mid-Callovian to upper Oxfordian Lower Member consisting of mostly hard and ridge-forming light to dark grey predominantly carbonaceous to coaly, fine to very fine grained, quartzose to polymictic sandstones with minor interbeds of black carbonaceous to coaly, sandy to very sandy siltstone. These ~~commonly~~ predominantly lagoonal to ~~paludal~~ deltaic sandstones are estimated to include 25 to 30 per cent of inner littoral (including supratidal) deposits characterized by a rich fauna of marine pelecypods. These littoral interbeds increase upwards until they become prevalent. This defines the base of the exclusively marine, about 985 feet thick Upper Member. The sandstones of this member are mostly buff, light orange, or rust-coloured, ferruginous, fine to very fine grained, quartzose to orthoquartzitic,non-carbonaceous and thinly bedded to laminated. They contain numerous 3 to 18 inch interbeds of pelecypod coquina and are commonly intensively crossbedded and ripple marked with the foreset beds ~~and were~~ usually inclined eastward at 5 to 15 degrees. The variegated invertebrate fauna consists mostly of marine (no brackish water types were seen) pelecypods diagnostic of the upper (?early Kimmeridgian) part of Buchia (Anaucella) concentrica zone and most or ?all of Buchia mosquensis (s. lato) zone. This fauna includes some poor ammonites, belemnites, starfish and brittle starfish indicating its littoral to ?inner neritic, stenohaline (i.e. open shelf) depositional environment. The Upper Member includes some 5 to 60 feet thick interbeds of dark grey, non-carbonaceous, sandy to pure siltstone with clay ironstone concretions comprising about 12 per cent of its thickness. The member grades upwards into the Husky Formation.

Another section of the Unnamed Upper Jurassic sandstone measured east of the second eastern confluent of Waters River (approx. at 137°01'W. Long. and 67°39'30" to 67°40'N. Lat.) differs from the above described section in the Upper Member including only rocks of Buchia (Anaucella) concentrica (s. lato) zone [with a possible addition of the basal beds (mid-Kimmeridgian) of Buchia mosquensis (s. lato) zone] and including at least 20 per cent of 5 to 70 feet thick interbeds of dark grey, non-carbonaceous siltstone with clay ironstone concretions. The upper part of the member containg the bulk of Buchia mosquensis (s. lato) zone is evidently replaced laterally by the basal siltstones of the

Upper tongue of the Husky Formation between the two sections concerned.

The Unnamed Upper Jurassic sandstone almost entirely shales out between the ~~latitude~~ longitude of 137°00' and the confluence of Bell and Little Bell Rivers. This is indicated by the following section roughly measured (mostly paced) across the northern shoulder of an about 2,500 feet high butte-like mountain overlooking Little Bell River from the south at the point $3\frac{1}{4}$ miles SW of the western end of Summit Lake (downward sequence):

Husky Formation (Upper Tongue)

1. Siltstone, jet-black, mostly pure, micaceous, friable, weathers recessively and flaky to fine rubbly; some rounded, 1-2-foot concretions of hard, bright orange weathering clay ironstone; top not reached in the syncline's axis atop of the butte; no fossils seen in this section but Buchia mosquensis (s. latc) fauna was found in the basal 20 feet of the unit in an adjacent section; lower contact gradational; visible 150' (est.).
2. Siltstone, jet-black to dark-brownish grey, slightly to markedly sandy for the most part otherwise as in unit 1; contains a considerable number of dull grey to brown-grey, sandy to very sandy, moderately hard siltstone increasing downward in the section; regular attitude 330°/17°E; locally strongly bioturbated and rich in work burrows; no fossils seen; lower contact gradational; thickness 135' (appr.).
3. Siltstone similar to more sandy varieties of unit 2 except for being hard and weathering-resistant; forms a 40-foot high precipitous bluff; no fossils seen; thickness 50' (est.).
4. Siltstone much as in unit 1 but with some shale interbeds and poor in clay ironstone concretions; no fossils seen; attitude as in unit 2 except near the base where the dips steepen rapidly to 50-60°N; lower contact gradational; thickness 700' (est.).

Unnamed Upper Jurassic Sandstone (Tongue of)

5. Sandstone, brownish-grey to dull grey, weathers dull brown to light brown or light grey, very fine grained, silty but fairly quartzose, hard and dense but not quartzite-like and with some visible porosity; thin bedded to laminated and commonly crossbedded on a small scale; locally ripple-marked; no fossils seen; attitude as in basal beds of unit 4; lower contact gradational; thickness 40' (est.)
6. Siltstone as in unit 2; no fossils seen; attitude as last; thickness 90' (appr.)
7. Sandstone as in unit 5 but with some 6 - 18 inch interbeds of coquinoid, intensively ripple-marked sandstone containing a rich shallow water pelecypod fauna of the lower part (?late Oxfordian) of Buchia concentrica zone; general attitude 210°-220°/± 90° and mostly strongly disturbed; lower contact gradational; thickness 12' (appr.)
8. Siltstone, as in units 2 and 6; attitude as last and equally strongly disturbed; no fossils seen; lower contact gradational; thickness 100' (appr.)
9. Sandstone, as in units 5 and 7; attitudes as last; rich shallow water pelecypod fauna including early forms of Buchia concentrica (Sowerby) occurs in the topmost 2-3 feet represented by a coquinoid sandstone; some similar coquinoid interbeds occur farther down; lower contact gradational; thickness 60' (appr.)

Husky Formation (Basal Tongue)

10. Siltstone as in unit 1; no fossils seen; attitude as last; grades downward into the Uppermost sandstone member of Bug Creek Formation; thickness 300' (appr.)

This section duplicates that previously described on the eastern flank of White Mountains (Jeletzky, 1972b, pp. 18–20) and indicates that the bulk of the Unnamed Upper Jurassic sandstone as developed in the Keele Range-Berry Creek-Waters River area is replaced laterally eastward by argillaceous rocks of the Husky Formation across the Bell Basin.

Husky Formation exhibit pronounced facies changes which are the reverse of those exhibited by the Unnamed Upper Jurassic sandstone. Namely it thins out and sands out westward as the latter sandstone thickens out in the same direction.

In the previously mentioned section measured east of the second confluent the Husky Formation is at least 1,200 feet thick (contact with the underlying at least 800 feet thick Unnamed Upper Jurassic sandstone is faulted), comprises rocks ranging from the ?middle part (?late Kimmeridgian) of *Buchia mosquensis* (s. lato) zone, and includes only one approximately 100 feet thick member of marine fine to very fine grained, quartzose, intensively ripple-marked and crossbedded sandstone. Moreover the about 700 feet thick black siltstone comprising the upper part of the Husky Formation in this section and believed to represent *Buchia fischeriana* to *Buchia okensis* s. str. zones is predominatly pure.

In the previously mentioned section measured across the southwestern shoulder of the 4,409' summit the Husky Formation becomes farther reduced. There it is only 760 feet thick, restricted to the mid-Portlandian (*Buchia piochii* zone) to latest Jurassic (*Buchia terebratuloides*-*Buchia* aff. *okensis* zone) or ?basal Cretaceous (?*Buchia okensis* s. str. zone) rocks and does not include any shale. However, it includes a number of 3–10 foot interbeds and two respectively 25 and 45-foot members of sandstone in the 435 feet thick upper part approximately corresponding to the 710 feet interval of mostly pure siltstone of the previously described section measured east of the second eastern confluent of Waters River. These non-carbonaceous to carbonaceous sandstones are lithologically identical to those of the underlying Unnamed Upper Jurassic sandstone. They comprise at least 25 per cent of the thickness of the upper part of the formation in the 4,409' section and evidently represent but the eastward pinching out wedges of the geologically contemporary uppermost part of the Unnamed Upper Jurassic sandstone of the Keele Range-Berry Creek area (see in the previous section). It is believed that the Husky argillites were completely replaced laterally by the arenites of the Unnamed Upper Jurassic sandstone unit in the Keele Range-Berry Creek sections even though this cannot yet be verified because of the incompleteness of all sections known (see Jeletzky, 1972b, pp. 38-41; 1971, pp. 205, 211-213, Fig. 2). It is postulated that in this area, which was situated at the eastern shoreline of the Upper Jurassic Keele-Old Crow Land (Jeletzky, 1972b, Fig. 1; 1971, Fig. 1; this report Fig. 1) the Unnamed Upper Jurassic sandstone unit ~~probably~~ merged imperceptibly in the littoral to nonmarine facies of the western equivalent of the Lower sandstone division.

The above data indicate that the Husky Formation of the Bell Basin is an almost entirely to entirely argillaceous eastern mid-basin facies of the Unnamed Upper Jurassic sandstone.

Lower sandstone division is widespread in the area but its thickness and lithology vary greatly from one section to another because of the lateral facies changes and the effects of the subsequent mid- to late Hauterivian uplift.

In most of the sections studied between the middle course of Waters River in the west and that of Bell River in the east the division is subdivisible into two lithological members.

In two best exposed sections measured on the eastern side of the second eastern confluent of Waters River at approximately 137° 01' W long. and 67° 40' N lat. and on the western side of Bell River at approx. 136° 52' W long. and 67° 48' lat. (3 miles west of the adjacent part of the river's bed). the Lower member is between 400 and 425 feet thick and lithologically similar to the restricted Lower sandstone division of the western headwaters of Bell River (Jeletzky, 1961b, pp. 28-29) and the eastern headwaters of Berry Creek (Jeletzky 1972b, pp. 41-42) with which it is geologically contemporary (all three units contain Buchia volgensis Jeletzky 1964 non Lahusen 1888 fauna throughout most or all of their thickness) and resumably contiguous. The Lower member of this part of northern Bell Basin represents, however, an offshore (presumably mid-basin) facies of the late Berriasian Sea as compared with that of the other two areas mentioned. The Lower member consists predominantly of a cyclical alternation of very fine grained, quartzose to orthoquartzite, commonly carbonaceous mostly quartzite-like to true quartzite, hard to very hard, ridge-forming sandstone in beds 1 to 5-foot thick with black to dark grey, sandy to pure, friable siltstone in beds 2 to 10 feet thick. The member is crowned by a 35 to 70 feet thick unit of such siltstone. Only one to a few 50 to 70 feet thick units of above described hard sandstone comprising considerably less than 50 per cent of the member's thickness occur in this facies of the Lower member.

Buchia volgensis Jeletzky 1964 non Lahusen 1888 occurs throughout the thickness of the Lower member. In the sandstone interbeds and members they form layers of single shells and 1-4 inch interbeds of coquinoid sandstone at irregular intervals; other pelecypods are rare or absent; the fossils occur invariably as single, often fragmentary single valves oriented along the bedding planes with the convex side upward. This indicates deposition of the sandstones in a fairly high energy inner neritic to outer littoral environment; the almost unfossiliferous siltstones were presumably deposited in a deeper and quieter, outer neritic environment.

The Upper member is from 85 to 100 feet thick in the two previously mentioned, best exposed sections and appears to be comparably thick elsewhere. The sandstone comprising the basal 20 to 40 feet of the member is usually cream to dirty white when fresh, weathers white with rusty specks and spots; mostly fine grained but with some interbeds of medium grained sandstone, predominantly quartzose to orthoquartzitic but with a 5-10 per cent (estim.) of orange limonite grains (probably deeply weathered glauconite) and some chert and feldspar grains; mostly non-carbonaceous; grains predominantly subrounded to well rounded and moderately to well rounded according to the size; hard and moderately dense but mostly not quartzite-like (some visible interstitial porosity); generally massive to heavily (1-3-foot) and indistinctly bedded, weathering-resistant and forms sharp crested ridges; locally crossbedded and with large scale (1 to 3 foot across) ripple marks; no fossils seen; lower contact poorly exposed but appears to be abrupt. This beach to lagoonal unit grades upward into 65 to 80 foot thick unit of sandstone, light grey to mottled dull grey and cream, weathering dirty white or rust-coloured; mostly fine to medium grained in the lower part, but including considerable but laterally variable layers, 1-5 foot interbeds, lenses and pods of medium to coarse grained, fine to coarse gritty and pebbly sandstone, grit, and fine to medium (1/8 to 2 inch pebbles predominate but larger pebbles occur also) pebble conglomerate; sandstone is mostly quartzose but includes 10-15 per cent (est.) of dark mineral (? coaly or/and ? black chert grains); 2-5 per cent (est.) of kaolinized feldspar or ? white chert grains and some (up to 10%) lithic fragments; sandstone appears to lack glauconite or limonite grains; ~~sandstone~~ is characteristically fairly to poorly rounded (subrounded to subangular grains predominate), and poorly sorted according to the size; pebbles and grit particles are predominantly poorly rounded to angular and consist largely of black to white chert with less abundant pebbles of black to light brown shale and grey, fine grained, quartzose to polymictic sandstone probably derived from the underlying Unnamed Upper Jurassic sandstone or Husky Formation; some flattened clay balls of orange to rust-coloured, ferruginous clay occur also; up to 5 foot thick interbeds of bluish grey, carbonaceous to coaly siltstone with ½ to 1 inch thick and up to 4 foot long pods and stringers of shiny pure coal and poor plant remains occur locally in the upper 20 to 25 feet of the unit (especially in the section situated at 136° 52' W long. and 67° 48' N lat.); interbeds of fine grained sandstone usually laminated with sharply delineated black carbonaceous to coaly lamellae alternating with light grey, non-to feebly carbonaceous ones; locally crossbedded and ripple marked with foreset beds inclined toward SW and S (? a northwestern source area); the topmost 5-15 feet of the unit are characteristically enriched in grit and pebble conglomerate interbeds and may locally be represented largely or entirely by these coarse clastics; the contact with the overlying Upper shale-siltstone division is abrupt and uneven.

Because of the gradational superposition on the reliably dated lower member and the lithological similarity with the mid- to late Valanginian White sandstone member of Eastern Richardson Mountains (Jeletzky, 1958, pp. 7-8; 1960, pp. 5-6) the Upper member, is correlative with the latter unit. Like White sandstone member, the Upper member appears to represent a largely to entirely non-marine eastern facies of the Blue-grey shale division of northwestern Richardson Mountains (Jeletzky, 1961b, pp. 13-14, Fig. 1) and of its siltstone equivalents in the eastern Keele Range (Section 1 of this report). Because of the abrupt and uneven, apparently erosional contact with the overlying Upper shale-siltstone division, the predominantly coarse clastic (piedmont) lithology of the uppermost beds and other data presented in the next section it is highly unlikely that the Upper member includes any equivalents of the Coal-bearing division of the Eastern Richardson Mountains (see Jeletzky, 1960, pp. 7-9; 1972b, pp. 6-7, 12-15) or the White and Coaly Quartzite divisions of western Richardson Mountains (Jeletzky, 1961b, pp. 14-18) and Porcupine Plateau (Jeletzky, 1972b, pp. 63-66; Section 1 of this report).

The westernmost section studied situated on the southwestern spur of the 4,409 foot summit (see Bell River sheet of 1:250,000 topo map)

approximately at 137° 07' W. long. and 67° 30' 45" N. lat. is exceptional in exposing about 135 feet of apparently nonfossiliferous sandstone, dark to dull grey or mottled grey when fresh, weathering mottled brown to dull orange or intensively rust-coloured, as a rule fine grained; quartzose to orthoquartzitic and mostly with only 2 to 5 per cent (est.) of dark mineral (? chert); carbonaceous to coaly (est. 5-20 per cent of coaly grains) and with a considerable number of coaly specks and spots in lower 55 to 60 feet; higher up mostly non-carbonaceous to slightly carbonaceous; grains mostly subrounded to subangular and fairly well sorted as to the size; heavily and indistinctly bedded (1-5-foot) and weathers large blocky to thick slabby; medium hard and dense but with a fair interstitial porosity; ridge-forming. This sandstone is referable to the Lower sandstone division because of its stratigraphic position between the arenaceous facies of Husky Formation carrying _Buchia_ ex gr. _terebratuloides_ (Lahusen) in its upper but not the uppermost part and the lithologically typical lower part of the Upper shale-siltstone division. It could be interpreted as the relatively thin western shoreline facies of the above described entirely marine, largely argillaceous facies of the Lower member of the division outcropping farther east. However, the relatively attenuated nature of the sandstone unit of the here discussed section is even better compatible with its representing the basal part of the Lower member (consisting of 55 to 70 feet of similar sandstone in adjacent sections) truncated by the early to late Hauterivian erosion (_see_ in next section). The apparent absence of marine fossils
8 may well be an accidental feature only.

The easternmost section of Lower sandstone division studied situated about 6½ miles SSE of the confluence of Bell and Little Bell rivers (approximately at 136° 33' 45" W long.; and 67° 39' 30" N lat.; see Figure 5) is also exceptional. This section is rather thin (about 125 feet) and is represented almost exclusively by
9 unfossiliferous, apparently alluvial to (?deltaic) sandstones, grits and fine pebble conglomerates closely similar lithologically to the non-marine facies of Lower sandstone division exposed on the Upper Treeless Creek and in the

adjacent parts of the eastern slope of Richardson Mountains (Jeletzky, 1960, p. 6). These arenaceous to rudaceous clastics overlie gradationally the sandy siltstone of the Upper Husky Formation and are overlain apparently disconformably by the high marine siltstone of the Upper shale-siltstone division. Therefore, they appear to be correlative with the basal beds of the Lower member of the previously described more westerly section of the division. Its younger beds are believed to be absent by nondeposition for reasons presented in the next section.

White and Coaly quartzite divisions were not found within the investigated part of northern Bell Basin (Figures 1, 2) in spite of their widespread occurrence to the north (Jeletzky 1972a, pp. 207-208), and northwest (Jeletzky 1961b, 14-18; 1972b, p. 43), of the area. The same is true of the approximately equivalent Coal-bearing division of northeastern and southern Richardson Mountains (Jeletzky, 1960, pp. 7-10; 1972b, pp. 7-9; 23-25) and the equivalent lower part of the Mid-Lower Cretaceous siltstone-sandstone division of the eastern Keele Range (Jeletzky, 1972b, pp. 63-66). For reasons explained in the preceding and the ~~next~~ following sections, these units appear to be absent by nondeposition rather than by a subsequent erosion.

Paleogeographical and structural setting in the mid-Valanginian to mid-Hauterivian time. The above described upward replacement of the mostly high marine sandstones and siltstones of the Lower member of the Lower sandstone division by the carbonaceous to coaly, commonly gritty to conglomeratic, nonmarine clastics
10 heralds the onset of the Mid-Valanginian orogenic phase previously recorded by Jeletzky (1961a, pp. 537-539) on the eastern flank of Richardson Mountains. The uplift apparently was spreading gradually westward judging by the previously mentioned lateral westward replacement of the alluvial to (deltaic) facies of the Lower member by high marine sandstones and siltstones. The gritty to conglomeratic (lithology) of the Lower member in the easternmost part of the area and the apparent absence of the Upper member there support this conclusion.

The above discussed upward and westward facies changes of the Lower sandstone division indicate that the northern Bell Basin was situated on the southwestern continuation of the crestal zone of the mid-Valanginian to mid-Hauterivian Aklavik Arch originally defined by Jeletzky (1961a, pp. 537-539, Figures 1, 22) on the eastern flank of Richardson Mountains. The uplifted crestal zone of the arch is now known to extend through the Central and Western Richardson Mountains at least to the middle course of the Waters River. It is believed to have extended yet farther west into the northeastern Keele Range, even though this cannot be demonstrated because of the apparent absence of early to mid-Lower Cretaceous rocks in the deeply eroded area between the Waters River and Lord Creek.

The localisation of the southwestern extension of the crestal part of the mid-Valanginian to mid-Hauterivian Aklavik Arch in the northern part of Bell Basin well to the north of its previously suggested position (see Jeletzky, 1961a, p. 539, Figure 22) suggests that its Aklavik Range culmination was still contiguous with the contemporary Lord Creek culmination of the arch. The Cretaceous right hand separation of these two segments of the arch suggested by Jeletzky (1961a, Figure 22; 1963, p. 66) apparently occurred in the post mid-Hauterivian time.

The previously described gradual upward coarsening of the nonmarine clastics of the Lower sandstone division culminates in the prevalence of poorly rounded to angular grit and pebble conglomeratic (a piedmont facies) followed by an early to mid-Hauterivian (time of the coal-bearing, White quartzite, and coaly quartzite divisions) hiatus. This facies trend and the unconformable overlap of the Lower sandstone division (see earlier in this section and in section 8) by the late Hauterivian siltstone of the Upper shale-siltstone division strongly suggest that neither marine nor nonmarine equivalents of the coal-bearing division of northeastern and southern Richardson Mountains or of the White and Coaly quartzite divisions of northwestern Richardson Mountains were ever deposited within the northern Bell Basin. This area extending at least from the Summit Lake area in the east to the valley of Waters River in the west must have been an elevated source area in the early to mid-Hauterivian time providing sediment [for the above] mentioned clastic units situated to the north and to the south of it (Figure 2).

Unlike the northeastern Richardson Mountains (Jeletzky, 1961a, p. 538) where the effects of the mid-Valanginian orogenic phase ceased to be apparent by the end of the Valanginian (i.e. end of the time of White sandstone member), this phase must have continued through the early to mid-Hauterivian
12 (and probably into the early upper Hauterivian) and peaked up sometimes during this time in the northern Bell Basin. These structural conditions apparently prevailed also on the eastern slope of White Mountains (see Figure 2 and in Section 8), where the partly arenaceous facies of the Upper shale-siltstone
13 division overlaps disconformably (and probably unconformably) the deeply eroded surface of the Husky Formation, and possibly yet farther north in the headwaters of Cache Creek and Fish Rivers. This appears to be yet another example of the
14 well known phenomenon of a "temporal migration" of orogenic phases along and across the structural grain of tectonically active belts.

The presence of ~~/~~ marine equivalents of the White and Coaly quartzite divisions to the west of their typical nonmarine facies in northwestern Richardson Mountains and eastern Keele Range (Jeletzky, 1972b, pp. 30-33, 63-66) and the previously discussed general east-west ~~trend~~ [changes] of the ~~early to mid-Hauterivian~~ [Valanginian] facies across the northern Bell Basin seem to favour the presence of a narrow marine [early to mid-Hauterivian] strait separating the Bell Basin Peninsula of Peel Landmass from the adjacent parts of Keele-Old Crow Landmass as indicated in Figure 2. It is also possible, however, that the crestal zone of the Aklavik Arch was elevated above sea level right across this interval and that only nonmarine clastics of the White and Coaly quartzite divisions were deposited in the area around the confluence of Driftwood and Porcupine ~~R~~[r]ivers (Figure 2). If so, the Jurassic to mid-Lower Cretaceous Porcupine Plain-Richardson Mountain Trough was geologically speaking briefly split up into a northern and a southern embayment by an isthmus in the early to mid-Hauterivian time.

Upper shale-siltstone division was found to be widespread in northern Bell Basin where a generally west-east-trending belt of its outcrops extends at least from the point west of Waters River Valley situated at about 67°30'N. Lat. and 137° 15' W. Long. to that on the western side of Bell River at about the latitude 67°34'N. West of the former point the division apparently is cut out by a major northeast-trending fault which brings the Albian shales against the Unnamed Upper Jurassic sandstone. East of Bell River extensive outcrops of the division are centered around the point situated at 67°35'N. Lat. and 136°32' W. Long. These outcrops appear to be contiguous with those on the eastern side of Bell River. South of the 67°35'N. Lat. and 136°32' W. Long. section (see Figure 5) the division appears to outcrop more or less uninterruptedly in a north-south-trending belt all the way to its "Pacific Rat River" sections ~~situated~~ described by Jeletzky (1972b, p. 15).

About 4,200 feet of argillaceous rocks of the Upper shale-siltstone division have been measured in the best known (principal), completely exposed but locally faulted section situated on the divide next east of the second eastern confluent of Waters River approximately at 137°00' W. Long. and between 67°39'10" and 67°38'15" N. Lat. This thickness is believed to approximate closely the true thickness of the division which appears to fluctuate between 3,500 and 4,200 feet everywhere between the westernmost known exposures west of Waters River and those on the western side of Bell River. This unusually thick western facies of the Upper shale-siltstone division appears to be subdivisible into two lithological members. The Lower member, which is about 1750 feet thick in the above mentioned principal section, consists of siltstone extremely monotonous, black to dark grey, dull to dark-bluish grey-weathering, massive to indistinctly and conchoidally bedded, friable to moderately hard, fine rubbly to flaky and recessively weathering, feebly sandy to pure, mostly micromicaceous. This siltstone is devoid of large concretions and bands of rust-weathering clay ironstone which are so abundant in the mostly ferruginous shale and siltstone of the equivalent Lower member of the division on the eastern flank of Richardson Mountains (Jeletzky, 1958, pp. 10, 56-65; 1960, pp. 11-12). It carries instead some distinctive spindle to sausage-like,

½ to 4 inch long and up to 1 inch thick concretions of hard black siltstone and rare flat (discus-like to angular), 3 to 10 inch concretions of bright orange-weathering ferruginous siltstone ("clay ironstone"). Except for its feebly sandy to pure lithology and prevalence of dark grey to bluish colours, the siltstone of the Lower member resembles closely that of the correlative Dark-grey siltstone division of the divide area between the headwaters of Bell and Driftwood Rivers (Jeletzky, 1961b, pp. 19, 33). The latter is now considered unreservedly to represent the more arenaceous, presumably shoreward phase of the here discussed siltstone facies of the Lower member of the Upper shale-siltstone division. The Lower member is extremely poor in fossils. Only a few Lima (Limatula) ex gr. consobrina d'Orbigny, generically indeterminate nuculid pelecypods and Dentalium-like shells have been found in it. The extreme rarity of pelecypods and the total absence of belemnites indicate that the member was deposited in an outer neritic (150 feet or deeper) or ? upper bathyal environment.

Although the lower contact of the division is uneven, sharp and obviously erosional in all appropriately exposed sections, no basal conglomerate or accumulation of arenaceous to gritty particles was observed immediately above it. This indicates a rapid, regional subsidence of the previously strongly elevated (see in the preceding two sections) area of northern Bell Basin.

The Upper member, which is about 2,365 feet thick in the above mentioned principal section, is represented by a generally cyclical alternation of 50 to 600 feet thick units of variegated siltstones including:

1. Siltstone lithologically identical with that of the Lower member;
2. Siltstone dull to dark grey weathers light grey and mottled, moderately sandy, moderately hard and weathering-resistant, forms precipitous bluffs and sharp ridges; massive to indistinctly bedded and mostly replete with ramifying to straight worm burrows 1/16 to ½ inch in diameter, and sometimes segmented (Nereis-like); this strongly bioturbated siltstone contains some calcareous Dentalium-like tubes at several levels;

3. Siltstone, black to dark grey, weathering dark brown to rust coloured, most pure, contains common to abundant clay ironstone concretions and bands, friable, weathers flaky and recessively; and

4. Siltstone, dark brownish grey to dark grey, weathers same but in alternating sharply delimited brown and grey lamellae and thin beds; pure to very sandy, ferruginous, micromicaceous; distinctly graded and crossbedded on a small scale within thin to very thin (¼ to 4 inches) recurrent beds which may exhibit fairly typical Bouma sequences; the very sandy basal parts of succeeding beds are commonly sharply and apparently erosionally delimited from the uppermost parts of preceding beds consisting of pure to feebly sandy siltstone. This distinctly flyschoid siltstone appears to be a deep water (? upper bathyal) turbidite deposited by feeble to ? moderate turbidity currents. It is prevalent in the upper part of the member comprising the bulk of its uppermost 700 to 750 feet (see Figure 3). Rare up to 15 feet interbeds of poorly sorted and rounded, lithic (greywacke-like), fine to medium grained, gritty and fine pebbly, unfossiliferous sandstone and rare 50 to 150 feet thick units of black, pure, friable shale with or without clay ironstone concretions and bands occur in the Upper member. Contact with the overlying Upper sandstone division is gradational.

No diagnostic fossils were found in the western, presumably deep water (mid-basin) facies of the Upper shale-siltstone division. However, its equivalence with the reliably dated, more shallow water (inner to ? outer neritic) facies of the division exposed on the eastern flank of Richardson Mountains (Jeletzky, 1958, pp. 11-15; 1960, p. 13) is indicated by its stratigraphic position between the reliably dated rocks of the Lower sandstone and Upper sandstone divisions.

The only section of the Upper shale-siltstone division studied but not measured east of Bell River at the point 6½ miles south-southeast of the confluence of Bell and Little Bell rivers (Figure 5), represents a different facies lithologically similar to and comparably thick (800 to 1,000 feet; estim.) with that encountered in sections previously measured on the "Pacific Rat River" and in the eastern headwaters of Rock River (Jeletzky, 1972b, pp. 7-8, 15).

The above described much thicker western facies of the Upper shale-siltstone division is believed to thin out rapidly east of Bell River because of a relative scarcity of the sediment derived from western and eastern source areas in the mid-basin to the deeper eastern shelf zones of the trough.

Like the western facies, the eastern facies of the division did not yield any diagnostic fossils in the northern Bell Basin and is identified on the lithology and stratigraphic position alone.

Upper sandstone division outcrops in exactly the same parts of the northern Bell Basin as does the Upper shale-siltstone division (see there). It forms sharp to rounded ridges flanking broad valleys and depressions underlain by the Upper shale-siltstone division.

The lateral facies changes of the Upper sandstone division are closely similar to those of the Upper shale-siltstone division, it being thick (at least 2,367 feet in the above mentioned principal section), containing more siltstone than sandstone, and predominantly argillaceous west of Bell River but becoming relatively thin (400 to 500 feet; est.) and predominantly arenaceous east and southeast therefrom.

The thick and silty western facies of the division can be subdivided into two lithological members. The Lower member is estimated to be between 850 and 900 feet thick in all sections studied. It is about 865 feet thick in the longest and best exposed section of this facies measured on the divide east of the second eastern confluent of Waters River approximately between 137°00' and 136°58' W. Long. and between 67°38'15" and 67°37'30" N. Lat. This section represents a continuation of the previously mentioned principal section of the western facies of Upper shale-siltstone division and is herewith designated the principal section of the western facies of Upper sandstone division.

The Lower member consists of a cyclical interbedding of 10 to 240 feet thick beds and units of sandstone with 18 to 170 feet thick beds and units of siltstone. The siltstone is more common than the sandstone in all sections studied, their approximate ratios (mostly estimated) fluctuating from 10:7 to 10:8. In the above mentioned principal section the Lower member includes about 505 feet of siltstone and 360 feet of sandstone. The sandstone is predominantly light grey to buff, weathers buff, orange, or rust-coloured, very fine (commonly grading into very sandy siltstone) to (rarely) fine grained, quartzose but with a variable (10-20 per cent, est.) admixture of glauconite grains, limonite grains and dark mineral (?chert), non-carbonaceous to slightly carbonaceous; hard and dense, fairly porous to true quartzite; mostly thinly and well bedded, crossbedded and ripple marked but with a considerable ratio of massive to heavily and indistinctly bedded sandstone; the thinly bedded varieties commonly contain numerous partings, laminae and ½ to 6 inch interbeds of hard to friable, sandy to pure siltstone; weathering-resistant and forms a series of precipitous to vertical bluffs (Figure 4).

Rare to very rare marine pelecypods occur in a number of thinly bedded to laminated interbeds and a few ½ to 3 inch interbeds of coquinoid sandstone were noted. The disarticulated and often fragmentary preservation of most pelecypods combined with the presence of starfish (and brittle starfish) suggest a fairly high energy, stenohaline, open marine (?inner neritic) depositional environment.

The siltstone varies from mottled light and dark grey or dull brown to dark grey or black. The lighter coloured varieties are mostly moderately to very sandy, moderately to very hard (flinty); thinly and well bedded to laminated, crossbedded and/or ripple marked. They commonly grade into and may be difficult to differentiate from the very fine grained sandstone. The dark grey to black varieties are usually friable to very friable, feebly sandy to pure, indistinctly bedded to massive (mudstone) more or less bioturbated and locally rich in worm burrows and hieroglyphic markings. This fact combined with the rare to very rare presence of mostly articulated marine pelecypods, starfish, and brittle starfish suggests a moderately high to low energy, stenohaline open marine (inner to ?outer neritic) depositional environment.

The hard, sandy, commonly flinty siltstone varieties are weathering-resistant and tend to form precipitous to vertical bluffs while the moderately hard to friable, feebly sandy to pure varieties weather recessively and form moderately steep slopes and or benches between the bluffs (Figure 4).

An about 400 to 450-foot-thick unit of above described, hard to very hard, mostly flinty sandstone and sandy siltstone forms the topmost part of the Lower member and is largely responsible for its forming prominent, sharpcrested ridges and summits (Figure 3).

The Upper member consists predominantly of the above described siltstone with the moderately hard to friable, mudstone-like varieties being more common than the hard to very hard, thinly bedded to laminated, crossbedded and ripple-marked sandy varieties. Only a few 1-10 foot beds and one 150 to 180 feet thick unit of very fine grained sandstone lithologically similar to that of the Lower member have been observed in the middle part of the Upper member. This results in the latter forming moderately steep to gentle, mostly poorly exposed slopes.

The Upper member contains rare to moderately common fauna of marine pelecypods at ~~most~~ many levels. Some poor starfish and brittle starfish were also found. The lithology and fauna suggest the same depositional environment as for the corresponding rock types of the Lower member.

The Upper member gradationally overlies the uppermost, weathering-resistant and bluffy part of the Lower member. The top is faulted in the longest and best exposed principal section where the member is about 1,500 feet thick. The contact with the overlying ?early (?or earliest late) lower Albian argillaceous rocks of the Sonneratia (s. lato) n. sp. A Zone (discovered and studied by F.G. Young) was not seen in any of the sections studied.

Only the Lower member of the western facies of Upper sandstone division resembles lithologically the typical Upper sandstone division of the eastern slope of Richardson Mountains (Jeletzky, 1958, pp. 10-11, 75-78; 1960, pp. 13-17), "Pacific Rat River", and eastern headwaters of Rock River (Jeletzky, 1972b, pp. 8, 15-16). However, the diagnostic Aptian Aucellina ex gr. aptiensis-caucasica (Jeletzky, 1964, pls XVIII, XX) ranges right through the Lower member and to the level 615 feet stratigraphically below the faulted top of the Upper member in the principal section. This fact and the absence of index fossils of the oldest known Albian zone (i.e. Sonneratia s. lato n. sp. A zone which was found elsewhere in the area by F.G. Young) in the uppermost 615 feet of the Upper member suggest a late Aptian age of these beds and their equivalence with the upper part of the lithologically typical (i.e. arenaceous) Upper sandstone division of Eastern Richardson Mountains. The lithology of the western facies of the division is, furthermore, similar to that of the Blow Pass-Bonnet Lake sections where ~~equally~~ similarly thick rocks known to be equivalent ~~to~~ with the Upper sandstone division of Eastern Richardsons according to their fossil content (Jeletzky, 1972a, pp. 208-209; 1972b, pp. 33-34) include more siltstone than sandstone. The thick, silty facies of Blow Pass-Bonnet Lake and northern Bell Basin appears to represent two segments of the same (presumably contiguous) belt of mid-basin facies of the Upper sandstone division.

The following conclusions about the thickness and lithology of the eastern facies of the Upper sandstone division are rather tentative, being based on a somewhat hurried study of a single section (see Figure 5) situated 6½ miles south-southeast of the confluence of Bell and Little Bell River (approx. at 136°33'45" W. Long. and 67°39'30" N. Lat.) supplemented by an analysis of air photographs of the adjacent area. In this unmeasured section the Upper sandstone division was estimated to be only 400 to 450 feet thick. It consists predominantly of a uniform sequence of very fine grained, silty sandstone lithologically similar to that of the previously measured sections on the "Pacific Rat River and in the eastern headwaters of Rock River (Jeletzky, 1972b, pp. 8-9, 15-16). The division appears to be overlain (distant observations only) by several hundred feet of shale and siltstone lithologically similar to the Albian shale-siltstone division of the other two above mentioned areas. No fossils were found in the Upper sandstone division of the 136°33'45" W. Long. and 67°39'30" N. Long. section and the here proposed identification and correlation of the division and the overlying argillaceous rocks is based on their lithology and stratigraphical position only. If the above conclusions are correct, the Upper sandstone division of the area east of the confluence of Bell and Little Bell rivers is closely similar to that of the more southerly areas of Western Richardson Mountains and rather unlike that of the eastern slope of White Mountains (*see* below in Section 8).

7. Western headwaters of Bell River

Husky Formation (Lower Tongue). An additional study of the basal part of the previously measured Section 5 (Jeletzky, 1961b, pp. 31-32) revealed the presence of an about 580 feet (measuring approximate only) thick siltstone unit stratigraphically below (contact covered) the bed 1 of the section. The siltstone is dark grey to dark brownish grey, weathers dark brown-grey with rust-coloured specks and spots, pure to slightly sandy, micromicaceous, fairly friable to moderately hard; weathers fine to very fine rubbly and recessively; massive to thinly but indistinctly and corrugatedly bedded; darker coloured, friable interbeds are commonly strongly bioturbated and ~~replete in~~ fucoid markings and various worm burrow (feeding trails?) including segmented, Nereites-like types; early forms of *Buchia mosquensis* (v. Buch) or ?late forms of *Buchia concentrica* (Sowerby) s. lato occur at several levels locally forming thin pods or interbeds (¼-1 inch) of coquinoid siltstone; and about 60 feet thick unit of sandstone lithologically similar to that of unit 1 of section 5 as redescribed below forms the visible base of the formation; base of the sandstone unit covered and appears to be cut off by a major 360°-trending subvertical (? normal) fault.

Unnamed Upper Jurassic sandstone (?tongue of). The basal 180 feet of unit 1 of Section 5 (Jeletzky, 1961b, p. 31) appears to be built predominantly of sandstone, dull brown to grey, commonly intensively rust-weathering, very fine grained, quartzose but silty, partly ferruginous, hard to very hard and dense, quartzite-like (little or no visible porosity), thinly to medium and well bedded to laminated, intensively crossbedded and ripple-marked; interbedded with, considerable siltstone as described by Jeletzky (1961b, p. 31). Buchia mosquensis (v. Buch) (?advanced forms) were collected on fresh, apparently locally derived float 80 feet above the visible base of the unit. The unit 1 as a whole appears to be better assignable to the attenuated offshore (inner neritic) facies of the Upper Jurassic sandstone than to the Husky Formation, all the more so as the 40 feet wide covered interval (i.e. unit 2; see Jeletzky, 1961b, p. 31) may possibly harbour a strong strike fault causing the disappearance of an unknown upper part of the Unnamed Upper Jurassic sandstone from the outcrop.

8. East Flank of White Mountains

Arenaceous facies of Upper shale-siltstone division. An additional study of the poorly understood upper part of the previously studied (Jeletzky, 1972b, pp. 20-21) section across a small, strongly faulted syncline on the eastern flank of White Mountains (at approx. Lat. 67°55'N. and Long. 136°27'W.) necessitates the above reassignment of beds described tentatively as shale equivalents of Lower sandstone and Coal-bearing divisions (Jeletzky, 1972b, pp. 20-21). The division consists of (ascending order):

1. Sandstone, light brownish grey, weathers brown to rust-coloured, very fine grained, fairly well rounded and sorted according to the grain size, quartzose but silty, non-carbonaceous to feebly carbonaceous, some bright orange limonite grains and those of a dark mineral (?chert); hard to very hard and quartzite-like to true quartzite, forms a 10-20-foot high escarpment across the slope; massive to indistinctly and medium bedded, apparently devoid of ripple marks and crossbedding except in one coarse grained interbed; contains

to persistent 4-12-inch thick bands and 5-10-foot-long pods of strongly ferruginous, rust- to orange-weathering, hard, very sandy siltstone to very fine grained sandstone ("clay ironstone"); at least one 1½-2 foot persistent interbed of coarse grained, gritty sandstone with small pods of fine grit; the contact with the underlying *Buchia volgensis* Jeletzky 1964 (non Lahusen 1888)-bearing, upper part of Husky Formation (Jeletzky, 1972b, p. 19) is sharp, uneven and evidently erosionally disconformable; no basal conglomerate or accumulation of coarse sand or grit particles were, however, seen at this contact; upper contact gradational; rare marine fauna occurring scattered throughout the unit's thickness includes: *Simbirskites* (*Simbirskites*) ex gr. *kleini* (Neumayr and Uhlig), *Acroteuthis* (*Boreioteuthis*) ex gr. *impressa* (Gabb), *Dicraniodonta* ex gr. *dowlingi* McLearn, *Astarte* n. sp. aff. *A*. *cantabrigiensis*. Woods, etc. Thickness 27 feet.

2. Shale, black to dark grey and/bluish tinged, fissile, fairly friable, weathers recessively and flaky to earthy; some scattered, rounded 2-8-inch concretions of the orange-weathering, hard clay ironstone; some 1-5 foot interbeds of dark grey, sandy siltstone near the base and the top; rare *Lima* (*Limatula*) cf. *consobrina* (d'Orbigny) occurs at several levels; thickness 165 feet.

3. Sandstone, lithologically similar to that of unit 1 but less quartose and containing 15-20 per cent (est.) of orange limonite grains and 10-15 per cent (est.) of dark mineral (?coaly or/and? chert grains); hard and dense but not quartzite-like for the most part; forms a 25-35-foot high escarpment across the slope; lower contact appears to be abrupt but is poorly exposed; upper contact covered; rare mid-Lower Cretaceous (?Hauterivian or Barremian) fossils include: *Pleuromya* n. sp., fragmentary *Inoceramus* sp. indet., *Dicraniodonta* sp. indet. etc.; no *Buchia* was found and the previously made tentative identification of *B*. cf. *volgensis* Jeletzky 1964 (non Lahusen 1888) (Jeletzky, 1972b, p. 20) is withdrawn herewith; thickness 55 feet (approx.).

4. Siltstone, dark grey to black when fresh, friable, weathers same or dull grey, fine rubbly to flaky and recessively, more or less sandy throughout; some concretions of hard clay ironstone as in unit 2; appears to grade into overlying and underlying

units through 35-40-foot thick zones of harder, lighter coloured, very sandy siltstone; no fossils seen; thickness 730 feet.

The presence of a late Hauterivian Simbirskites (Simbirskites) ex gr. kleini fauna in the unit 1 indicates the assignment of units 1-4 to the Upper shale-siltstone division. A major hiatus corresponding to all of the Coal-bearing and Lower sandstone divisions and to the uppermost beds (i.e. the sandy siltstone beds of the Upper member; Jeletzky, 1958, p. 4) of Husky Formation must occur between the lower contact of the unit 1 and the underlying upper Husky Formation. This fact and the arenaceous facies of the Upper shale-siltstone division indicate that the eastern slope of White Mountains formed part (presumably the northern flank) of the same crestal zone of the mid-Valanginian to mid-Hauterivian Aklavik Arch as the previously discussed northern Bell Basin (see in Section 6 and Figure 2). Because of the erosion of the Husky Formation it is not known whether or not the eastern slope of White Mountains was uplifted above sea level in the mid-Valanginian to mid-Hauterivian time and formed part of the same source area as the northern Bell Basin. This uncertainty is indicated in Figure 2. However, the Mostly inner to outer neritic, arenaceous facies of the overlying Upper shale-siltstone division suggests that it may have been. This facies of the division is a considerably more shallow water deposit than its northern Bell Basin counterpart and must have been derived from an adjacent southern or/and southeastern source area (? a residual island within the submerged crestal zone of the arch). This considerably lesser subsidence of the eastern slope of White Mountains in the Hauterivian-Barremian time in comparison with the northern Bell Basin suggests that it was at least as strongly (or stronger) elevated in the mid-Valanginian to mid-Hauterivian time as the latter area. These depositional tectonical relationships indicate that the Aklavik Range Culmination of the mid-Valanginian to mid-Hauterivian Aklavik Arch extended considerably farther north and northwest than previously believed. Its extension into northeastern White Mountains is consistent with the erosional truncation or the shallow water, nearshore facies of the Lower sandstone, White Quartzite and Coaly quartzite divisions in adjacent parts of the Fish River-Cache Creek area noted by Young (1972, p. 230; 1973, p. 31). This area must have formed part of a broad shelf-like, eastern zone of the Porcupine Plain-Richardson Mountain Trough in the mid-Valanginian to mid-Hauterivian (and in part in the late Hauterivian to Barremian) time. Throughout this time the deeper, mid-basin zone of the trough must have been situated farther west in the headwaters of Rapid Creek-Blow Pass area (see Jeletzky, 1971, pp. 208-209; 1972a, Figs. 2-3; 1972b, pp. 30-34, Figs. 2-3; this report Figure 2) and south therefrom in the areas of Porcupine Plateau and eastern Keele Range.

Upper sandstone division. The following conclusions concerning the thickness and lithology of the Upper sandstone division of northeastern White Mountains are rather tentative, being based on the study of a single, considerably faulted section which did not yield any diagnostic Aptian fossils. These conclusions are therefore only based on the lithology and stratigraphic position of the rocks concerned. The upward sequence of these rocks is the following:

Lower sandstone member which is about 435 feet thick and overlies the unit 4 of the Upper shale-siltstone division gradationally. It consists of grey, buff or dirty white sandstone commonly weathering light brown, dull yellow or orange. The sandstone is almost exclusively fine to very fine grained, quartzose to orthoquartzitic, with or without an appreciable (up to 20 per cent; est.) admixture of limonite and dark mineral grains; non-carbonaceous to slightly carbonaceous sandstone alternates irregularly with a somewhat lesser but always major ratio of strongly carbonaceous to coaly sandstone locally containing ¼ to 1 inch coaly fragments and specks; sandstone is mostly fairly to well sorted as to the grain size and with subrounded to rounded grains predominating; the structure varies from moderately porous to true quartzitic and very hard and dense varieties alternate with moderately hard ones. However all varieties are weathering-resistant and ridge-forming; massive to indistinctly and heavily bedded varieties alternate irregularly with the fine to medium and well bedded to laminated varieties; the latter are mostly intensively crossbedded and ripple marked on a medium to large scale and exhibit an alternation of dark and light-grey coloured sharply delimited ~~more or~~ (respectively more and) less carbonaceous or coaly lamellae and layers. The member is almost unfossiliferous, only a few indeterminate, ?marine pelecypods having been seen locally. The topmost 5-6 feet of the member are built of a mottled dull to greenish grey, dark brown to wine red speckled sandstone which weathers mottled brown, rust and orange. This intensively ferruginous (common limonitic weathering) sandstone is fine to medium grained, with an admixture of coarse grains and gritty particles; the grains are mostly subangular to angular. This fairly quartzose sandstone is distinctly enriched with lithic fragments and contains considerable admixture of limonite and dark mineral (? chert) grains. It is strongly carbonaceous to coaly throughout and rich in ¼ to 5 inch irregularly shaped to rounded inclusions of hard, orange-weathering clay ironstone or very ferruginous siltstone or sandstone. The sandstone is hard and dense but not quartzite-like. The upper contact is extremely sharp and uneven and has a strongly but irregularly pitted (? burrowed) appearance.

The above described lithological and sedimentological characteristics of the member suggest a lagoonal to outer bar depositional environment with a supratidal climax ended by an abrupt subsidence of the area.

Lower siltstone member is 405 feet thick and lithologically similar to unit 4 of the underlying Upper shale-siltstone division. Only a few nuculid pelecypods were found in this apparently outer neritic deposit which grades upward into the Middle sandstone member.

Middle sandstone member is about 300 feet thick (appr.) and consists almost exclusively of thinly bedded to laminated, intensively crossbedded and ripple marked sandstone lithologically similar to the corresponding varieties of the Lower sandstone member. The bedding surfaces of this sandstone are commonly silt- or mica flakes lined. The sandstone is interbedded and interlaminated with varying locally major ratios of 2 inch to 2-foot beds, thin layers, laminae and partings of sandy siltstone as in the underlying Lower siltstone member. Bedding surfaces of sandstone and siltstone commonly covered by variously shaped hieroglyphic marks and worm burrows; longranging Aptian-Albian variegated shallow water marine pelecypods occur at several levels scattered or forming ¼-4 inch coquinoid layers. However, they are largely restricted to the interbeds of siltstone and extremely fine silty sandstone. This circumstance combined with the single valved, often fragmented preservation of shells suggest a high energy, intertidal to supratidal, possibly lagoonal depositional environment for the fine grained ripple marked and crossbedded sandstones forming the bulk of the member. Upper siltstone member appears to overlie the Middle sandstone member conformably but the actual contact is covered. The dark grey commonly lined with silt- or mica flakes. The sandstone is interbedded and interlaminated with varying, locally major (up to 40 per cent in uppermost 100 feet) quantities of 2-inch to 2-foot beds, layers, laminae and partings of sandy siltstone as in uppermost beds of the underlying Lower siltstone member. Bedding surfaces of sandstone and siltstone commonly covered by various hieroglyphic markings and worm burrows. Variegated, long-ranging (generally Aptian-Albian), shallow water, marine pelecypods occur at several levels scattered or forming ¼-4 inch coquinoid siltstone layers and pods. This fauna is rare or absent in the intervening beds of intensively crossbedded and ripple marked sandstones probably because of their high energy, intertidal to supratidal depositional environment being inemical as a habitat. The lithology of the siltstones, shallow water nature of their fauna and the single valved, often fragmented preservation of most shells indicates their somewhat quieter (?lagoonal) but nevertheless inner littoral depositional environment.

Upper siltstone member appears to overlie Middle sandstone member conformably and is estimated to be some 2,000 feet thick in spite of generally poor exposures and a considerable faulting. The siltstones of the member are dark grey to black in fresh and weathered state, mostly pure and micromicaceous, fairly friable to moderately hard and weather recessively and fine rubbly to flaky. A considerable number of rounded 4 to 12-inch concretions of hard, orange-weathering clay ironstone and very hard, dark-grey siltstone (including cannonball concretions) and 3 to 8-inch bands of the same occur at variable intervals throughout the member's thickness. At 250 to 450-foot level the member contains several 5 to 25-foot interbeds of fairly hard, feebly to moderately sandy siltstone interfingered with dull brown grey, very fine grained, quartzose sandstone intensively crossbedded on a small scale (current type). Very rare, scattered 1/8 to ½ inch chert pebbles occur in these interbeds. No fossils were seen, except at 200-foot level where a clay ironstone band has yielded Pecten (Entolium) cf. irenense McLearn, Tancredia cf. stelcki McLearn, Nucula sp. indet. and other longranging pelecypods of a general Aptian-Albian affinities. A general neritic, possibly outer neritic depositional environment is suggested for the member.

Upper sandstone member forms the visible top of the sequence. It has an estimated exposed thickness of 400 feet but the top is covered everywhere. This member is lithologically and presumably environmentally identical with the Middle sandstone member and contains the same variegated fauna of longranging, shallow water, marine pelecypods.

The above described rocks assigned to the Upper sandstone division appear to be considerably thicker than those of any other known section of the division in the Porcupine Plain-Richardson Mountain Trough, their exposed thickness being in order of 3,500 feet. A few hundred more feet of the division may be concealed stratigraphically above the covered top of the Upper sandstone member in the badly faulted axial part of the syncline centered approximately at $136^{\circ}23'$W. Long. and $67^{\circ}55'$N. Lat. in the valley of the north-south-trending branch of Fish Creek (see Bell River sheet of 1:250,000 topo map).

The Upper sandstone division of northeastern White Mountains closely resembles lithologically the considerably thinner sections of the division exposed in the headwaters of Rapid Creek (Jeletzky, 1971, pp. 208-209, 1972b, pp. 33-34) which also consist of three sandstone members separated by two siltstone members. The Upper sandstone division of northeastern White Mountains is equally similar lithologically to the thick and argillaceous western facies of the division outcropping in the northern Bell Basin (see in Section 6). The two sections resemble each other in containing considerable sandstone in the lower parts and in being predominantly argillaceous in the upper parts.

In spite of the above described similarities with the sections of the division exposed in the Blow Pass-Bonnet Lake and northern Bell Basin areas, the Upper sandstone division of northeastern White Mountains does not seem to form part of the mid-basin belt of the Aptian trough but to lie east of it in the proximity of some local southern or southeastern source area (?a residual island on the crestal zone of Aklavik Arch rather than a promontory of the Peel Landmass). This is suggested in particular by the apparently restricted inner littoral, outer bar and lagoonal origin of all sandstone members of the division in the northeastern White Mountains, in contrast to the deeper water, open marine origin of the equivalent sandstone members in the Blow Pass-Bonnet Lake (including the headwaters of Rapid Creek) and northern Bell Basin areas. Strong ? tectonically caused fluctuations in the depth of the Upper sandstone division sea of northeastern Richardson Mountains are indicated by the intercalation of the very shallow water to supratidal sandstones with neritic siltstones. The area must have remained just as anomalous palaeogeographically and structurally in the Upper sandstone division (Aptian) time as it was in the Upper shale-siltstone (late Hauterivian and Barremian) time. More work must be done to elucidate the reasons for this anomalous behavour.

9. Blow Pass-Bonnet (=Bonny) Lake area

Kingak shale and Unnamed Upper Jurassic sandstone

An extremely important section of the Kingak shale (restricted) and the Unnamed Upper Jurassic sandstone was measured across the valley (i.e. in the west-east direction at approximately 68°17'45"N. Lat. and between 138°06°30" and 138°05'30" W. Long.) of a northflowing confluent of the southwestern branch of Blow River. The upward sequence is:

Kingak Shale (Restricted)

1. Irregular interbedding of superficially similar, pure siltstone and silty shale. Both rock types are dark grey and friable; they weather dull to ash-grey, recessively and fine flaky to earthy. A few ½ to 3-foot thick interbeds and some rows of irregularly rounded 4-18 inch to lenticular (discus-like) 1-4-foot long and 4-12-inch thick concretions of siltstone, dull grey, weathering light grey to buff, pure to very sandy (locally grading into very fine grained, silty sandstone) and hard to very hard occur at irregular intervals. One 32-foot thick member of moderately hard sandstone, dark to blackish grey, weathering dull brown grey and chunky, very fine grained and silty (sublithic to ?lithic), thinly to medium but indistinctly and conchoidally bedded occurs 297 to 329 feet above visible base.

The basal 300 feet exposed are of an early Bajocian (= Aalenian) and ? Toarcian age as a juvenile ammonite closely resembling Pseudolioceras M'clintocki (Haughton) was found at 258-foot level and Pseudodicoelites sp. was found in the sandstone member at 298-303-foot level. Higher beds are of a later Bajocian to Bathonian age as Pachyteuthis (? new subgenus) n. sp. A (see in Section 3 of this report) and Inoceramus (Retroceramus) aff. menneri Koshelkina were found at 350 to 370-foot level and another fauna including Inoceramus (Retroceramus) ex aff. retrorsus Keyserling and an ? Arctocephalites-like cadoceratid ammonite was found at about 495-foot level. All above age determinations are based on the tentative field identifications of the writer.

In spite of an argillaceous lithology the unit apparently was deposited largely or (?) entirely in an inner neritic (above 150 feet) environment. The base covered and faulted about 250 yards west of the above mentioned conflent and the top is covered on its western bank. Visible 585 feet (approx.).

The unit appears to be largely or completely ~~absent~~ faulted out in the middle part of the previously measured (Jeletzky, 1972b, p. 26) section of Kingak shale situated just southeast of Barn Mountains. The suggested thickness of this section should accordingly be increased to at least 1,350 feet.

2. A completely covered interval on the eastern bank of the confluent apparently corresponding to about 550 feet of the section and concealing the Callovian and early Oxfordian part of the Kingak shale exposed in the upper part of the section situated just southeast of Barn Mountains (Jeletzky, 1972b, p. 26).

3. Siltstone dull to dark grey, weathers dull to brownish grey or buff, recessively and flaky to chippy; pure to sandy, micromicaceous; includes some (?minor) ½ to 4-inch interbeds of dull grey to buff, very fine grained, quartzose but more or less silty, apparently noncarbonaceous, thinly bedded to laminated sandstone; a few Buchia (Anaucella) cf. concentrica (Sowerby) found in fresh, locally derived float at 120 to 130-foot level; both contacts covered; visible 200 feet (approx.)

side heading

Unnamed Upper Jurassic Sandstone

4. Siltstone as in unit 3 but interbedded with a considerable (?almost equal) amount of hard, very sandy siltstone and very fine grained, quartzose, quartzite-like, thinly and well bedded to laminated sandstone; these two rock types form laminae, layers, and thin (1-6 inch) to very heavy (up to 10-foot) beds; outcrops patchy and poor; no fossils seen; upper contact covered; visible 180 feet (est.).

5. Sandstone, light grey, dull grey, or brown grey, weathers same, buff, or dull brown to rust-coloured, fine to very fine grained, fairly quartzose but with 5-15

per cent of orange limonite grains and the same ratio of black mineral (? cherty); mostly noncarbonaceous to feebly carbonaceous but with some strongly carbonaceous to coaly laminae, layers and interbeds up to 10 foot thick; subrounded to rounded grains predominate and sorting as to the grain size is mostly good; hard and dense but not quartzite-like or true quartzite for the most part; weathering-resistant and underlies the crestal part of the 2000 + feet high, sharp, almost straight, north-south-trending ridge situated about ½ mile east of the above mentioned confluent (see Blow River sheet of 1:250,000 topo map); predominantly thinly and well bedded to laminated and intensively crossbedded to ripple marked on a large scale; the carbonaceous to coaly interbeds tend to be medium to thinly but indistinctly and conchoidally to corrugatedly bedded; they may be rich in various worm burrows and contain some subvertical coaly tubes (? plant rootlets); only very rare indeterminate marine pelecypods were found except at about 100-foot level where Pecten (Entolium) nummulare Eichwald, Lima (Limea) aff. blackei Cox, and poor, generically indeterminate belemnites occur. No Buchia were seen.

The bulk of the unit was probably deposited in a fairly high energy, inner littoral (including supratidal) environment but the carbonaceous to coaly, indistinctly bedded sandstones with ? plant rootlets may be outer bar or lagoonal deposits. Upper contact covered; visible 345 feet.

side heading

Husky Formation

6. Shale or siltstone, dark brown to dark grey (only weathered rock seen), friable and weathers flaky to earthy, mostly pure; no fossils seen; upper contact covered on the eastern side of above mentioned ridge and the formation appears to be faulted against the Upper Aptian to Lower Albian flysch (Jeletzky, 1971, pp. 209-210) which outcrops extensively farther to the east.

Another section of the uppermost Kingak shale (restricted) and Unnamed Upper Jurassic sandstone was measured from west to east across the sharp 2,500 + feet high ridge situated ½ to 1½ mile west of the traversed part of above mentioned confluent of the southwestern branch of Blow River (centered at 138°09'W Long. and 68°17'30" Lat.). The much thicker Unnamed Upper Jurassic sandstone of this section is subdivisible into two lithological members.

The <u>Lower member</u> is approximately 840 feet thick and consist of a cyclical alternation of four 40 to 80-foot thick members (totalling 235 feet) of weathering-resistant, ridge-forming sandstone with four 35 to 450-foot thick members (totalling 605 feet) of friable to moderately hard, recessively weathering siltstone.

The sandstone is mostly dark grey or mottled light and dark grey, weathers dull grey with orange specks or orange to brown, invariably fine to very fine grained, hard and dense to only moderately hard, often quartzite-like to true quartzite, mostly poorly sorted and rounded most grains being subangular to (more rarely) angular; the lithological composition varies from quartzose to lithic (greywacke-like). The latter varieties may contain up to 30 per cent (est.) of orange limonite grains, black mineral (? chert) grains, and lithic fragments combined. Some lithic varieties contain 5 to 20 per cent (est.) of white ?kaolinized feldspar (or ? white chert). Carbonaceous to coaly sandstones are common. They are characteristically indistinctly and conchoidally to corrugatedly bedded, moderately to strongly bioturbated, locally rich in worm burrows and subvertical coaly tubes (? plant rootlets), and poor in or devoid of the crossbedding and ripple marks. Crossbedding and ripple marks are also rare in the noncarbonaceous to feebly carbonaceous thinly and well bedded sandstones, except locally in the upper parts of the members. Contacts with the underlying and overlying siltstone members are mostly covered or poorly exposed but appear to be gradational whenever visible. The member overlies the Kingak shale conformably and apparently gradationally. The latter includes at least one 25 feet thick interbed of the ridge-forming sandstone ~~as above~~ (lithologically similar to those of the Lower member) some 300 feet below the assigned top. Fossils are generally absent. However, rare Buchia (Anaucella) ex gr. concentrica (Sowerby) occur in the basal sandstone unit of the member and a few shells including the early forms of Buchia (?Anaucella) ex gr. mosquensis (von Buch) of a late to mid-Kimmeridgian age occur in the fourth sandstone ~~member~~ unit 525 to 450 feet below the top.

The siltstone is black to dark grey, pure to sandy, commonly micro-micaceous; ~~and with~~ contains some carbonaceous to coaly interbeds; friable to moderately hard, weathers recessively and fine chunky to flaky; outcrops are mostly patchy and poor; no fossils seen.

The rocks of the Lower member are believed to be deposited mainly in a lagoonal to deltaic environment with only a minor interbeds of stenohaline, inner littoral facies.

The Upper member is about 620 feet thick and consists of weathering-resistant sandstone underlying most of the above mentioned ridge. The sandstone includes the same varieties as the equivalent unit 5 of the preceding section. However, the carbonaceous to coaly, medium to thinly but indistinctly bedded varieties poor in or completely lacking crossbedding and ripple marks are strongly prevalent. In contrast to the preceding section the relatively rare thinly and pronouncedly bedded to laminated, crossbedded and ripple marked varieties tend to be carbonaceous to coaly and to feature an alternation of sharply delimited dark and light-grey (correspondingly more ~~or~~ and less carbonaceous or coaly), lamellae, layers and thin beds with the bedding planes lined by silt particles or mica flakes. The indistinctly bedded varieties may be rich in worm burrows and subvertical coaly tubes (? plant rootlets); some limonite filled mud cracks were noted also. Very rare marine fossils have only been found at two or three levels in the lower 270 feet of the member where the noncarbonaceous, intensively crossbedded and ripple marked, presumably inner littoral sandstones are more common. No fossils were seen higher up. The member appears to be largely a lagoonal, outer bar or deltaic deposit with the ratio of nonmarine rocks sharply increasing upward in the section. The contact with the overlying Husky shale covered but is believed to be normal.

The two sections above described document the previously suggested (Jeletzky, 1972b, p. 28) eastward and southeastward attenuation and shaling out of the Unnamed Upper Jurassic sandstone accompanied by a far-reaching lateral replacement of the deltaic, lagoonal and outer bar facies by that of a shallow but open sea. These facies changes are well illustrated by the disappearance of all partly carbonaceous to coaly, ridge-forming sandstone units of the Lower member of the western section in the equivalent, predominantly argillaceous units 3 and 4 of the eastern section. These units are besides largely or entirely shallow water open sea deposits, in contrast to their predominantly lagoonal to deltaic western equivalents.

The Upper member of the western section becomes strongly attenuated in the eastern section where the equivalent unit 5 is only 345-foot thick. Its lagoonal, outer bar and deltaic component becomes strongly reduced in the eastern section ~~at~~ in the ~~expense~~ favor of the inner littoral (including supra-tidal) stenohaline deposits (as documented by the presence of belemnites.

The eastward attenuation and shaling out of the Unnamed Upper Jurassic sandstone results in a marked diachronism of the upper boundary of the Kingak shale in this direction. In the western section the Kingak shale does not include any upper Oxfordian rocks as the first <u>Buchia</u> (<u>Anaucella</u>) ex gr. <u>concentrica</u> appear in the basal arenaceous beds of the Unnamed Upper Jurassic sandstone. However, in the eastern section <u>B</u>. (<u>A</u>.) ex gr. <u>concentrica</u> appears at least 80 feet stratigraphically below the top of the marine siltstone of the unit 3 forming the topmost part of the Kingak shale.

It was not possible to document palaeontologically the probable eastward lowering of the upper boundary of the Unnamed Upper Jurassic sandstone.

The above discussed data support the previously made suggestion (Jeletzky, 1972b, p. 28) that the Unnamed Upper Jurassic sandstone of the Blow Pass-Bonnet Lake area was derived from: "a nearby source area (situated; writer's addition) to the northwest or ? north of the area (? within Barn or Buckland Mountains)." This inferred source area is assumed to be a large eastward prograding deltaic lobe of the Keele-Old Crow Landmass and is indicated accordingly in Figure 1. However it could have been an island within the western part of the Porcupine Plateau-Richardson Mountain Trough.

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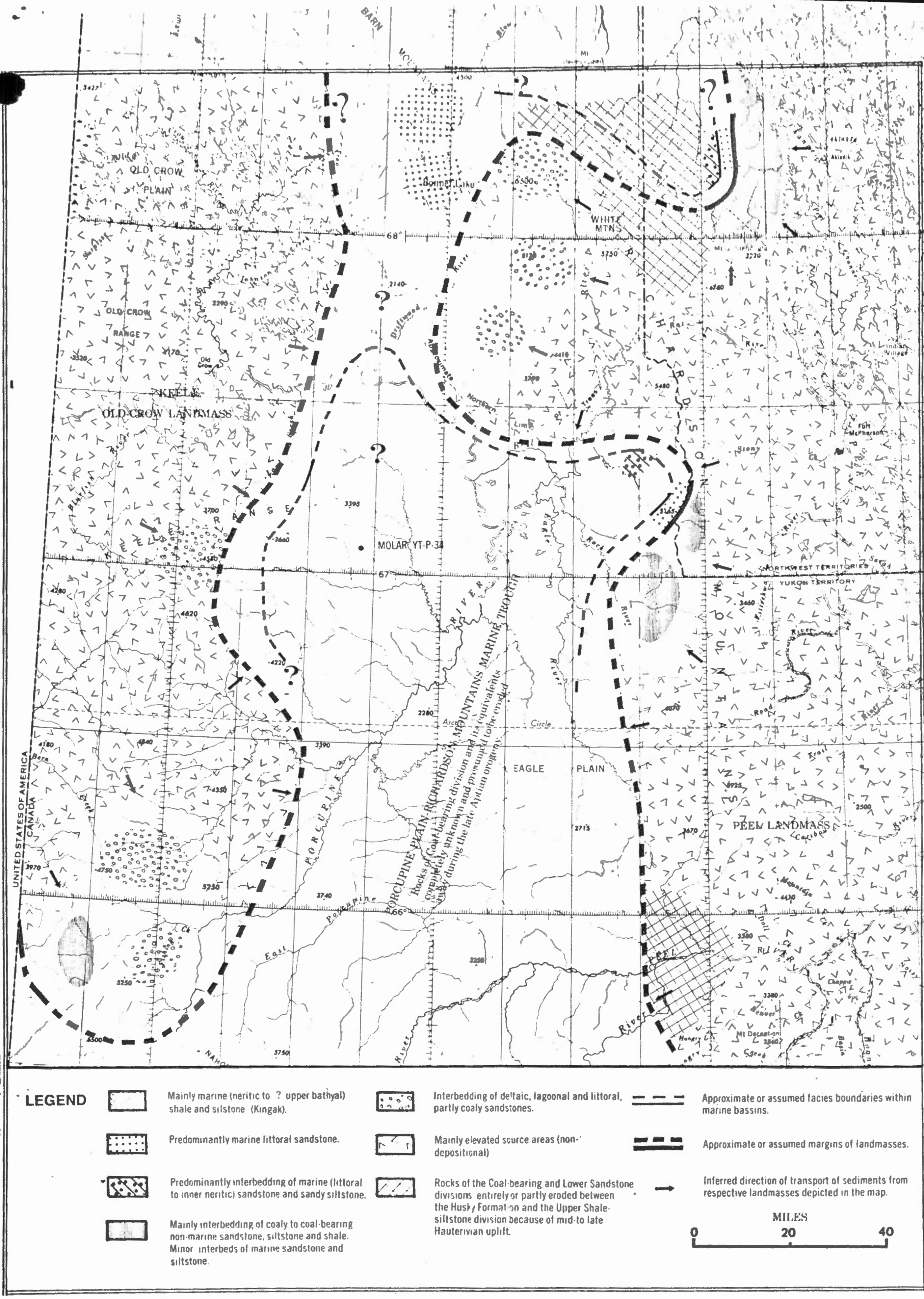
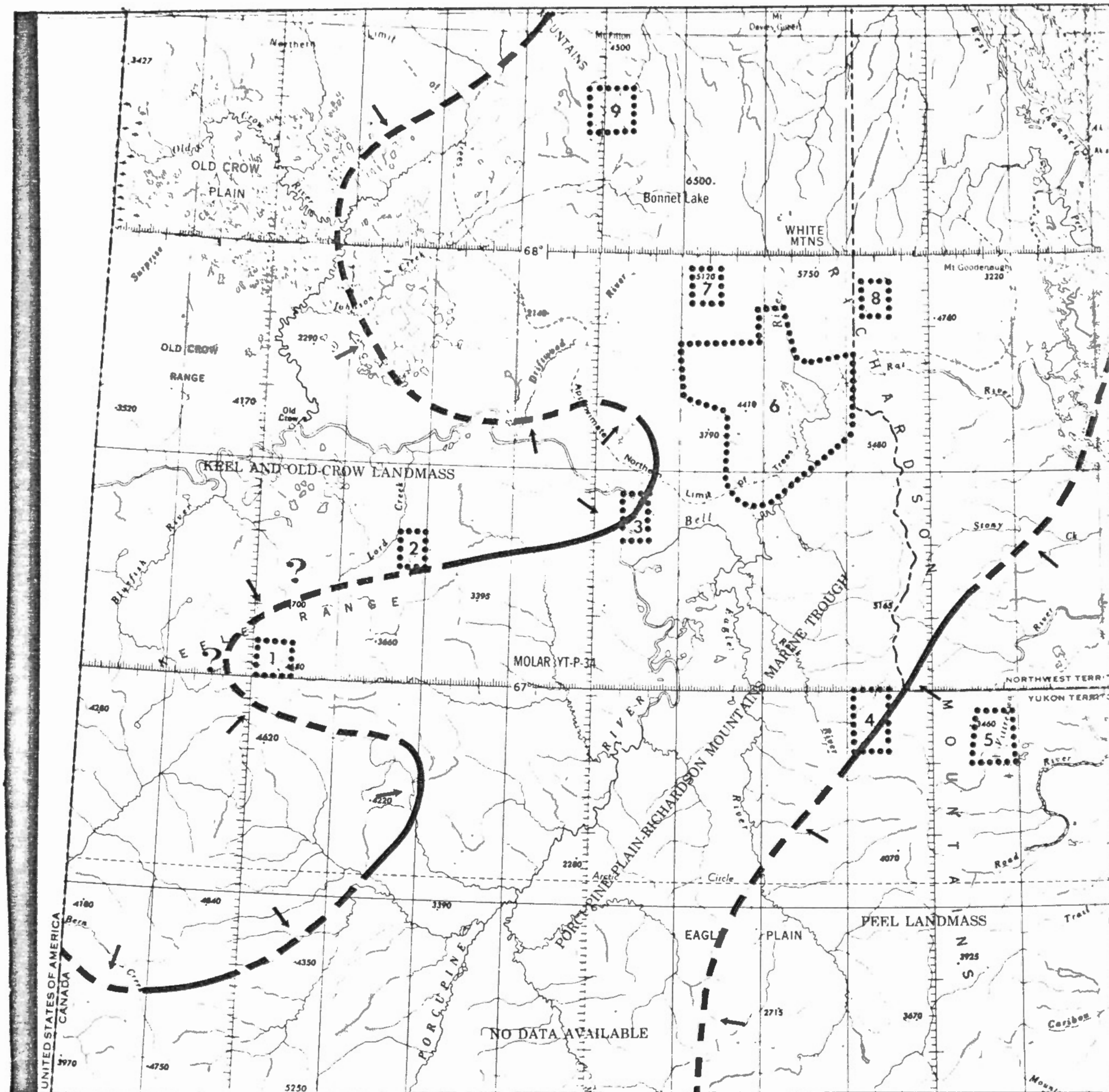


FIG. 4 Early to mid-Hauterivian palaeogeography (time of the Coal-bearing division and its non-marine to marine equivalents e.g. White quartzite and Coal-bearing quartzite divisions, "White sandstone member" of NW Ogilvie Mountains, unnamed marine sandstones



LEGEND

Approximate or assumed shorelines of the late Oxfordian to late Volgian (approx. time of Husky Formation and Unnamed Upper Jurassic sandstone unit) landmasses (maximum extent).

Approximate boundaries of surveyed areas.

Inferred directions of transport of sediments from respective landmasses.

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