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TRIASSIC STRATIGRAPHY OF NORTHERN YUKON TERRITORY

(Report, 3 figures and appendices)

Eric W. Mountjoy

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Eric W. Mountjoy

DEPARTMENT OF ENERGY, MINES AND RESOURCES

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ABSTRACT

This report presents a general outline of the Triassic stratigraphy based on field work carried out on a reconnaissance geologic study of the northern part of Yukon Territory. Triassic strata occur in three widely separated localities: the British and Barn Mountains, Richardson Mountains and northwestern Ogilvie Mountains. Triassic strata are most abundant in the British Mountains where representatives of the Lower Triassic Sadlerochit Formation and Upper Triassic Shublik Formation are present. The Ivishak Member of the Sadlerochit Formation consists of marine, fine-grained sandstones and siltstones with shale interbeds. The Shublik consists of thin-bedded shales and sandstones which grade laterally into carbonates and reflect deposition in relatively shallow waters close to shore on a stable shelf. The Richardson Mountain Triassic consists of marine limestones except for non-marine sediments near Rat River. A thicker sequence of black shales with thin limestone interbeds occurs in the Ogilvie Mountains.

During Triassic time most of the region appears to have been moderately positive with some relief except for areas of the British and Barn Mountains and the northwestern Ogilvie Mountains. Early Triassic seas encroached from the west (?) onto the extreme western British Mountains. Middle Triassic sediments are only known at present to occur in Tombstone area of Ogilvie Mountains. Late Triassic seas inundated the region from the northwest and west along a shallow depression developed along the axis of the Brooks and British Mountains. The eastern edge of the Late Triassic shoreline appears to have extended from eastern Barn Mountains southeast across northern Richardson Mountains and thus was separated from the Sverdrup basin of the Arctic Islands.

These Triassic strata do not appear to be favourable for the accumulation of petroleum.

TRIASSIC STRATIGRAPHY OF NORTHERN YUKON TERRITORY

INTRODUCTION

This report is based on field work carried out during the summer of 1962 as part of Operation Porcupine, a project directed by D.K. Norris. This was a helicopter-supported reconnaissance geologic study of the northern part of Yukon Territory between 65 degrees north latitude and the Beaufort Sea, and 132 degrees west longitude and the International Boundary. For completeness it also includes the results of work in the area to the south by Green and Roddick (1962, and personal communication, 1963) as well as some of the available data from adjacent parts of Alaska.

Previously, only a few occurrences of Triassic rocks had been reported from northern Yukon. These are included in a list of Triassic localities of Western Canada by Tozer (1961a, see p. 16 for Upper Triassic of the Yukon). The Triassic stratigraphy of the adjoining parts of Alaska was summarized by Martin (1916, 1926). Recently summaries of stratigraphic work in the eastern Brooks Range in Alaska have been published (Brosgé, 1962, et al.; Keller et al., 1961; and Sable, 1959).

The distribution of Triassic rocks in northern Yukon has been published in a generalized geological sketch map compiled by members of Operation Porcupine (Norris, et al., 1963). It should be noted that Triassic outcrops are more widespread than indicated especially in the British Mountains. A general summary of the Triassic stratigraphy of northern Canada has been prepared by Douglas et al. (1963, Table 5 and Fig. 28).

A complete and thorough investigation of all areas of Triassic outcrop was not possible within the scope of the objectives of Operation Porcupine. However enough information was obtained from this reconnaissance study to provide a general outline of the Triassic stratigraphy.

ACKNOWLEDGMENTS

The writer was capably assisted in the field investigation of Triassic rocks by student assistants D. MacAuslan, D. Mayes, U. Upitis and D. Wetter. Grateful acknowledgment is also extended to E.W. Bamber, L.H. Green, J.A. Jeletzky, A.W. Norris, D.K. Norris and R.A. Price of the Geological Survey for additional stratigraphic observations. The use of Green and Roddick's unpublished data is especially appreciated. Officials of Triad Oil Company have kindly granted permission to publish data on fossil collections from the British Mountains. The writer is also grateful to

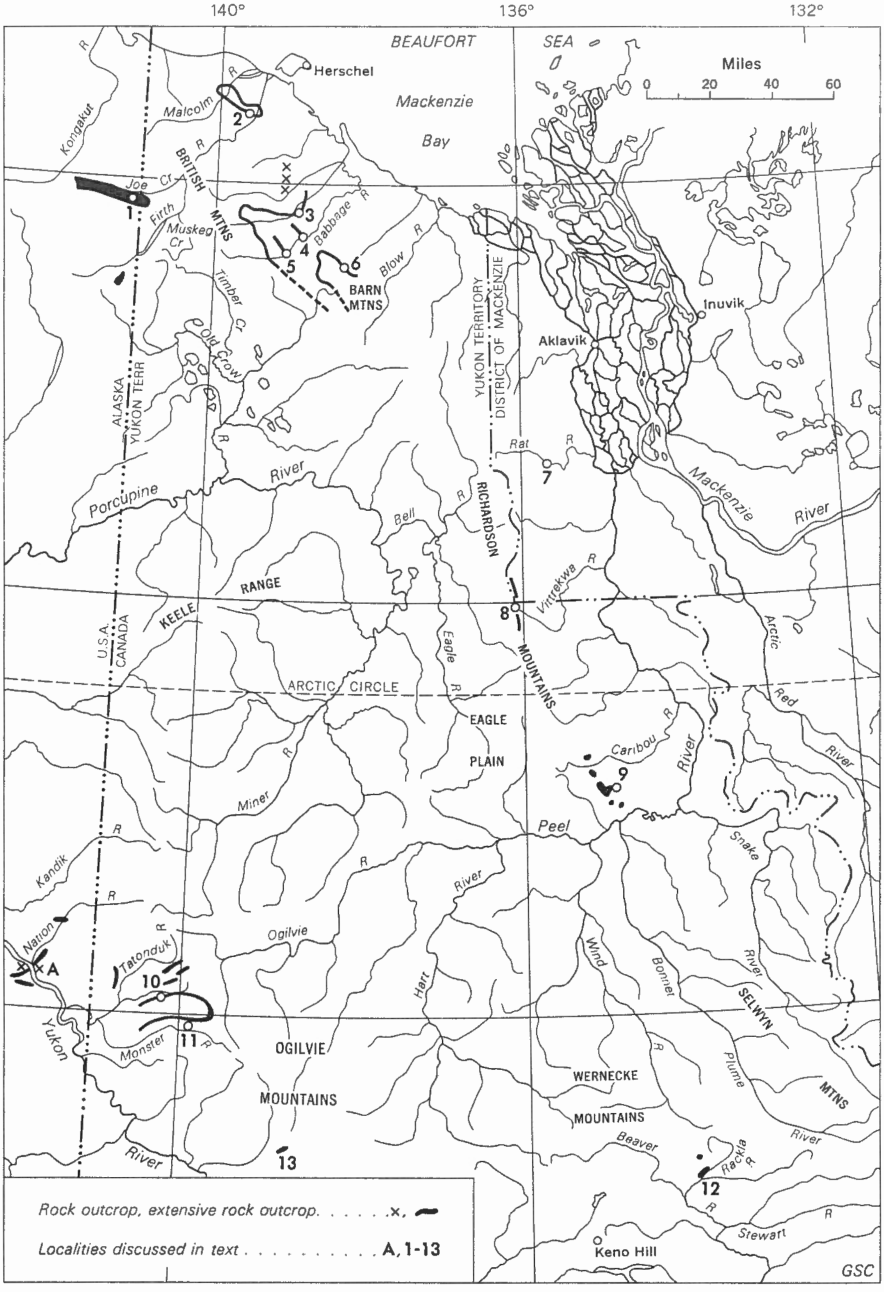

Figure 1. Triassic localities, northern Yukon Territory, District of Mackenzie, Canada and Alaska, U.S.A.

W. P. Brosgé and E. E. Brabb of the United States Geological Survey for information from Alaska including that from their current field investigations. All fossil determinations, except where otherwise noted, are those of E. T. Tozer of the Geological Survey who also contributed additional information on fossil occurrences.

AREAL DISTRIBUTION

Triassic strata occur in widely separated localities in the northern Yukon. There are three main regions of Triassic exposures: the British Mountains, the Richardson Mountains and the northwestern Ogilvie Mountains. Triassic rocks are relatively common in the British and Barn Mountains (Fig. 1, localities 1 to 6), in contrast to the three known occurrences in the Richardson Mountains (7 to 9, Fig. 1) and the few scattered localities in the Ogilvie Mountains (10 to 13, Fig. 1). Most of these outcrops contain Late Triassic fossils. The stratigraphy of the various localities within these three regions is outlined in the following pages and summarized in the correlation chart (Fig. 2) and columnar sections (Fig. 3).

BRITISH MOUNTAINS

Two Triassic Formations are present in the British Mountains. The late Triassic Shublik Formation is widespread whereas the Early (?) Triassic and Permian Sadlerochit Formation is restricted to the area around Joe Creek, a western tributary of Firth River near the Alaska-Yukon boundary about latitude 68°55'N. Westward both formations are mappable over a distance of about 200 miles along the north side of the eastern Brooks Range (Brosgé, 1962; Keller et al., 1961; Detterman et al., 1963; Sable, 1959). Patton and Tailleur (1964, p. 492) indicate that the Shublik continues westward for another 400 miles to Cape Lisburne. The occurrence of Upper Triassic strata in this region has been known for some time (Maddren, 1912; Martin, 1926).

Sadlerochit Formation

The Sadlerochit Formation was established by Leffingwell (1919, p. 113) for a sequence of rocks "consisting of about 300 feet of light sandstone or dark quartzite ... (which) overlies the Lisburne limestone with conformable contact and underlies the Shublik Formation with unknown contact but with parallel bedding". The type locality was not designated but appears to have been on the south side of the Sadlerochit Mountains (about 69°35'N, and 145°00'W) according to Keller et al. (1961, p. 177). In the region west of the type area Keller et al. (1961) used essentially the same definition but found the Sadlerochit to include considerable shale, siltstone, limestone and

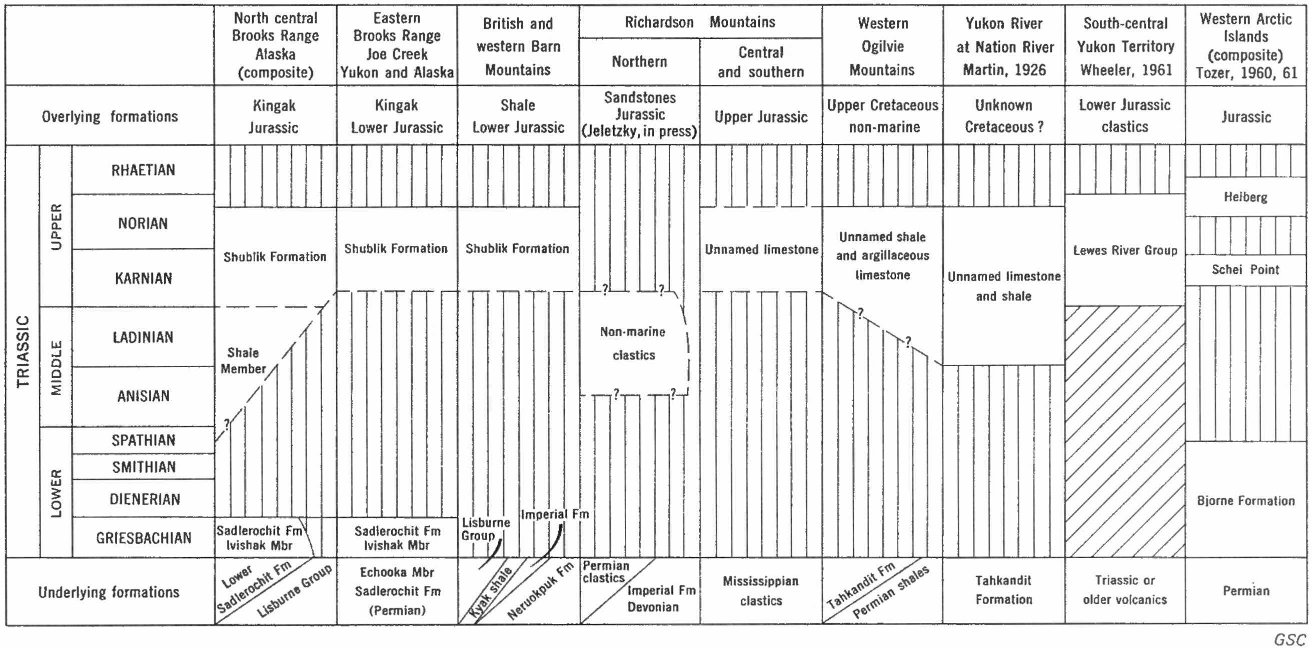

Figure 2. Correlation chart of Triassic strata, northern Yukon Territory, Western Arctic Islands, Canada, and eastern Alaska, U. S. A.

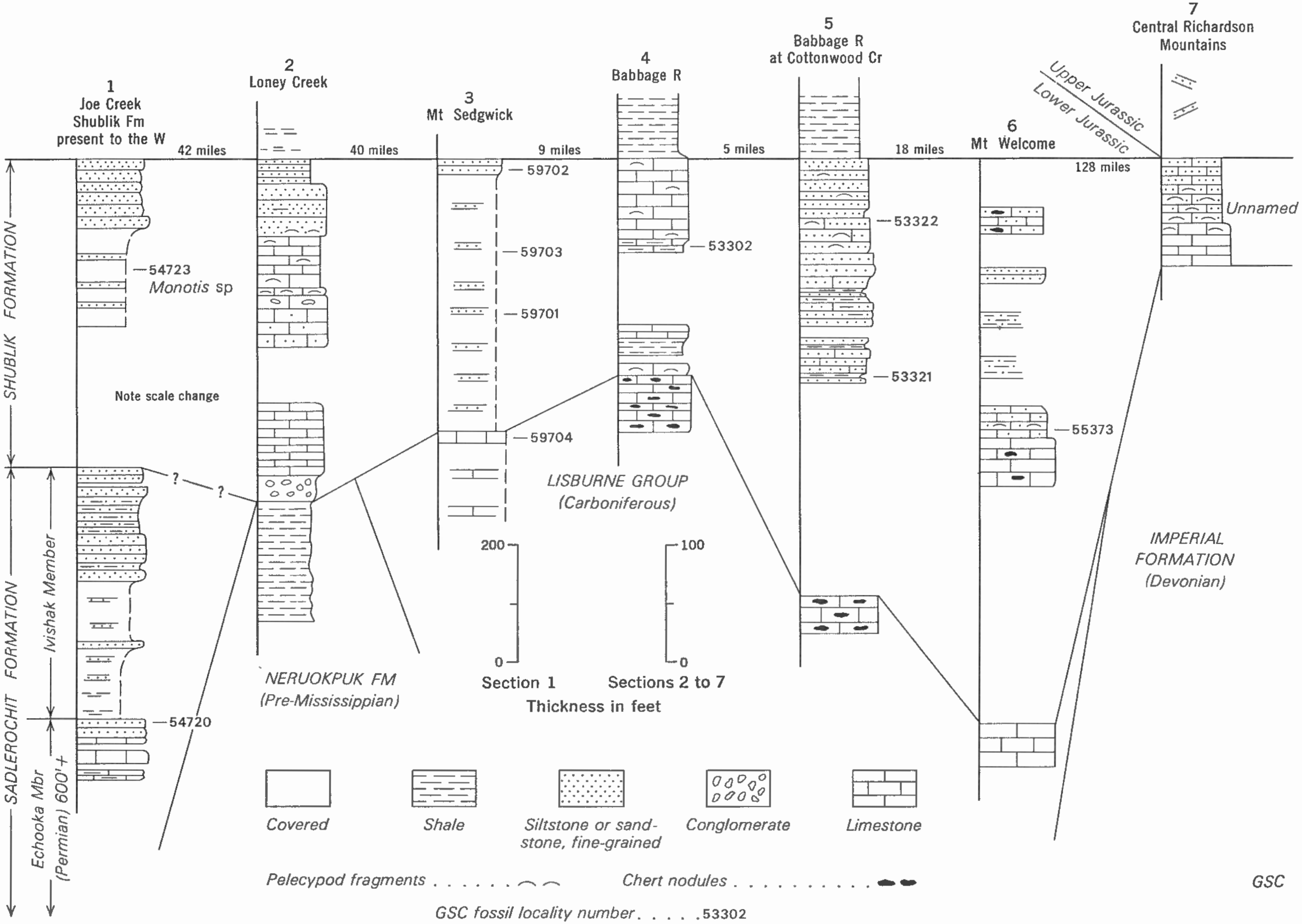

Figure 3. Columnar sections of Triassic strata, northern Yukon Territory.

chert. There they split the formation into a lower Echooka Member of Permian age and an upper Ivishak Member of Early Triassic age. These two members appear to be mappable locally in the Romanzof Mountains (Sable, 1959) but do not seem to have regional significance (Brosgé et al., 1962, p. 2193). The Sadlerochit Formation forms a series of brown weathering, alternating resistant cuestas and recessive intervals. The Sadlerochit Formation, presumably along with the Shublik Formation, has been traced eastward from the type area along the north side of the Brooks Range to near the Alaska-Yukon boundary by Brosgé et al. (1962, p. 2194). In Alaska the Sadlerochit Formation generally overlies the Lisburne Group unconformably and basal beds are sometimes conglomeratic. The lower part of the Sadlerochit appears to range in age from Early to Late Permian whereas the upper part contains Early Triassic Griesbachian ammonites (Brosgé et al., 1962, p. 2194 and Fig. 7 and Keller et al., 1961). Recent work on the northern slope of the central Brooks Range in Alaska suggests that strata assigned to the Shublik Formation may be as old as Early Triassic. In the Killik-Itkillik region Patton and Tailleur (1964) assigned a lower shale member containing Early (?) and Middle Triassic fossils, to the Shublik Formation. The relationships between the Shublik Formation and the Ivishak Member of the Sadlerochit Formation of central Brooks Range have not been clearly established. Silberling and Patton (1965) observed that the shale member of Patton and Tailleur extends as far east as Sagavanirktok Lake (148°W) and was characterized by a middle Early Triassic fauna that also occurs in the Ivishak Member. They suggested that these different units may have juxtaposed during deformation as no transition from Shublik to Ivishak lithologies has been observed.

A section of Sadlerochit Formation over 2,400 feet thick was measured by A. W. Norris on the south side of Joe Creek about 1 1/2 miles west of the Yukon-Alaska boundary (latitude 68°55'N, and longitude 141°03'W, See Fig. 3 and Appendix 1). It consists of a sequence of interbedded silty shale, siltstone and fine-grained sandstone with minor carbonate beds, and is divisible into a lower resistant part and an upper, generally more argillaceous part. The lower more resistant part contains Permian fossils and is tentatively assigned to the Echooka Member. It is about 2,000 feet thick but the lower 1,400 feet contains several dip reversals. A study of air photographs and supplementary geological data from the adjoining part of Alaska kindly supplied by Brosgé (1962, and personal communication, 1964) indicate that the lower part of this section is probably folded and faulted. Consequently only a minimum thickness of about 600 feet can be obtained from this section. The upper 430 feet of the section contains thicker, shaly intervals and appears to be lithologically equivalent to the Triassic Ivishak Member of the Sadlerochit Formation. It is overlain by similar but more argillaceous fine-grained sandstones, tentatively assigned to the Shublik Formation; these are mostly talus covered and contain Monotis sp. To the west the Ivishak Member tends to be more argillaceous and fossils are rare except in calcareous concretions in the lower part (Brosgé et al., 1962; Keller et al., 1961). The strata here assigned to the Ivishak Member consist of a lower recessive silty shale interval about 200 feet thick and an upper argillaceous siltstone and sandstone unit 150 feet thick. The latter forms a prominent resistant rib on the mountains in this area and seems to correlate with the cuesta-forming unit in the Canning River area (Keller et al., 1961, p. 179). No fossils were found in the strata assigned to the Ivishak Member.

Elsewhere in the British Mountains the Sadlerochit Formation appears to be absent. A few feet of unfossiliferous siltstone occur immediately beneath Monotis-bearing beds, as for example in the Cottonwood Creek and along "Loney" Creek (sections 5 and 2) but these rocks appear to be related to the Upper Triassic depositional sequence (see below).

Shublik Formation[1]

The Shublik Formation was established by Leffingwell (1919, pp. 115-116) for about 500 feet of dark limestone, shale and sandstone of Late Triassic age, that overlie the Sadlerochit Formation and underlie the Jurassic Kingak Shale. The type area was designated on Canning River on the southwestern side of the Shublik Mountains (latitude 69°30'N, and longitude 146°00'W) immediately south of the Sadlerochit Mountains. Keller et al. (1961) demonstrated that this formation is mappable for about 100 miles to the southwest and Detterman et al. (1963) observed the Shublik another 100 miles farther west. Brosgé et al. (1962, Fig. 7 and p. 2194) and Mangus (1953) indicate that the Shublik Formation is mappable eastward to the Alaska-Yukon boundary in the vicinity of Joe Creek.

The Shublik forms a poorly exposed, dark grey recessive weathering interval and is characterized by black shale, with some interbeds of phosphatic siltstone, buff-weathering limestone and abundant Late Triassic fossils (Keller et al., 1961, p. 188). Commonly the limestones are pelecypod coquina and are sometimes sandy or cherty. Minor amounts of oil shale have also been reported (Detterman et al., 1963, p. 349). In the western part of the Brooks Range south of Colville River the Shublik Formation contains considerable yellow and green chert which cannot be distinguished on a lithological basis from abundant cherts present in Permian and Jurassic strata (Detterman et al., 1963, p. 350). The Shublik is overlain unconformably by black shales of the lithologically similar Kingak Formation. Thus it is often difficult to distinguish Shublik from overlying basal Kingak shales

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[1] More recent study of fossil collections from the Shublik Formation in the Mount Michelson and adjacent areas in northern Alaska indicates that they range in age from Ladinian through latest Triassic and include a full development of Karnian and Norian assemblages. The topmost part of the Shublik Formation in northern Alaska also contains fossils of Early Jurassic age (U.S. Geol. Surv., Prof. Paper 525A, pp. A123, A124, 1965).

without palaeontologic evidence (Leffingwell, 1919, p. 116). Both Karnian and Norian fossils have been collected from the Shublik Formation (Martin, 1926, p. 105; Keller et al., 1961, pp. 190-191). Middle Triassic Anisian fossils have been collected from the westernmost outcrops of the Shublik Formation in the Brooks Range (Chapman et al., 1964, p. 350).

Extensive outcrops of siltstones, silty shales and limestones containing Upper Triassic Monotis occur on the north and northeast side of the British Mountains. These strata are lithologically similar to the Shublik Formation in adjoining parts of Alaska and occur at the same stratigraphic position, and they are therefore assigned to that formation.

Occurrences of Shublik Formation near the Alaska-Yukon boundary will be discussed first, followed by an outline of the Triassic stratigraphy near the mouth of the Firth River, and west and east of the Babbage River.

Triassic localities along the Alaska-Yukon boundary

During the Alaska-Yukon boundary survey Maddren (1912, pp. 312-13) discovered Upper Triassic strata at several localities (listed in Martin, 1926, pp. 102-103):

1. about 80 miles north of Porcupine River and a mile west of the boundary (also described as 5 miles south of Firth River),

2. about 108 miles north of Porcupine River and 6 1/2 miles west of the boundary near Joe Creek,

3. latitude 68°56'10"N about 8 miles west of the International Boundary (Joe Creek area).

At the first locality Maddren (see Martin, 1926, p. 102) collected Monotis subcircularis and Halobia sp. from impure, flaggy limestone interbedded with sandy shale. It is difficult to pinpoint this locality but it appears to be about 2 miles west of monument 26, at about latitude 68°34'N, approximately 10 miles north of Ammerman Mountain (Martin, 1926; and Brosgé, personal communication, June, 1964). This region was examined from a helicopter by Norris and Price. Along the boundary between Ammerman Mountain and Firth River they observed gently folded Lisburne carbonate rocks (see Geol. Surv. Can. map 10-1963). They did not observe any sandy shales and flaggy limestones similar to those reported by Maddren (1912) and the possible extension of Triassic strata into Canada in this area was not apparent to them. The Triassic strata outcrop about 2 miles west of the boundary and form an outlier covering an area of about 10 square miles, an outlier that is infolded and rests unconformably on Lisburne carbonate rocks. (U.S. Geol. Surv. Table Mountain quadrangle map, and Brosgé, personal communication, 1964).

Joe Creek

The second and third of Maddren's localities lie within a portion of a long, east-trending, faulted syncline which follows the south side of Joe Creek and which contains Mesozoic rocks which are in part overlain by a folded thrust plate of Lisburne carbonate rocks. Monotis subcircularis and Halobia were collected from deformed calcareous and ferruginous sandy shales and limestones between 6 1/2 and 8 miles west of the International Boundary (Maddren, 1912, p. 312; and Martin, 1926, pp. 102-103). These strata are considered to be part of the Shublik Formation.

The section on Joe Creek includes 521 feet of strata at the top which contain Monotis sp. and is presumably equivalent to the Shublik Formation. It consists of a lower 400-foot covered interval containing talus of sandstone and an upper 100-foot resistant, brown weathering very fine grained sandstone, a sequence not easily distinguished from underlying sandstones of the Sadlerochit Formation. These Upper Triassic beds do not appear to extend eastward across the International Boundary.

Along strike 4 to 6 miles to the west of the Joe Creek section, Maddren collected Upper Triassic fossils from equivalent strata (Maddren, 1912, p. 312; Martin, 1926, pp. 101-103; Brosgé et al., 1962; and Brosgé, personal communication, June 1964). Jurassic strata also appear to be present because Maddren collected Jurassic Pentacrinus sp. from shales nearby in this same area (Martin, 1926, p. 264).

Lower Firth River (locality 2, Figure 1)

The highly folded and deformed sequence of sedimentary rocks along the Firth River were examined in 1914 by O'Neill (1915, 1924) during the Canadian Arctic Expedition of 1913 to 1918. He established the presence of Middle Jurassic shales along the lower part of the Firth River (1924, pp. 14-15A) and suggested that older Mesozoic rocks, similar to those reported by Leffingwell (1919) near Demarcation Point, may be present. Mangus (1953, p. 17), in a review of published information, incorrectly stated that O'Neill found Triassic fossils in shales along the Firth River. The geology of the Engigstciak archaeological site, about one-half mile southeast of the Firth River Jurassic shale locality, has been briefly outlined by Mackay et al. (1961) and Mathews (personal communication, 1963). They reported the presence of two small outcrops of fossil fragment limestone of possible Palaeozoic age (1961, p. 51).

A structurally depressed area of Mesozoic rocks occurs between the Firth and Malcolm Rivers about latitude 69°25'N. This area is 3 miles wide, 15 miles long and appears to be synclinal. Exposures along Loney Creek, a western tributary of Firth River, at the southern margin of the area indicate that the rocks are deformed by a series of vertical faults and small close northwest trending folds. Triassic rocks outcrop around the eastern margin. No definite Triassic outcrops were observed around the northwest part of the area near Malcolm River. A thin sequence of deformed black Jurassic shales occurs in the centre of the area.

A section of Shublik Formation was measured along the upper part of Loney Creek (Appendix section 2). There the Shublik Formation is 285 feet thick and comprises thin upper siltstone and fine-grained sandstone underlain by about 200 feet of fine- to coarse-grained grey calcarenite and pelecypod coquina. There is a 20-foot white quartz conglomerate near the base. Triassic outcrops were also examined in a faulted anticlinal structure a mile downstream where they consist of about 100 feet of sandy pelecypod limestone coquina with equal amounts of shale and Monotis-bearing siltstone and fine-grained sandstone at the top. These siltstones and sandstones form a distinctive brown weathering, moderately resistant unit in the Loney Creek area. The limestones weather light grey to brown and unconformably overlie the Neruokpuk Formation. The Neruokpuk Formation comprises all the slightly metamorphosed sedimentary rocks of pre-Mississippian age in the British Mountains. This usage conforms with that in the type area (Leffingwell, 1919, p. 103) and in the eastern Brooks Range of Alaska (Brosgé et al., 1962, p. 2182). No fossils have been found in the Neruokpuk Formation but on a lithological basis it is correlated with Devonian rocks by Brosgé et al. (1962, p. 2184).

The very fine quartz pebble conglomerate assigned to the base of the Shublik Formation of section 2 (unit 2) may correlate with similar conglomerates on Firth River. In an outcrop on the west side of the Firth River, about 6 miles east of section 2, D.K. Norris observed 1 foot of conglomerate with pebbles of white quartz and green and black chert beneath a 15-foot limestone coquina and above black chert of the Neruokpuk Formation. This limestone contains Permo-Carboniferous fossils thus indicating the presence locally of small amounts of late Palaeozoic sediments between the Shublik and Neruokpuk Formations. The lower part of the succession assigned to the Shublik Formation in section 2 on Loney Creek may be in part Palaeozoic (units 1 to 3).

The lower contact of the Shublik Formation on upper Loney Creek appears to be an unconformity. There is a pronounced discordance between the bedding of strata assigned to the Shublik Formation and that of the nearby Neruokpuk Formation. The discordance could be due in part to later faulting as the actual contact is not exposed and a number of faults cut the Shublik and Kingak Formations farther downstream. As noted above it is difficult to locate accurately the Mesozoic-Palaeozoic contact. However the Shublik Formation just south of Loney Creek clearly overlaps trends in the underlying Neruokpuk Formation providing strong evidence for an angular unconformity. To the northwest in the vicinity of Malcolm River the Mesozoic rocks are largely covered and it is not known whether Triassic rocks occur beneath the Lower Jurassic Kingak shales If present they overlie carbonate rocks of the Lisburne Group (see Geol. Surv. Can. map 10-1963). The upper contact with the overlying Kingak black shales is generally poorly exposed, but appears to be conformable. One exposure along Loney Creek about one mile downstream from section 2 revealed an abrupt but conformable contact. Dark grey to black, very thin bedded shales occur with a sharp contact on dark grey siltstones containing a few siltstone pebbles up to one half inch diameter and Monotis sp. ? fragments.

Several fossil collections were obtained from the Shublik Formation of Firth and Malcolm River areas. Some of these are included in section 2. Other collections mostly those made by Triad Oil Company are listed in Appendix 2. Most fossiliferous beds are coquinoid. The commonest fossil is Monotis sp. a few of which can be identified specifically as Monotis ochotica (Keyserling) which according to E. T. Tozer is of Late Triassic and probably late Norian age.

Babbage River and Barn Mountain region (sections 3 to 6)

The Shublik Formation outcrops extensively near the headwaters of the Babbage River and its various tributaries between latitudes 68°30'N and 69°N and longitudes 138°30' and 139°30'W (not shown on Geol. Surv. Can. map 10-1963). A series of northwest-trending faults and folds repeat the lower part of the Mesozoic and the upper part of the Palaeozoic sequences.

Few good exposures are present however except in some narrow canyons eroded by some of the creeks. Because the Shublik Formation is only moderately resistant to erosion it is often covered by solifluction deposits and talus and rubble of frost-heaved material. Outcrops of Shublik Formation were examined at widely scattered localities in northeastern British Mountains where they occur between the Lisburne Group and the overlying Jurassic Kingak shales. This distribution suggests that the Shublik Formation has continuity in this region.

Triassic fossils other than those localities mentioned above are known to occur on the extreme southwest side of the British Mountains in the poorly exposed area of Old Crow drainage. However there may be some Triassic strata at the base of the poorly exposed, presumably Jurassic Kingak shales especially near the headwaters of Timber Creek (tributary of Old Crow River) and Muskeg Creek (tributary of Firth River). South of Barn Mountains, Triassic strata were not recognized and appear to be absent. On the southeast side of Barn Mountains part of the coal-bearing clastic rocks which occur conformably beneath Lower Jurassic sandstones north of Bonnet Lake and referred to the Lower Jurassic by Jeletzky (1962, p. 78) may be in part of Triassic age. Similar coal-bearing clastic rocks occur on the east side of the Richardson Mountains (Jeletzky, in press) and are tentatively dated as Triassic according to palynological studies made by D. C. McGregor (see discussion below; Rat River, p. 13). Other occurrences of non-marine clastics of possible Triassic age may therefore be expected here and there beneath Jurassic strata in the area east of Barn Mountains.

Several isolated occurrences of Shublik Formation are known on the basis of fossil collections made by geologists of Triad Oil Company from between 8 and 15 miles north of Mount Sedgwick, about halfway between the Firth and Babbage Rivers. At all of these localities the Triassic rocks rest with angular unconformity on folded Neruokpuk strata. The collections are listed in Appendix 2.

Four sections of Shublik Formation were measured in this region; section 3 near Mount Sedgwick, sections 4 and 5 near the head of the Babbage River, and section 6 on Mount Welcome on Barn Mountains (see Appendix 1). The lithology varies considerably from dark grey, in part silty limestones in sections 4 and 6 to fine-grained quartzose and calcareous sandstones in sections 3 and 5. These rocks generally weather moderately resistant in stream exposures but are commonly covered by solifluction and talus deposits on ridges and mountain sides. The weathered colour varies from light brownish grey to brown and is generally darker than that of the underlying Lisburne Group. In the Mount Welcome area on the other hand the difference in weathering colour is not distinctive as both the Shublik and upper Lisburne carbonate rocks have similar weathering characteristics. No widespread units or members were recognized. The Shublik Formation is about 300 feet thick, but varies from about 200 feet to 400 feet. These measurements are somewhat inexact owing to covered intervals and similarity in lithology of the Shublik and Lisburne carbonate rocks.

Throughout most of the Babbage River region the Shublik Formation conformably overlies the Mississippian Lisburne Group. On the north flank of Barn Mountain, 4 miles southeast of Mount Welcome, observations from the air suggest that the Shublik Formation unconformably overlies steeply southwest-dipping Mississippian Kyak (?) shales and older Neruokpuk strata. No basal conglomerates were observed in the Shublik Formation in the Babbage River region.

The Shublik Formation is overlain with a distinct but conformable contact by the black shales of the Jurassic Kingak Formation throughout the Babbage River region. No conglomeratic or phosphatic intervals were observed at or near the contact.

A number of fossil collections have been obtained from the Shublik Formation in the Babbage River region both from measured sections (Appendix 1) and isolated outcrops (Appendix 2). Many of the fossiliferous beds consist of Monotis coquinas most of which were identified by E. T. Tozer as Monotis ochotica (Keyserling) of Norian and probably Late Norian age.

RICHARDSON MOUNTAINS

Outcrops of Triassic strata and strata tentatively assigned to the Triassic are only known at present from three widely separated localities in the Richardson Mountains: the east flank of Richardson Mountains near the mouth of Brat Creek,a tributary of Rat River (Fig. 1, locality 7), the west flank of the central Richardson Mountains at the head of Vittrekwa River (locality 8), and the east flank of southern Richardson Mountains between Caribou and Peel Rivers (locality 9). The Triassic limestones at localities 8 and 9 appear to represent isolated remnants of a once more extensive Shublik sea that were preserved from Jurassic uplift and erosion. The coal-bearing clastic rocks that occur at locality 7 have been tentatively dated as Triassic on the basis of spores and pollen. With more detailed mapping other isolated occurrences of Triassic rocks may be found in this region.

Rat River Gorge (locality 7)

Between 50 and 65 feet of poorly exposed dark grey to light grey, in part carbonaceous, shales with lenses of impure coal have been observed (Jeletzky, in press) conformably beneath Middle Jurassic sandstones and siltstones. According to Jeletzky the lower contact is sharp and irregular with deep depressions cut in the underlying chert and sandstone pebble conglomerates of the Brat Creek Formation tentatively dated as Triassic which occur above Permian clastics. The Brat Creek conglomerates have been tentatively dated as Triassic? on the basis of pollen but these data do not rule out a possible Upper Permian age. Poorly preserved plant remains occur locally. Spores and pollen collected by Jeletzky from the main part of this unit were identified and dated by D.C. McGregor (GSC Plant loc. No. 5279) as follows:

"*Acanthotriletes* cf. *A. ramosus* B. and H.
Calamospora sp.
Deltoidospora (*Leiotriletes*) sp.
cf. *Ginkgo*
Granulatisporites micronodosus B. and H.
Granulatisporites sp.
Lophotriletes cf. *L. triassicus* (Mal.) K. and M.
Monoletella fabarielliformis Mal. and Dansk.
Monosulcites cf. *M. carpentieri* Del. and Sp.
Monosulcites cf. *M. subgranulosus* Couper
Ovalipollis sp.
Platysaccus sp.
cf. *Pteruchipollenites microsaccus* Couper
Punctatisporites sp.
Reticulatisporites sp.

Striatites sp. (sensu Jansonius)
Vittatina? hiltonensis Chals. and Clarke
Vittatina sp. (Marsupipollenites B. and H. in part?)

The overall constitution of this assemblage indicates that it is most likely Triassic. It has some Permian affinities, the most obvious being the presence of Vittatina. However, striate coniferoid forms are rare and such typically Permian genera as Nuskoisporites, Hamipollenites and Aumancisporites were not found. Monosulcites and cf. Pteruchipollenites are relatively common, and in conjunction with the rarity of striate bisaccate pollen suggest the sample may be Middle Triassic, or possibly Upper Triassic."

Divide between Rocky and Vittrekwa Rivers (locality 8)

In Richardson Mountains immediately south of where the Yukon-Northwest Territories boundary makes a right angle bend at latitude 67° north, approximately 90 feet of possible Upper Triassic strata occur conformably beneath Upper Jurassic sandstones and unconformably above the Upper Devonian Imperial Formation. These beds consist of fine-grained, calcareous sandstones and light grey limestones. Pelecypods are relatively abundant and in part occur as coquina. Those from the middle 30 feet are tentatively dated as Upper Triassic or possibly younger by Tozer (see appendix, section 7). These calcareous sandstones and limestones could be of Jurassic age but because of their lithology and stratigraphic position they are more likely Triassic. Mostly quartz sandstones containing considerable conglomerate occur in adjacent sections of Upper Jurassic or Lower Cretaceous ages, as for example along Vittrekwa River 13 miles northeast and along the east flank of the Richardson Mountains (Jeletzky, 1960, and in press) and at Vittrekwa River headwaters 10 miles to the north.

A study of the air photographs suggests that this distinct light grey weathering unit extends north to latitude 67°10'N and south to where the Mesozoic strata terminate against a major northwest trending transcurrent fault at latitude 66°55'N. Exposures along this 20 mile interval are generally covered by Jurassic sandstone talus.

Elsewhere in this region Jurassic rocks unconformably overlie the Devonian Imperial Formation and locally some Carboniferous rocks (Geol. Surv. Can. map 10-1963, and Jeletzky, 1961).

Southern Richardson Mountains (locality 9)

Between Caribou Lake and Peel River a series of isolated exposures or remnants (map-unit 10, Geol. Surv Can. map 10-1963) of Triassic limestones, occur immediately east of the major transcurrent fault bordering the east side of the Richardson Mountains. These limestones are relatively flat lying and more resistant to erosion than underlying rocks, and form a series of mesas and buttes.

The limestones are very poorly exposed because the tops of the mesas are almost completely moss covered. There are a few exposures around the edges of some of these hills. One of the larger mesas near the centre of this group south of Caribou River (66°10'N and 134°53'W) was examined and described by D.K. Norris. According to Norris the limestone is a light grey, coarse-grained, skeletal calcarenite, with a few interbeds of silty limestone; it weathers yellowish grey in plates 0.1 to 1 foot thick and forms a resistant cap to the hill. Owing to the poor exposures the thickness of these strata can only be estimated from the Trail River (106L) topographic map. These strata occupy about one-half a 500 foot contour interval and thus have a minimum thickness of between 250 and 300 feet.

The limestones contain abundant pelecypods, star-shaped crinoid columnals, gastropods and some plant fragments. Some of the fossils collected by D.K. Norris and R.A. Price were identified as Oxytoma sp., and Myophoria cf. urbana McLearn and are considered by E.T. Tozer to be Triassic, and probably Late Triassic age (GSC loc. 55142).

Overlying beds have been removed by erosion. The underlying beds consist of a sequence of poorly exposed, interbedded shales, siltstones and sandstones. To the north, east and southeast, these strata are relatively gently dipping or broadly folded. The contact between the Triassic beds and underlying strata is not exposed but appears conformable. On the basis of two widely separated collections of plants these underlying beds appear to be of Mississippian age. About 35 miles north of the Triassic outcrops just west of the Road River near longitude 135°28'W and latitude 66°46'N, D.K. Norris and R.A. Price collected fossil plants (GSC loc. 6606) from a loosely consolidated chert and quartzite pebble conglomerate. W.A. Bell reported the following:

> "Material is mainly too fragmentary and too poorly preserved for positive identification. Larger imprints, however, are much decorticated Lepidodendropsis like those of L. acadica (Dawson) of early Mississippian age, and Lepidodendropsis as a genus is characteristically Mississippian."

The other plant locality is about 10 miles southeast of Caribou Lake where the Triassic outcrops on a northern tributary of the Peel River near longitude 134°30'W and latitude 66°03'N. W.A. Bell reported the following from GSC loc. 6567 collected by O.L. Hughes:

> "Lepidodendron veltheimianum Sternberg. The specimens of the above are decorticated and specific identification is slightly doubtful. L. veltheimianum is a widely spread Lower Carboniferous form that occurs only seldom in lower Upper Carboniferous (Namurian). A Mississippian age seems highly probable".

OGILVIE AND WERNECKE MOUNTAINS

Triassic strata occur in western Ogilvie Mountains between Monster and Tatonduk Rivers and in southern Wernecke Mountains at Rackla River near Kathleen Lake (Fig. 1, localities 10 and 11, and locality 12, respectively).

In western Ogilvie Mountains Triassic fossils have been collected from a distinctive shaly, recessive weathering unit that lies between resistant cliff-forming cherty carbonate rocks of the Permian Tahkandit Formation and moderately resistant, non-marine sandstone and shales of late Cretaceous or Tertiary age. This unit can be followed around the Monster syncline, a broad east-west trending feature that extends for about 25 miles and lies between Monster and Tatonduk Rivers (Green and Roddick, 1962; Norris *et al.*, 1963). It may also be represented by shaly, recessive beds capping the Tahkandit Formation between the Monster syncline and Tatonduk River and west of Tatonduk River beneath the Yukon thrust (Norris *et al.*, 1963).

Monster syncline area

a. South side of syncline, near Monster River (locality 11).

The recessive weathering Triassic unit outcrops on the south limb of the Monster syncline. Several observations and fossil collections were obtained from this unit by members of Operation Ogilvie (Green and Roddick, 1962) and the following data are compiled from information kindly supplied by L.H. Green (personal communication, 1963).

The rocks consist mainly of black fissile shales which weather dark grey to light brown with occasional argillaceous limestone interbeds less than 1 foot thick. Calcareous and ironstone nodules and concretions are often present. No sections were measured but thicknesses can be estimated using topographic maps. A minimum thickness of between 500 and 1,000 feet is estimated for these beds in the area near longitude 140°05'W.

A well-exposed Triassic section occurs on the north bank of Monster River at longitude 139°50'W and latitude 64°56'N. There, close to 1,000 feet of tightly folded and faulted beds are exposed. *Halobia* sp. and crushed ammonoids were collected from this outcrop. According to Green (personal communication, 1963) the rocks are thin-bedded, argillaceous limestone with a few calcareous siltstone interbeds less than a foot thick. He estimates the true thickness of these beds to be more than 300 feet.

Much of this shale and limestone unit is fossiliferous and several collections of *Monotis* sp. and *Halobia* sp. of Upper Triassic Norian age were obtained by members of Operation Ogilvie from the upper part. The various collections are listed in Appendix 2 and marked on Geol. Surv. Can. maps 13-1962 and 15-1962. Further study of these strata may reveal the presence of older Triassic strata near the base of the formation similar to that found immediately to west in Alaska (see below) and in central Alaska (Reeside et al., 1957, p. 1501, and Chapman et al., 1964, p. 350).

b. North side of Monster syncline (locality 10)

Triassic strata are poorly exposed on the north side of Monster syncline. Examination of air photographs suggests that there is not a completely exposed section of Triassic beds here and that the best exposures occur at two localities: near 65°02'N, 140°16'W and 65°06'N and 139°52'W, west and east respectively of locality 10. Observations from the air suggest that this unit consists of shale with a few limestone interbeds. The Mesozoic-Permian sequence was measured on the north side of Monster syncline near longitude 140°15'W where the Shublik Formation is totally covered and measured 780 feet in thickness.

To the north and northwest several isolated areas of black shales occur above the resistant Permian Tahkandit Formation in synclinal cores. These are assumed to be the same unit and have been mapped as Triassic on Geol. Surv. Can. map 10-1963. To the northwest, in the footwall of the Yukon thrust between Cathedral Creek and Tatonduk River a similar recessive interval occurs beneath Cretaceous clastics and the Tahkandit Formation. No fossils were collected from this unit but equivalent strata to the south contain Upper Triassic fossils (see above). These outcrops are thus equivalent in age to the Upper Triassic Shublik Formation of the British Mountains.

The Tahkandit Formation thins eastward to longitude 139°35'W presumably due to post-Permian erosion. East of this point these recessive weathering Triassic beds cannot be distinguished from equally recessive Permian beds (Middle Recessive unit of Nelson, 1961). As a result the Triassic and Permian intervals can no longer be readily mapped. Farther east Green and Roddick (1962) have mapped a large area as Triassic (map-unit 18 of Geol. Surv. Can. map 13-1962) in a region of very poor outcrops. The exposures observed suggest considerable structural complexity and because of similar lithologies this area may well include older Permian strata, though no Permian fossils have been found. A thickness of about 1,000 feet is estimated for the recessive weathering Triassic unit of the eastern part of the Monster syncline.

Of particular interest is the presence of limestones and shales in the adjoining part of Alaska near Nation, on the Yukon River (A on Fig. 1, 65°10'N, 141°35'W) about 45 miles west of the Monster syncline area. The geology of these strata has been summarized by Martin (1926, pp. 95-99) and the palaeontology has been briefly reviewed by Reeside et al. (1957, p. 1500).

Over 900 feet of dark grey to black, calcareous shale, argillaceous limestone and limestone outcrop on both sides of the Yukon River (Martin, 1926; Brabb, 1962) and overlie the Permian Tahkandit Formation without marked discordance. Their relationship to overlying rocks is not known but they are overlain by possibly Jurassic and definite Lower Cretaceous or younger strata which cannot be separated lithologically from them (Brabb, 1964). The lowest 60 feet contain a fauna similar to the Nathorstites fauna which is now considered by Tozer (1961a, 1962) to be late Middle Triassic Ladinian age. Halobia sp. occurs in the middle portion of these beds and Monotis subcircularis is present near the top. These beds have the same lithology and similar stratigraphic relationships as the Triassic strata of the Monster syncline.

Rackla River area (locality 12)

Several scattered outcrops of tectonically disturbed black shales and limestones occur in stream cuts along the Rackla River just south of Kathleen Lakes (about 64°13'N and 134°05'W) in the Nash Creek map-area (106D, Green and Roddick, 1962, Geol. Surv. Can. map 15-1962). The limestones are dark grey to black and generally very fine grained but include a few coarse-grained beds. The interbedded shales are dark grey to black, and calcareous. Both rock types are typically thin-bedded and beds seldom exceed a thickness of 6 inches. The thickness of this sequence is difficult to estimate in view of the complicated structure and extensive cover but the unit is probably between 1,000 and 4,000 feet thick. These strata are similar lithologically to Triassic rocks of the Monster syncline area.

The complex structure and poor exposures make it difficult to determine contact relationships with adjacent rock units. According to Green and Roddick (1962) the Triassic unit appears to overlie massive quartzite of unknown age without discordance. Rocks younger than Triassic are not present in this area.

Several fossil collections were obtained from the Triassic strata along Rackla River by members of Operation Ogilvie. All fossils are of Late Triassic age and include Monotis, Halobia, Arcestes, Juvavites, and Sirenites sp. (see Appendix 2). These beds were first noted by Keele (1906) and he collected Monotis subcircularis and Monotis alaskana (McLearn, 1953, p. 1213).

Approximately 100 miles to the south, Roddick and Green (1961) have found similar Upper Triassic rocks. These consist of interbedded dark grey to black, friable, micaceous sandstone and shale, with minor conglomerate and concretionary shale and occur in isolated exposures along the Tay River for a distance of 4 miles near longitude 133°22'W and latitude 62°43'N. It was not possible to obtain an accurate thickness but it is estimated that more than 500 feet of strata are present. These occur beneath Tertiary andesites and basalts, but relationships to underlying rocks are not known. Monotis subcircularis is reported from these shales and sandstone (GSC loc. 42873).

Tombstone area (locality 13)

About 30 miles northeast of Dawson (13, Fig. 1) in the Tombstone area the recent detailed investigations of Templeman-Kluit (1966a, 1966b, and personal communication) have demonstrated the presence of Triassic thin-bedded siltstones, shales and dark grey limestones. The Triassic unit is about 200 feet thick and contains Lower Triassic (Smithian?), Middle Triassic (Anisian), and Upper Triassic (Norian) pelecypods. These Triassic beds, about 5 miles west of Tombstone Mountain, overlie Permian Tahkandit limestones disconformably and are overlain by black slates correlated with similar slates in an adjacent thrust sheet which contain Middle and Upper Jurassic fossils. Templeman-Kluit (1966b) suggests that the Triassic strata at the Rackla River locality may occur in a similar stratigraphic succession to that of the Tombstone area.

DEPOSITIONAL ENVIRONMENT

The Sadlerochit Formation consists of marine clastics that appear to represent a shallow water, shelf environment. The most likely source rocks appear to be sediments of the underlying Neruokpuk Formation. On a basis of northward thinning Sable (1959, p. 58) suggested a source area in the Romanzof Mountain area of the northern Brooks Range.

In the British Mountains the Shublik Formation changes abruptly over short distances from marine shales and sandstones, to carbonate rocks. The local occurrence of siltstone and fine-grained quartz sandstone suggests local source areas of slight relief. The pelecypod coquinas are indicative of shell accumulation in agitated, shallow marine waters without influx of terrigenous materials. The black shales, which are in part oil shale and phosphatic, suggest slow sedimentation in a restricted, poorly circulated anaerobic environment.

Previous extent

The sporadic but widespread occurrences of the Upper Triassic strata in northern Yukon and its widespread distribution in Alaska suggests that Upper Triassic strata were once more extensive in northern Yukon. The present distribution of Triassic rocks is of course in part controlled by later erosion. Several major unconformities occur in the Jurassic and Cretaceous sequences of this region and considerable erosion must have occurred during this time in parts of the region (Martin, 1959; Jeletzky, 1961, 1962). Where the Shublik Formation is overlain by Lower and Middle Jurassic rocks it is relatively continuous as in the British Mountains. On the other hand in the region south of the British Mountains, where overlain by Upper Jurassic and younger sediments, the Shublik Formation has a very erratic distribution (Fig. 1; Geol. Surv. Can. map 10-1963). On the Peel Plateau, Lower Cretaceous rocks occur unconformably on Mississippian and Devonian strata and in much of Eagle Plain Lower and Upper Cretaceous rocks rest directly on Permo-Carboniferous strata. These major unconformities represent periods during which Jurassic and older rocks were being eroded.

Correlation

Correlation of Triassic beds of northern Yukon with south-central Yukon, eastern Alaska and the western Arctic are summarized in Figure 2. The closest Triassic rocks to the south occur in the Whitehorse Trough of southern Yukon (Wheeler, 1961; Tozer, 1958) on the south side of the Tintina fault zone and trench. These rocks are referred to the Lewes River Group and consist of a thick sequence of Upper Triassic greywacke, limestone and shale with considerable volcanic rocks. These rocks are of a markedly different facies than those in northern Yukon and Wheeler (1960, 1961) has suggested that they are representative of an eugeosynclinal sequence. A volcanic arc along the axis of the present Coast intrusions (Wheeler, 1960; 1961, p. 110) appears to have separated these volcanic rocks from Upper Triassic sediments lacking volcanics of southwestern Yukon and adjoining parts of eastern Alaska.

The nearest Triassic outcrops in the Arctic Islands are more than 600 miles to the northeast on Melville Island and adjacent islands and form the southwestern margin of the Sverdrup basin. Three formations are present: Lower Triassic marine clastics of the Bjorne Formation on Melville Island, Upper Triassic (Karnian) calcareous siltstones of the Schei Point Formation on Borden Island, and Upper Triassic (Norian and Rhaetian) dominantly non-marine clastics of the Heiberg Formation on Brock Island. These sequences are believed to represent near-shore sediments (Tozer, 1960, 1961b).

It is thus evident that Upper Triassic seas were widespread in the western Arctic as elsewhere in the Canadian Arctic (Tozer, 1961b) and western Cordillera (McLearn, 1953; Tozer, 1961a) and most of Alaska (Martin, 1926).

SUMMARY AND PALEOGEOGRAPHY

The Triassic period in general marks a transition between two major depositional phases of the Cordilleran geosyncline and associated shallow epeirogenic seas bordering the western Canadian Shield. During the

Palaeozoic thick sequences of carbonates and shales were the dominant sediments deposited although coarse clastics were deposited during the Devonian and Permian. In contrast during Jurassic and Cretaceous times coarse clastics were deposited in more restricted and local basins. Permian rocks are absent in three large areas: part of northern British and Barn Mountains, parts of Keele Range and adjoining Eagle Plain, and the area bordering the Canadian Shield east of Richardson Mountains. These regions probably represent areas of low to moderate uplift during Permian and to some extent Triassic time.

There are insufficient outcrops and information with which to infer unequivocally probable depositional basins and patterns of the Triassic. Later Jurassic uplift and erosion in this region also further complicates interpretation of the geological history. However some general but tentative suggestions can be interpreted. Triassic strata are rather widely scattered in this region (Fig. 1) reflecting both moderate uplift during Triassic times and to some extent later erosion. Triassic rocks are known to be absent in many parts of this region: eastern Barn Mountains, most of northern and central Richardson Mountains, Lower Peel and Arctic Red Rivers, Eagle Plains, west end of Monster syncline, David Lord Ridge and mouth of Driftwood River on Porcupine River. Consequently most of the region south of the British Mountains appears to have been moderately positive during Triassic time and probably formed a peninsula of land extending west and northwest from the craton to the east. This region on the other hand may have been thinly covered by Triassic sediments which were eroded during Jurassic or later periods. The Triassic sediments of the British Mountains were protected from later erosion by a cover of Early Jurassic and younger sediments. Locally, the Shublik Formation and Triassic rocks unconformably rest on older strata - in parts of the British Mountains it overlies Devonian? or older Neruokpuk Formation; in central Richardson Mountains the Triassic(?) rocks rest on Upper Devonian Imperial Formation; and in southern Richardson Mountains and Barn Mountains Triassic strata apparently overlie Mississippian strata. All of these occurrences, together with the lack of Lower and Middle Triassic rocks in much of northern Yukon provides good evidence for broad epeirogenic uplift and warping during this part of the Triassic. These unconformities also partly reflect older periods of diastrophism or epeirogenic uplift such as the Permian and Carboniferous uplifts of portions of British Mountains and the pre-Carboniferous diastrophism (Caledonian?) of Neruokpuk sediments in the same region (Martin, 1959; Douglas et al., 1963).

During Early Triassic times seas encroached from the west (?) and deposited sands and shales of the upper Sadlerochit Formation in the western Brooks Range. There are no Middle Triassic sediments in the area studied, except that they may be present in the Monster syncline because Middle Triassic beds are known to occur near Nation, Alaska and in the Tombstone area. Thus the entire northern part of the region must have been emergent at this time. Late Triassic rocks are more widespread but dispersed suggesting that much of the region remained moderately positive. The eastern edge of the Late Triassic shoreline probably extended from east of Barn Mountains across the northern Richardson Mountains, the Brat Creek deposits being a local non-marine development related to this shoreline. Whether or not this sea extended farther south is not known. Thus this basin appears to have been separated from the Sverdrup basin of the Arctic Islands. The Shublik sediments reflect deposition in relatively shallow waters close to shore on a stable shelf. The adjoining land had slight to moderate relief thus permitting rather rapid facies changes from carbonate to clastic rocks. The Shublik sea appears to represent an inundation from the northwest and west along a shallow depression developed along the axis of the Brooks and British Mountains. This development contrasts with transgressions from the north in the case of the Sverdrup basin (Tozer, 1961b, p. 41). Triassic strata in the vicinity of Caribou River are difficult to relate to other late Triassic beds. It appears reasonable that they represent a northeastern incursion of the Triassic seas which covered the area between Nation and Rackla Rivers and which probably joined with the Whitehorse basin to the south and the Triassic basin of northeastern British Columbia. To the northwest this basin may have joined with the Shublik sea via the region of the present Yukon River and lower Porcupine River in Alaska.

In central Brooks Range where considerable geological mapping and stratigraphy has been done a similar sequence of events took place. It is not clear why Permian strata are missing at several places; whether they are missing because of non-deposition or erosion has not been determined (Brosgé et al., 1962). Patton and Tailleur (1964, p. 492) explain the absence of Triassic beds by means of non-deposition and concluded that the Shublik Formation represents intervals of slow sedimentation interrupted by extended periods of non-deposition under very stable conditions. They further concluded (p. 493) that "The Triassic and older rocks are primarily shelf deposits and were derived chiefly from a northerly source" as does Keller et al. (1961, p. 214). In contrast the overlying Jurassic and Cretaceous rocks are geosynclinal sediments derived from the south. Gates and Gryc (1963, p. 269) also suggested the presence of an earlier landmass in northern Alaska because of facies changes in Permian, Mississippian and Devonian strata. They also pointed out that the end of the Palaeozoic was marked in southern Alaska by considerable volcanism, part of which may also be of Early Triassic age.

Some of the Early Triassic epeirogenic activity of northern Yukon appears to coincide with the Cassiar orogeny of White (1959). For a regional discussion of Triassic and Permian diastrophism see the summary compiled by Dott (1961).

ECONOMICS

In much of the area Triassic strata outcrop at the present surface or only slightly below it and therefore do not appear favourable for the accumulation of petroleum. Triassic strata may possibly occur beneath portions of the Arctic Plateau between Fish and Blow Rivers and locally in parts of the Eagle Plain forming irregular wedge-shaped areas of sediments between two major unconformities. Similar geological configurations elsewhere are known to be favourable for petroleum accumulations. The dark shales of the Nation River and Monster syncline areas are considered in part to be bituminous and to contain oil shales and may have acted as source beds for petroleum. Unfortunately these strata are too close to the surface and are in structures unsuitable for entrapment of petroleum.

The Triassic strata also provide information concerning the uplift and deformation of the region which may be useful for determining when underlying sequences were uplifted and tilted. This information is of considerable importance in determining when fluid movements in these rocks, including migrations of any petroleum present, may have occurred.

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APPENDIX 1

Section 1: JOE CREEK (117C/1, 68°55'N; 141°05'W)

The section was measured by A. W. Norris in late July on a north-south mountain spur on the south side of Joe Creek, a tributary of the Firth River, 3 miles west of the International Boundary and about 4 1/2 miles southwest of boundary monument 17 (RCAF air photograph A 13138-168). The Sadlerochit strata outcrop on the north limb of a faulted syncline and form a series of dark weathering ridges above the light grey weathering Lisburne carbonates. Younger strata appear to outcrop farther west in the core of the syncline.

The succession forms a prominent resistant sandstone unit and a recessive argillaceous unit. The lower resistant and recessive units appear to correlate with similar units in the Canning River area (Keller et al., 1961, p. 179, Fig. 28).

Unit No.		Thickness in Feet: Unit	Thickness in Feet: Total from base
	Overlying beds form a recessive, possibly argillaceous interval in core of syncline a few miles to the west. Shublik and Kingak equivalents are probably present as Maddren (1912) found Upper Triassic and Jurassic fossils somewhere in this area.		
	Shublik (?) Formation (521.5 feet)		
	Top of ridge and top of exposed section.		
21	Sandstone, very fine grained, light to dark grey, laminated; weathers medium brown, resistant, strongly developed fracture cleavage.	20	952
20	Sandstone, very fine grained as above.	53	932
19	Sandstone quartzose very fine grained, light to dark grey, laminated, weathers medium to dark brown, poorly exposed, thin-bedded.	23.5	879.0

Unit No.		Thickness in Feet Unit	Total from base
18	Sandstone as above but weathers medium brown, resistant and cliff-forming.	20	855.5
17	Covered talus outcrops slope of sandstone as above; Monotis sp. (Upper Triassic, Norian), 90 feet above base. GSC loc. 54723.	165	835.5
16	Covered with vegetation forms recessive saddle.	240	670.5

Sadlerochit Formation

Ivishak Member (430.5 feet)

Unit No.		Unit	Total from base
15	Sandstone, quartzose, very fine grained, medium to dark brown, laminated, highly fissile, weathers dark brown, resistant.	13.5	430.5
14	Discontinuous resistant beds of sandstone similar to underlying unit.	13.5	417
13	Talus of sandstone, very fine grained, laminated medium to dark grey, weathers medium orange brown.	5.5	403.5
12	Sandstone, quartzose, fine-grained, light brownish grey with thin laminae of dark grey, fine-grained argillaceous sandstone, weathers medium brown, resistant, scarp forming.	20.5	398
11	Interbedded thin laminae of fine-grained, light grey sandstone and dark argillaceous sandstone, fissile crosslaminated weathers dark brownish grey, moderately resistant, form a sequence of resistant bands on ridge, transitional upwards to overlying sandstone.	65	377.5

Unit No.		Thickness in Feet Unit	Total from base
10	Sandstone, very fine grained, light brownish grey with dark grey argillaceous sandstone laminae, very fissile, scarp forming, weathers dark brownish grey.	45	312.5
9	Covered by talus with fragments of sandstone as above.	9.5	267.5
8	Sandstone, fine grained, light grey interlaminated with dark grey shale, very fissile; weathers dark brownish grey moderately resistant.	20	258
7	Covered, talus similar to underlying unit, presumably interbedded with shale.	100	238
6	Covered ridge forming unit with talus of sandstone, very fine grained, quartzose, crosslaminated, light grey, with dark argillaceous laminae, very thin-bedded weathers dark brownish grey.	10	138
5	Covered, talus fragments of sandstone, quartzose to argillaceous, very fine grained, very thin-bedded, weathers dark brownish grey.	62	128
4	Covered forming a deep recessive saddle with a few fragments of shale, dark grey, fissile, silty.	66	66
	Echooka Member? (Permian) topmost beds only		
3	Sandstone, quartzose, very fine grained, mostly rubble, weathers light to dark grey; numerous coarsely costate spiriferids (Permian) some bryozoans. GSC loc. 54720.	15	

Unit No.		Thickness in Feet Unit	Total from base
2	Sandstone, very fine grained, dark grey, hard thick-bedded to massive; weathers medium dark brownish grey, forming a very resistant unit.	15	
1	Limestone, slightly silty, fine grained, dark grey, resistant, weathers orange brown.	6.5	

Section 2: LONEY CREEK (117B/11, 69°20'N; 139°49'W)

Section was measured on south side of Loney Creek about 7 miles upstream from Firth River; the most westerly exposure of Triassic strata along the creek. Here the Triassic rocks appear to rest with angular unconformity over Neruokpuk metasediments. Triassic beds are also exposed a mile downstream but are complexly folded and faulted. The uppermost Triassic beds contain abundant Monotis ochotica.

The section was measured in late July (RCAF Aerial photograph A15462-13).

Unit No.		Thickness in Feet Unit	Total from base
	Kingak Formation (base)		
13	Shale, black, weathering dark grey to black, very thin bedded. Overlying or equivalent strata downstream contain Lower Jurassic ammonites.	5	457
12	Covered, estimated.	150	452
11	Shale, black.	2	302
10	Covered.	15	300
	Shublik Formation (285 feet)		
9	Siltstone, partially covered dark grey, weathers very thin bedded, brown.	20	285

Unit No.		Thickness in Feet Unit	Total from base
8	Siltstone and sandstone very fine grained, calcareous, light to medium grey; weathers light brown, resistant, in 2 to 5 foot beds. Abundant large Monotis collected 5 feet above base. GSC loc. 52794.	44	265
	Monotis cf. ochotica (Keyserling), Norian probably late Norian.		
7	Limestone, very coarse grained, light grey in part pelecypod coquina; weathers light grey in 1/2 to 4 foot beds. GSC loc. 52796.	43	221
	Collected 5 feet from top. Oxytoma sp. Upper Triassic.		
6	Limestone coquina, very coarse grained, in part calcirudite, mostly pelecypod fragments, light grey; weathers light grey to brown in one bed.	6	178
5	Limestone, calcirudite and calcarenite, pelecypod coquina, medium grey, with abundant coarse sand grains, weathers reddish brown, resistant; in 1 to 5 foot beds; interval of fine chert pebble conglomerate at top.	44	172
4	Covered.	43	128
3	Limestone, essentially a pelecypod coquina, light grey with abundant medium- to coarse-grained quartz grains; weathers light grey to light brown, resistant, in 1 to 3 foot beds.	60	85
2	Conglomerate, very fine, medium grey, mostly angular fragments of white quartz less than 1/16 inch diameter, a few rock		

Unit No.		Thickness in Feet Unit	Total from base
	fragments in dark grey silty? limestone matrix; weathers reddish brown in 1 to 12 inch beds.	21	25
1	Limestone, fine-crystalline, medium grey, silty in part pelecypod coquina, weathers light brown in 2 to 4 foot beds.	4	4
	Contact with underlying Neruokpuk sediments appears to be unconformable. Triassic strata strike 130 degrees and dip vertical, Neruokpuk strata strike 100 degrees and dip about 35 degrees south. Exposures insufficient to rule out possibility of faulting.		
	<u>Neruokpuk Formation</u>		
	Contact unconformable.		
	Phyllite, reddish grey, weathering brown, recessive, in 1 to 12 inch beds, estimated.	100	
	Cover, estimated.	100	
	Limestone, fine-crystalline, medium grey, with silt laminations; weathers light grey in beds up to 2 feet thick, estimated.	50	
	Phyllite, greyish green, with a few lenses of siltstone, crenulated and drag folded, cut by white quartz veins; weathers light grey in thin plates less than 1/4 inch, estimated.	1000	

Section 3: MOUNT SEDGWICK (117B/3, 68°51'N; 138°57'W)

A poorly exposed section was measured on the ridges on the east side of Trail River about 5 miles east of Mount Sedgwick. Triassic portion of section was measured near the head of a small western tributary of Philip Creek. Section was measured by E. W. Bamber, in early August(RCAF Aerial photograph A13470-127).

Unit No.		Thickness in Feet Unit	Total from base
	Kingak Formation (base)		
	Shales, black, exposed in creek bottom.	10	
	Covered, estimated.	200	
	Shublik Formation (228 feet, minimum)		
3	Sandstone, fine grained, quartzose with calcareous cement, medium to dark grey, bedding 1/2 to 2 feet; weathers light grey to brownish grey, breaking into 2 to 12 inch slabs and blocks, resistant. GSC loc. 59702 Monotis sp., Norian Upper Triassic.	12	228
2	Rubble covered interval of sandstone same as above. Two fossil collections from talus.	124	216
	58 feet above base GSC loc. 59703 Monotis sp. 4 feet above base. GSC loc. 59701 Monotis sp., Norian Upper Triassic.		
1	Rubble covered interval of sandstone, fine grained, dark grey, quartzose with upper 30 feet calcareous.	92	92
	Lisburne Group		
	Rubble with occasional slumped outcrops of limestone, fine to medium crystalline, light to medium grey, cherty and with silt laminae. GSC loc. 59704 5 feet from top.	175	

Section 4: BABBAGE RIVER SOUTHWEST OF TROUT LAKE (117B/13, 68°41'N; 139°03'W)

Measured on north side of Babbage River about 5 miles downstream from Cottonwood Creek, section 5. Measured by U. Upitis and D. Mayes, in late July (RCAF airphoto A13470-159, field No. 14 Neu).

Unit No.		Thickness in Feet Unit	Total from base
	Lower Jurassic		
	Shale, dark grey mostly covered microfossil sample 14 Neu. 2.	50	
	Shublik Formation		
7	Limestone, very fine crystalline, bluish black, weathers light grey to light brown in 2 to 4 foot beds, pelecypods on weathered surface.	68	183
6	Limestone, argillaceous, black, weathers dark grey in 1/2 to 4 inch beds, numerous pelecypods. GSC loc. 53302.	10	115
	Monotis ochotica (Keyserling), Norian, probably late Norian .		
5	Covered.	62	105
4	Limestone, fine grained, bluish grey, minor pyrite, weathers light bluish grey in 1 to 4 foot beds.	12	43
3	Shale, black with nodules or plate-like limestone concretions, fine grained, siliceous, bluish black, also pyrite nodules, limestone forms about 70 per cent of rock and is in lenticular wavy beds; weathers dark grey in 1/2 to 1 foot beds.	14	31
2	Covered.	7	17

Unit No.		Thickness in Feet Unit	Total from base
1	Limestone, calcarenite, light grey, filled with unoriented coarse brachiopod and pelecypod fragments, weathers light grey.	10	10
	Lisburne Group? (Mississippian)		
	Limestone, very fine grained to fine sugary texture, light grey, with 20 per cent blue chert inclusions; weathers grey.	25	
	Limestone, fine grained, light grey with echinoid columnals, 50 per cent blue-black chert concretions in intervals parallel to bedding; weathers brown to light grey.	26	

Section 5: BABBAGE RIVER AT JUNCTION OF COTTONWOOD CREEK (117B/14, 68°41'N; 139°11'W)

Measured on south side of Babbage River opposite mouth of Cottonwood Creek. Measured by U. Upitis and D. Mayes, early August (RCAF airphoto A13470-159, Field No. 15 Neu).

Unit No.		Thickness in Feet Unit	Total from base
	Lower Jurassic shale unit?		
19	Shale with some sandstone and concretionary interbeds, estimated.	300	
18	Shale, black, non-calcareous, forms sharp contact with underlying sandstones.	45	

Unit No.		Thickness in Feet Unit	Total from base
	Shublik Formation Upper Triassic		
17	Sandstone, slightly calcareous, blue-grey; weathers light grey in 2 to 4 foot beds, a few pelecypods on weathered surface.	42	369
16	Sandstone, blue-grey; weathers light grey in 1 to 4 foot beds, in part streaked yellow, calcite on bedding planes, a few weathered-out pelecypods.	8	327
15	Sandstone, slightly calcareous, light blue-grey; weathers light grey, in part brown, in 2 to 4 foot beds; pelecypods obtained from upper 5 feet where rock was more deeply weathered. GSC loc. 53322 *Monotis ochotica* Keyserling Norian probably late Norian and from 4 feet above base. GSC loc. 53320 *Monotis* sp.	30	319
14	Sandstone, light grey; weathers blue-grey with yellow streaks in 2 to 4 foot beds.	20	289
13	Sandstone, calcareous, light bluish grey; weathers greyish brown in 2 to 4 foot beds.	11	269
12	Shale, slightly siliceous, blue-black; weathers light bluish grey in 6 to 12 inch beds.	3	258
11	Sandstone, slightly calcareous, light grey; weathers brown with yellow stains in 3 foot beds.	3	255
10	Sandstone with numerous shale partings, light grey, slightly calcareous; weathers dark brown.	5	252

Unit No.		Thickness in Feet Unit	Total from base
9	Sandstone, slightly calcareous, very fine grained, 1/2 inch shale partings between beds; weathers light grey and brown in 2 to 4 foot beds.	20	247
8	Covered.	10	227
7	Sandstone, calcareous, very fine grained, light grey; weathers light grey-brown, massive.	5	217
6	Shale, black, pyritic; weathers light grey.	3	212
5	Sandstone, calcareous, light grey; weathers dark brown to grey.	9	209
4	Sandstone, calcareous, very fine grained, light grey weathers light grey in 1 to 3 foot beds with 2 to 6 inch black, pyritic shale interbeds 8, 13 and 14 feet above base.	14	200
3	Shale, black, very fine grained, pyritic; weathers dark grey to brown in 18 inch beds; brachiopods collected from unit and base of overlying sandstone. GSC loc. 53321 – indeterminate Spiriferoid-brachiopods.	2	186
2	Sandstone, calcareous, very fine grained, grey; a few small pyrite concretions, weathers brownish grey, 2 to 4 foot beds.	5	184
1	Covered.	179	179
	Lisburne Group? (Mississippian)		
	Limestone, slightly siliceous, finely crystalline, bluish grey; black chert in lenses 1 to 2 feet long and 6 inches thick, few calcite vugs about 5 inches diameter; weathers light grey to yellow-grey in 1 to 4 foot beds.	30	

Section 6: MOUNT WELCOME, BARN MOUNTAINS (68°36'N; 138° 28'W)

A partial section of Triassic strata on the top and west side of Mount Welcome in the Barn Mountains. This mountain forms part of the drainage divide between the Babbage and Blow Rivers. Section measured by D.K. Norris, early August (RCAF Aerial photograph A13383-138, Field number NC 227).

Unit No.		Thickness in Feet Unit	Total from base
	Shublik Formation		
	Overlying beds not present, top of mountain.		
7	Limestone, quartzose, fine-crystalline medium to light grey, with abundant stringers and small nodules of light to dark grey chert locally forming up to 50 per cent of rock. Thin quartzitic layers weather in relief and are crossbedded.	23	237
6	Covered.	29	214
5	Sandstone, fine grained, light grey weathering orange-brown in sheets and blocks 1/2 to 2 feet thick.	13	185
4	Mostly covered, some dark grey, silty shale showing through cover in lower 40 feet, remainder covered by sandstone blocks of overlying unit.	105	172
3	Limestone, silty, fine crystalline, medium dark grey, weathers yellowish brown in 1 to 6 inch beds. One foot pelecypod coquina 15 feet above base. GSC loc. 55373, Monotis ochotica Keyserling (Upper Triassic-Norian).	27	67
2	Limestone, fine crystalline, light grey with scattered small nodules and stringers of light grey chert; massive		

Unit No.		Thickness in Feet Unit	Total from base
	weathering in 1 to 6 inch beds. Base covered.	40	40
1	Covered, estimated.	200	
	Carbonates presumed top of Lisburne Group.	70	

Section 7: CENTRAL RICHARDSON MOUNTAINS (116I/8, 66°59'N; 136°08'W)

Section was measured across ridges on divide between Vittrekwa and Rock Rivers near latitude 66°69'N and longitude 136°08'W immediately south of where the Yukon-Northwest Territories boundary makes a right angle bend.

The Triassic rocks outcrop in a series of poor discontinuous exposures on the east side of the prominent west-dipping homoclinal ridge which forms the divide. They form a prominent thin, light grey unit on the RCAF air photograph A14368-36. The section was measured by writer in late August.

Unit No.		Thickness in Feet Unit	Total from base
	Upper Jurassic sandstones		
5	Mostly covered, forming a prominent recessive gully along crest of ridge. GSC loc. 52751 collected from concretionary sandstone 40 feet below top: Buchia ex gr. mosquensis-piochii. According to J. A. Jeletzky late Kimmeridgian to late Tithonian age.	105	503
4	Sandstone, fine grained, quartzose, light to medium grey; weathering light greyish brown in 2 inch to 4 foot beds, forming a prominent resistant cliff.	145	398

Unit No.		Thickness in Feet Unit	Total from base
3	Covered; mostly sandstone talus from overlying unit. Some fine pebble conglomerate present in talus. Five feet of sandstone with conglomerate lenses 112 feet above base.	165	253
	<u>Shublik Formation</u> (88 feet)		
2	Sandstone, very calcareous, fine to medium grained, light brownish grey to dark grey, with a few 1 to 3 inch dark grey argillaceous siltstone interbeds and shale partings; weathers light greyish brown in 1 to 3 foot beds; upper 25 feet only 50 per cent exposed. Contact with underlying limestones is abrupt. Abundant poorly preserved pelecypods occur in basal 30 feet, GSC loc. 52729.	54	88
	<u>Gryphaea</u> sp., and <u>Meleagrinella</u> sp. (possibly Upper Triassic according to E. T. Tozer).		
1	Limestone, aphanitic, light brownish grey; weathers light grey in indistinct 1/2 to 3 foot beds, moderately resistant. GSC loc. 52748 from upper 2 feet – pelecypods indet.	34	34
	<u>Imperial Formation</u>		
	Covered, forms grassy hillside, scattered outcrops of dark grey shales and siltstones occur along strike and beneath covered interval. They are assigned to the Upper Devonian Imperial Formation by A. W. Norris (in press).	500	

APPENDIX 2

Location of Fossil Collections other than those listed in described sections.

The following list includes fossil collections made at isolated localities by geologists of Triad Oil Company, and L.H. Green and J.A. Roddick in western Ogilvie Mountains. The various collections are positioned by latitude and longitude using the 1: 250,000 National Topographic Series maps which are available for the entire area covered by Operation Porcupine.

GSC loc. No.	Field No.	Location	Determination and age
Firth River area			
52795	176 MJ 1a	69°20'N 139°47'W Loney Creek, east limb of anticline	*Monotis ochotica* (Keyserling) Norian, probably Late Norian
44273	C1195	69°20' 139°49' Loney Creek	pelecypods indet.
44263	C1203	69°23' 139°34' Creek north of Loney Creek	*Oxytoma* sp. and spiriferids
Headwaters of Spring and Crow Creeks			
44256	C1184	69°06' 139°15'	*Monotis* sp.
44252	C1185	69°03' 139°15'	*Monotis* sp.
44249	C1186	69°02' 139°15'	*Monotis* sp.
44248	C1188	69°01' 139°14'	*Monotis* sp.
44250	C1189	68°59' 139°13'	*Monotis* sp.
Babbage River region			
a. **Trail River area**			
44258	770	68°46'30" 139°32'	*Monotis* sp.

GSC loc. No.	Field No.	Location		Determination and age
44272	772	68°47'30"	139°32'	Monotis sp.
44257	773	68°48'	139°30'	Monotis sp.
44270	776	68°48'	139°26'	Monotis sp.
44267	778	68°49'	139°26'	Monotis sp.
	b. Cottonwood Creek area			
44254	363	68°45'	139°25'	Monotis sp.
44255	1177	68°44'	139°19'	Monotis sp.
44253	1178	68°43'30"	139°19'	Monotis sp.
44251	1179	68°43'	139°18'	Monotis sp.
44269	1181	68°43'	139°17'	Monotis sp.
	c. Northern Barn Mountain			
44266	1111	68°36'30"	138°32'	Monotis sp.
44275	1112	68°36'30"	138°32'	pelecypods indet.
44259	1160	68°38'	138°28'	Monotis sp.
	722	68°36'	138°26'	Monotis sp.
	721	68°36'	138°25'	Monotis sp. and rhynchonellids
	718	68°35'	138°26'	Monotis sp.
44263	719	68°35'	138°26'	rhynchonellids
44271	720	68°35'	138°24'	Monotis sp.
44260	723	68°35'30"	138°20'	brachiopods indet.
South side of Monster syncline				
47163	RD 61(F) 501 4720	64°56'	141°18'	Halobia sp. Upper Triassic

GSC loc. No.	Field No.	Location		Determination and age
47132	GC 476A	64°58'	140°05'	Monotis sp. Norian
47139	GC 483	64°56'	139°55'	Halobia? sp. crushed ammonoids Upper Triassic
47138	GC 472B	64°57'30"	139°52'	Halobia sp. Upper Triassic
47133	GC 482	64°59'30"	139°38'	Halobia sp. Upper Triassic
47140	GC 482I	64°59'30"	139°38'	Halobia sp. Upper Triassic
47137	GC 482A5	64°59'30"	139°38'	Monotis sp. Upper Triassic
Rackla River				
47135	GC 37d	64°13'	134°07'	Juvavites (Anatomites) cf. knowltoni Smith Sirenites cf. senticosus (Dittmar) "Arcestes" sp. – Karnian
47130	GC 37dI	64°13'	134°07'	Halobia sp. Upper Triassic
47131	GC 37dII	64°13'	134°07'	Halobia sp. Upper Triassic
47136	GC 37dIII	64°13'	134°07'	Arcestes sp. Upper Triassic
47141	GC 38A	64°13'	134°07'	Monotis sp. Norian
47134	GC 27	64°13' Ridge west of Kathleen Lakes	134°20'	Monotis sp. Distichites? sp. Norian
Tombstone area				
68899		64°23'45"	138°52'	Daonella cf. D. tyrolensis Mojsisovics Middle Triassic probably lower Ladinian
68900		64°23'45"	138°52'	Monotis subcircularis Gabb Upper Triassic, upper Norian
69117		64°23'45"	138°52'	Posidonia cf. P. oberg probably Lower Triassic (Smithian)