GEOLOGICAL SURVEY OF CANADA
PAPER 90-22

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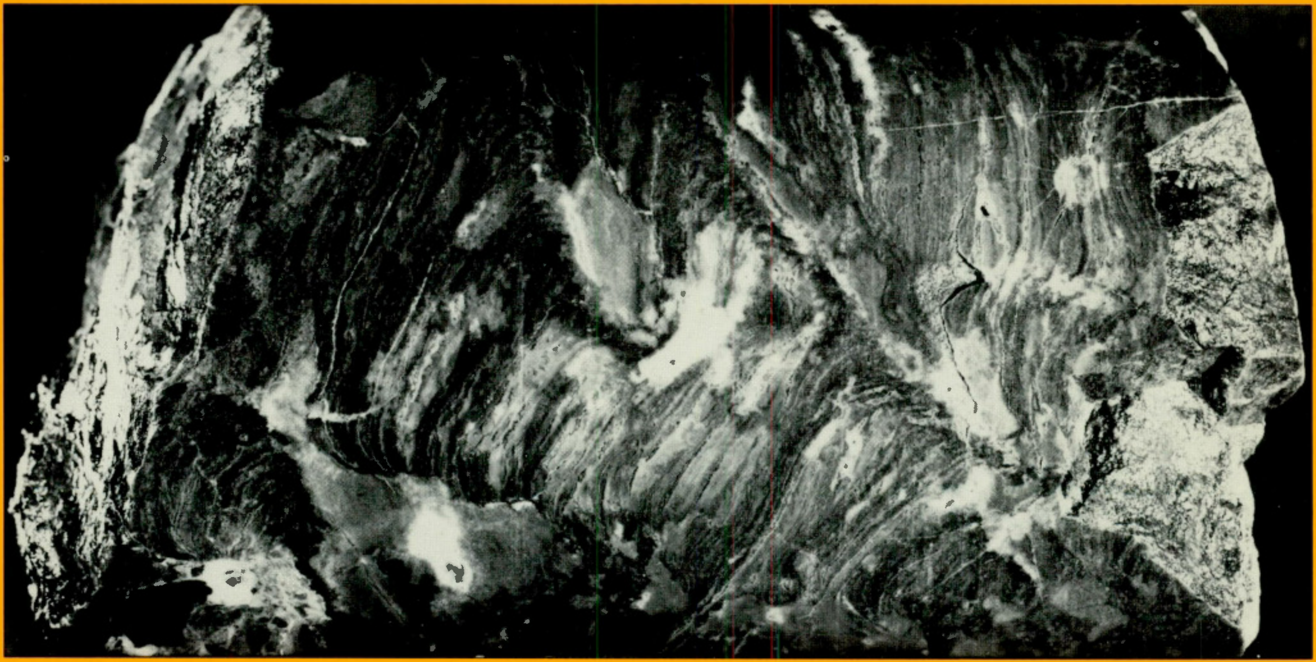
J.B.W. Wielens



1992

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Available in Canada through authorized
bookstore agents and other bookstores

or by mail from

Canada Communication Group — Publishing
Ottawa, Canada K1A 0S9

and from

Geological Survey of Canada offices:

601 Booth Street
Ottawa, Canada K1A 0E8

3303-33rd Street N.W.,
Calgary, Alberta T2L 2A7

A deposit copy of this publication is also available for reference
in public libraries across Canada

Cat. No. M44-90/22E
ISBN 0-660-14219-8

Price subject to change without notice

Cover illustration

Stromatolites in Precambrian to Cambrian carbonate in core from the Eskimo J-07 well

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Manuscript submitted: 90.03.07
Approved for publication: 90.10.28

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THE PRE-MESOZOIC STRATIGRAPHY AND STRUCTURE OF TUKTOYAKTUK PENINSULA

Abstract

On the Tuktoyaktuk Peninsula northeast of the Mackenzie Delta, Northwest Territories, Mesozoic and younger strata are underlain by a succession of pre-Mesozoic formations that form a complex system of horsts and grabens. These formations are penetrated to varying depths by about 50 wells, and substantial amounts of core and drill cuttings are available. Pre-Mesozoic subcrop lithotype patterns allow an accurate definition of the elements of the ancestral Eskimo Lakes Arch. The Tuk Horst forms the backbone of this Arch, and trends to the northeast, obliquely across the Peninsula and into the Beaufort Sea. Based on lithology, conodonts, and other fossils, none of its lithotype units correlates with formations in the Northern Interior Plains. The Tuk Horst contains, from older to younger, dolomite, clastic sequences, dolomite, volcanic rocks, quartzite, and dolomite. The clastic rocks, overlain and underlain by dolomite, are considered to be Precambrian. Hydrothermal alteration prevented absolute dating of the volcanic rocks; a latest Precambrian or earliest Cambrian age is suggested. The quartzite is Early Cambrian in age, and the dolomite at the northern end of the Tuk Horst is Middle Ordovician. The latter may overlie the quartzite unconformably or, more probably, by fault contact.

The Campbell Uplift is related in structural style and history to the Tuk Horst, and includes strata as young as the Middle Devonian Hume Formation. Large amounts of sand throughout the Ronning carbonate in the nearby Inuvik D-54 well may indicate an emergence of the uplift during early Paleozoic time. The lithotype of the Lower Cambrian rocks on the Tuk Horst indicates that the area was underlain by a Cambrian basin; the westward pinchout of the Lower Cambrian sandstone in the Northern Interior Plains basin shows that the basins were separated by a threshold or high, which later could have been the clastics source during Ronning carbonate deposition (Inuvik D-54).

The Tuk Horst is bound on the southeast side by a regular succession in the homocline of the Northern Interior Plains, with the Upper Devonian Imperial Formation as the youngest pre-Cretaceous rocks. The succession can be correlated through the Kilannak A-77 well to formations present on Banks Island. Of note is conglomerate in the upper part of the Imperial Formation adjacent to Tuk Horst. This lithotype is rare outside the study area and indicates an emergent area nearby; this demarcates the initial phase of tectonic activity of the ancestral Eskimo Lakes Arch.

To the northwest, the Tuk Horst is flanked by the "Tuk Flank," which consists of step-faulted blocks from southwest to northeast with alternating subcrop of carbonate of Early Ordovician to Early Devonian age. Part of the carbonate is Middle Ordovician; this age interval is represented by a lacuna in the Northern Interior Plains, but is present in the Mackenzie, Richardson, and Ogilvie mountains. In the Parsons area, Ronning carbonate changes facies to basinal shales. The carbonate farther to the southwest is overlain, probably unconformably, by rocks tentatively considered Permian.

Structurally, the alternating subcrop pattern in the Tuk Flank indicates the presence of pre-Permian and post-Devonian or "Ellesmerian" deformation, which appears to link the study area to the Richardson and Ogilvie mountains. It is unclear if the carbonate formations butt against the Tuk Horst or if they swing around to parallel the Horst, as appears to be indicated by dip measurements.

Résumé

Dans la péninsule de Tuktoyaktuk, au nord-est du delta du Mackenzie, dans les Territoires du Nord-Ouest, des strates mésozoïques et plus jeunes reposent sur une succession de formations pré-mésozoïques qui constituent un système complexe de horsts et de grabens. Une cinquantaine de puits ont été forés à diverses profondeurs dans ces formations; ils nous fournissent une quantité considérable de carottes et de débris de forage. Grâce à la configuration des lithotypes dans les affleurements enfouis pré-mésozoïques, il nous est possible de définir avec précision les éléments du proto-arche des lacs Eskimo. Le horst de Tuk constitue l'arête de l'arche; elle est orientée vers le nord-est, obliquement à travers la péninsule, et se prolonge jusque dans la mer de Beaufort. À en juger pas la lithologie, les conodontes et d'autres fossiles, aucunes de ses unités lithotypiques ne peut être mise en corrélation avec les formations dans le nord des plaines Intérieures. Le horst de Tuk contient les lithologies suivantes, données en âge ascendant : dolomie, séquences clastiques, dolomie, volcanites, quartzite et dolomie. Les roches clastiques, qui sont sous-jacentes et susjacentes à la dolomie, remontent au Précambrien. En raison de l'altération hydrothermale, il est impossible d'établir l'âge absolu des unités volcaniques, qui pourraient remonter au Précambrien terminal ou au Cambrien initial. Le quartzite date du Cambrien inférieur, tandis que la dolomie à l'extrémité nord du horst de Tuk remonte à l'Ordovicien moyen. Cette dolomie pourrait reposer en discordance sur le quartzite ou, ce qui est plus vraisemblable, être séparée de lui par un contact de faille.

Le style structural et l'histoire du soulèvement de Campbell associent cette structure au horst de Tuk; le soulèvement contient des strates qui ne remontent qu'au Dévonien moyen (Formation de Hume). La présence de quantités importantes de sable dans l'ensemble du carbonate de Ronning, dans le puits Inuvik D-54 qui se trouve à proximité, pourrait témoigner de l'émersion du soulèvement au Paléozoïque inférieur. Dans le horst de Tuk, le lithotype des roches du Cambrien inférieur indique que la région reposait sur un bassin cambrien; dans le bassin de la partie nord des plaines Intérieures, le grès du Cambrien inférieur disparaît progressivement en biseau vers l'ouest, ce qui montre que les bassins étaient séparés par un seuil ou une hauteur qui, plus tard, pourrait avoir été la source des sédiments clastiques au cours de l'accumulation du carbonate de Ronning dans le puits Inuvik D-54.

Le horst de Tuk est limité au sud-est par une succession régulière dans l'homocline des Plaines Intérieures du nord; la Formation d'Imperial, du Dévonien supérieur, représente les roches pré-crétacées les plus jeunes. La succession peut être corrélée à partir du puits Kilannak A-77 jusque dans l'île Banks. La présence de conglomérat dans la partie supérieure de la Formation d'Imperial, près du horst de Tuk, est notable. En effet, ce lithotype est rare à l'extérieur de la zone à l'étude, et il indique la présence d'une zone émergente voisine, qui marque la phase initiale de l'activité tectonique du proto-arche des lacs Eskimo.

Le versant de Tuk longe le horst de Tuk au nord-ouest; il se compose de blocs faillés disposés en gradins du sud-ouest au nord-est, avec alternance d'affleurements enfouis de carbonates de l'Ordovicien inférieur au Dévonien inférieur. Une partie des carbonates remonte à l'Ordovicien moyen; cet intervalle d'âges, que représente une lacune dans le nord des plaines Intérieures, est reconnu dans les monts Mackenzie, Richardson et Ogilvie. À proximité de Parsons, le carbonate de Ronning subit un changement de faciès et se transforme en schistes argileux de bassin. Plus loin au sud-ouest, il repose vraisemblablement en discordance sous des roches qui remontent provisoirement au Permien.

Du point de vue de la structure, la configuration alternée du Tuk Flank témoigne d'une déformation pré-permienne et post-dévonienne ou «ellesmérienne», qui semble relier la zone étudiée aux monts Richardson et Ogilvie. Nous ne savons pas si les formations carbonatées butent contre le horst de Tuk ou si elles le contournent pour lui devenir parallèles, ce que semblent indiquer les pendages.

INTRODUCTION

The Tuktoyaktuk Peninsula lies to the northeast of the Mackenzie Delta in the Northwest Territories, between latitudes 68°20′ and 70°20′N and longitudes 129° and 135°W (Fig. 1). Cenozoic and Mesozoic clastic sequences are underlain by Paleozoic and Proterozoic clastic and carbonate strata. Differential uplift and subsidence by faulting and possibly by folding has produced a complex subcrop pattern beneath the sub-Mesozoic unconformity. Initial interpretation of a Geological Survey of Canada deep-reflection seismic line, crossing the southwest part of the peninsula (Fig. 1), indicates potential major pre-Mesozoic deformational foreshortening (Cook et al., 1987). In addition, relief on pre-Mesozoic structures, with or without modification by Mesozoic tectonism, has produced regionally significant potential hydrocarbon traps, which under the right conditions could host a major oil or gas field. A thorough understanding of the pre-Mesozoic geology of the Tuktoyaktuk area is fundamental to understanding the hydrocarbon potential of the area.

Objective and methods

A geological study of pre-Mesozoic strata underlying Tuktoyaktuk Peninsula, based on borehole data, was

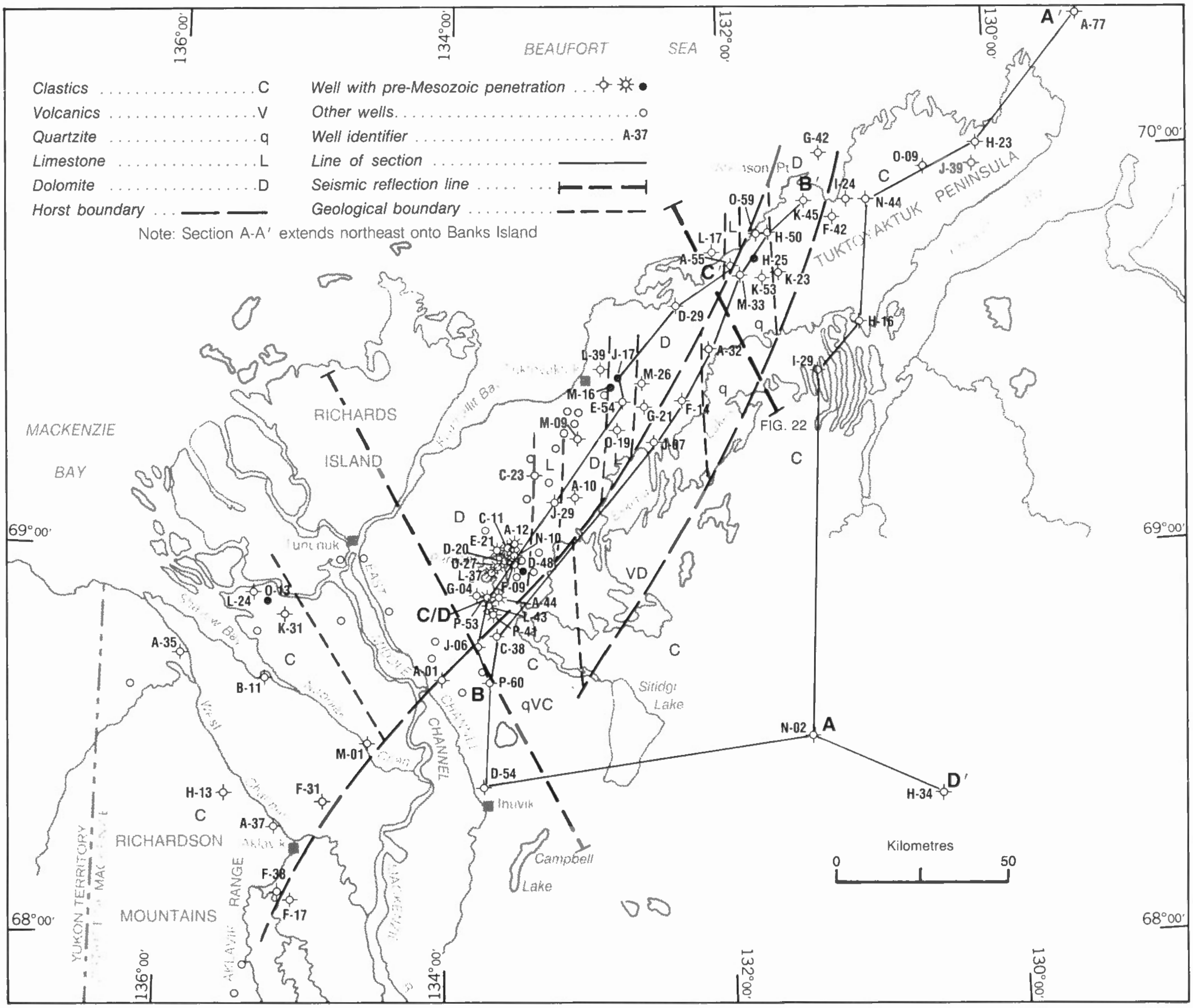

Figure 1. Wells penetrating pre-Mesozoic strata, and location of cross-sections A–A′, B–B′ and Figure 22.

initiated in late 1986. The objective was to gather as much information as possible about the relatively unknown geological history, stratigraphy, and structure and to develop a model pertaining to these three components. This involved a detailed study of virtually all ditch cutting samples and core from the entire Tuktoyaktuk Peninsula to compare the stratigraphy with that of the adjacent Northern Interior Plains. Many cores and cutting intervals were sampled for microfossil ages and other data to assist in correlation. Wireline logs, lithology logs, and well history reports were used to obtain correlation and structural information; seismic lines were used to resolve structural questions.

Previous work

Most of the previous studies of the pre-Mesozoic sequences in the area are limited in scope. A general regional overview and some seismic lines from this and adjacent areas have been presented by Lerand (1973); he considered mainly the Beaufort Basin and its general geological and tectonic relationship to the basins and arches in the Northern Yukon, southwestern Arctic Islands, and Northern Interior Plains. Paleontological age determinations for several wells have been published by Brideaux et al. (1975, 1976). Glaister and Hopkins (1974) interpreted cores from Nuvorak O-09 in the northern part of the Peninsula as turbidity current deposits of Devonian Imperial Formation age.

Dyke (1975) described the Campbell Uplift as an elongated dome-like feature, cut by numerous, mainly vertical, longitudinal faults with a general northeast trend. According to Dyke, the Precambrian rocks display locally severe deformation, whereas the Paleozoic succession, which overlies them unconformably, dips gently away on all sides from the central part of the dome. However, M.P. Cecile and L.S. Lane (pers. comm., 1987), in preliminary remapping of the uplift, found no evidence of severe deformation of Proterozoic strata. The total structural relief produced by the faults is in the order of 1000 to 1500 m (Dyke, 1975). Although the present Campbell Uplift is of Laramide age, it is possibly a rejuvenation of "Ellesmerian" structures. Norris and Calverley (1978) described exposed rocks of Precambrian, Paleozoic, and Mesozoic age in the Campbell Uplift. They found that of the Paleozoic formations, the youngest, Middle Devonian carbonate strata overlie Paleozoic Vunta dolomite of Ordovician to Silurian age. This in turn unconformably overlies Precambrian grey quartzite, red, green, and grey argillite, and silty, greyish red, fine grained dolomite with stromatolites. Norris (1981b) published a regional geological map and structural cross-section of the uplift.

A deep-reflection seismic line (see Fig. 1) recently acquired by the Geological Survey of Canada (GSC) was interpreted by Cook et al. (1987). They found evidence of major pre-Mesozoic, probably compressional, structural deformation. Mesozoic and younger formations are cut by listric normal faults, which at depth are parallel to reflections that probably represent Precambrian strata. Thrust faults offsetting Proterozoic formations under the Campbell Uplift are Proterozoic or late Paleozoic in age. This implies that "Ellesmerian", or older, compressional structures may underlie the Arctic Coastal Plain.

Wielens (1987) presented a preliminary study of the pre-Mesozoic geology of the area. The main findings of the study were the presence of formations that appear correlatable to the Imperial, Landry and Arnica, and Ronning age formations in the adjacent areas, and the presence of complex pre-Mesozoic (Ellesmerian?) structures involving Paleozoic and Precambrian formations. Wielens outlined a northeast trending paleo-ridge cored by Precambrian(?) quartzite, flanked on the southeast by Upper Devonian clastic rocks and on the northwest by Paleozoic carbonates and shales in a complex subcrop pattern.

A large, post-Paleozoic, positive gravity trend across the Peninsula was named the Eskimo Lakes Arch by Young et al. (1976). It is part of the Aklavik Arch of Jeletzky (1961). The authors do not precisely define the boundaries of each arch.

Several authors mention the present study area in reports describing geological features in the Northern Interior Plains and present them in a regional relationship. Williams (1986b) coined the term "Pre-Identifiable Paleozoic" or PIP rocks for wells wherein the age of the bottom-hole formation is uncertain. He identified several of these wells on the Eskimo Lakes Arch. Williams (1987) presented an overview of the distribution of the Cambrian formations and their depositional environments. D.K. Norris (1974) mentioned the area in the light of regional tectonic evolution. Gilbert (1973) touched on the area with some of his regional time-slice maps.

Mesozoic and Cenozoic successions on the Tuktoyaktuk Peninsula have been described by Dixon (1982, 1986). A list of formation tops in the wells drilled in the study and surrounding area has been published by Dixon et al. (1987) and updated by Dixon and Peach (1988).

GEOLOGICAL SETTING

Geological background

The study area is a physiographic region of the Mackenzie Delta (Douglas, 1970). A setting for the geology of the study area is provided by the geology of the adjacent area north of 66° latitude in the Northern Interior Plains (containing Anderson Plain, Peel Plateau, Peel Plain) as described by Pugh (1983), and Yorath and Cook (1981).

The Precambrian crystalline basement outcrops east of Great Bear Lake and is overlain by a westward thickening sedimentary wedge. Successively younger formations, ranging in age from Precambrian through Quaternary, outcrop toward the west and northwest. The sedimentary sequence can be divided into four major units of Proterozoic, Paleozoic, Mesozoic, and Cenozoic age, each bounded by unconformities representing major time gaps.

The Proterozoic succession (Aitken and Pugh, 1984) of unmetamorphosed clastic and carbonate rocks, deformed by large-scale folds and faults below a major, terminal Proterozoic erosional event, was peneplained before the onset of Cambrian sedimentation in a subsiding basin (Williams, 1987). Locally, the Precambrian appears to be capped by volcanic rocks of unknown age. The Paleozoic sequence is composed of a thick carbonate succession with clastic rocks deposited during the initial and final stages. The depositional centre of the Cambrian clastic sequence in the Plains was located far to the southeast of the study area (near Colville Lake area). These units, especially the sandstone of the lowermost formation, the Mount Clark or Old Fort Island, thin to a zero edge southeast of Tuktoyaktuk Peninsula. The shape of the central part of that Early Cambrian basin is roughly outlined by the overlying evaporitic sequence of the Saline River Formation.

Thick, platform-type carbonate rocks constitute the bulk of the Paleozoic rocks. They change facies into shale in the Richardson Trough at the western boundary of the Interior Plains. The carbonate is overlain by a rapidly westward-thickening wedge of clastic rocks of up to Mississippian age. A period of westward tilting and extensive erosion preceded the onset of Mesozoic sedimentation. The Mesozoic unit (Yorath and Cook, 1981) forms an unconformable, thin veneer of clastic rocks in the east which thickens drastically toward the west and north. In the same directions it truncates progressively younger Paleozoic rocks. Tertiary clastic rocks are present in the study area and offshore in the Beaufort Sea. Much of the Interior Plains is covered by a thin, unconsolidated Quaternary glacial till.

Structurally, the Paleozoic formations form a gently west and northwest dipping homocline.

Geology of the study area

As will be illustrated in the following chapters, the ages of the stratigraphic units subcropping the Mesozoic of Tuktoyaktuk Peninsula define a horst running obliquely in a north-northwest direction across the peninsula and into the Beaufort Sea. The horst is flanked by much younger Paleozoic formations and forms the backbone of the ancestral, pre-Mesozoic phase of Eskimo Lakes Arch (Young et al., 1976). It is called Tuk Horst in this paper. Here, the oldest rocks underlying the Mesozoic unconformity are found: Precambrian, Cambrian, and Middle Ordovician rocks subcrop. None of these units is directly correlatable to known formations in the Northern Interior Plains. The section consists of siliciclastic, carbonate, and volcanic rocks, which tend to become younger in a northeasterly direction. The Campbell Uplift forms part of the Tuk Horst and is the only outcrop of this feature; rocks ranging in age from Precambrian to Middle Devonian are present. The Early Cambrian quartzite on Tuk Horst indicates the presence of a Cambrian basin, separated by a high from one in the Northern Interior Plains as described above.

On the southeast side of the horst (the Stable Platform), clastic rocks of the Imperial Formation subcrop. Structurally, they belong to the stable mainland "platform", and form a stable reference point for the tectonic movements in the study area. The strata can be correlated lithologically to similar rocks toward the south in the Northern Interior Plains, and also toward the north through the Kilannak A-77 well in the Beaufort Sea to similar rocks in the Orksut I-44 well on Banks Island. Unlike Imperial rocks elsewhere, the formation contains conglomerate in several well locations on the peninsula. The conglomerate indicates a nearby emergent area, for which the Tuk Horst and its adjacent area to the west-northwest is a plausible candidate. The composition of the pebbles is similar to that of rocks present in that direction. The contact of the Stable Platform with the Tuk Horst is a fault, the exact nature (thrust, normal, or lateral) of which is unknown. Although it could be composed of a series of step faults, seismic data severely limit the area where those can be present. Some truncation and thinning of the Imperial formation is visible on seismic lines close to the contact with the Tuk Horst. The vertical movement of the horst is in the order of kilometres with respect to the Stable Platform.

On the opposite, northwest side of the Tuk Horst the subcropping units are mainly carbonate and shale. They define the "Tuk Flank" and are the second component of the ancestral Eskimo Lakes Arch. The strata range in age from Ordovician Ronning Group through Devonian Landry Formation. The carbonate rocks subcrop in a repetitive pattern of alternating ages, which indicates pre-Laramide, Ellesmerian structure; their directional trend is either discordant to and possibly truncated by the Tuk Horst or it may swing to parallel the horst. Some of the dolomite in this area, and that mentioned on the Tuk Horst, is of Middle Ordovician age. Rocks of this age are unknown in the adjacent Northern Interior Plains; to explain their presence, a Middle Ordovician hinge line in the neighbourhood of the Peninsula has to be postulated. Other dolomite in this area correlates to the Franklin Mountain Formation. In the Parsons area, adjacent localities with cherty shale and cherty dolomite indicate that the position of the facies change from dolomite to shale for this formation probably extends northwest from the Richardson Trough into this area. The contact of the carbonate area with the Tuk Horst is a series of step faults, visible on seismic lines, but the nature of the faults is unknown. The Tuk Flank has been moved upward a considerable distance with respect to the Stable Platform area. Toward the southwest, near East Channel of the Mackenzie Delta, instead of carbonate, a succession of interbedded clastic and carbonate rocks subcrop. These bear a strong resemblance to the Carboniferous-Permian formations described by Bamber and Waterhouse (1971). This Permian succession appears to overlie Silurian to Devonian carbonates unconformably with an enormous amount of section being absent locally, somewhat analagous to the situation in the northern Richardson Mountains, where Carboniferous to Permian rocks unconformably overlie substantially older formations.

REGIONAL STRATIGRAPHY

A reference framework of the stratigraphy in the general area is necessary in order to understand the geology and structure of the pre-Mesozoic of Tuktoyaktuk Peninsula. A brief, relevant description of the stratigraphic sequence of the pre-Mesozoic formations of the adjacent Northern Interior Plains, in the area roughly north of latitude 64°, is presented to lay this foundation. The strata have been described in some detail by Tassonyi (1969), Aitken et al. (1973), Pugh (1983), and Aitken and Pugh (1984). This outline is followed by the description of the succession in the study area.

The pre-Mesozoic formations are outlined in Table 1 and consist of a succession of lithotypes, several of which are generally not easy to distinguish from each other. Although Precambrian rocks in the subsurface are penetrated in only a few wells and to a depth of only a few tens of metres, they have been tentatively correlated by Aitken and Pugh (1984) to formations exposed in the Mackenzie Mountains. The Paleozoic succession is fairly well understood (Pugh, 1983).

Precambrian strata

A tremendous thickness of Precambrian supracrustal rocks underlies the Northern Interior Plains. Seismic line data, submitted to the Canadian Oil and Gas Lands Administration (COGLA), show 8-12 km of layered sequences beneath an angular sub-Cambrian unconformity; gentle, large-scale folds (wavelengths of a few kilometres) and faults (offsets of a few hundred metres) are evident within this sequence below a major unconformity within the Precambrian. The folded and faulted strata have not been penetrated in wells. Beneath this supracrustal succession is a seismically transparent zone, assumed to be crystalline basement.

Precambrian formations are exposed in the Mackenzie Mountains (Aitken et al., 1982), in the Brock Inlier on the Coppermine Arch (Balkwill and Yorath, 1970), and on nearby Banks and Victoria islands (Thorsteinsson and Tozer, 1962; Miall, 1976).

Where penetrated in the subsurface of the Northern Interior Plains, the Precambrian comprises a wide variety of lithotypes. A correlation of the subsurface rocks to the formations of the Mackenzie Mountains supergroup (Aitken, 1981) has been presented by Pugh (1983) and Aitken and Pugh (1984) for the area to the northwest of their Fort Norman Structure (far older rocks subcrop to the southeast of it). From older to younger, the formations are: 1) Sub-H1 beds; 2) Map unit H1 of Aitken et al., (1982); 3) Tsezotene Formation; and 4) Katherine Group. Lithologically, these units resemble part of the Shaler Group (Thorsteinsson and Tozer, 1962) exposed on Banks and Victoria islands.

In the subsurface, Sub-H1 beds are over 200 m thick (all thicknesses are from Pugh, 1983), and consist of varicoloured siliceous shale with intercalated silicified siltstone and sandstone. The Map-unit H1 is a distinctly coloured dolomite succession over 250 m thick, containing varicoloured chert. The colours range from pink to yellow, green or white, locally with characteristic red streaks. Black shale or siltstone may be present, especially near the base of Map-unit H1. The Tsezotene Formation consists of over 800 m of black, siliceous argillite. Some varicoloured chert and orthoquartzite may be present in the section. It overlies the dolomitic unit with a sharp contact. The Katherine Group is composed

TABLE 1

General table of formations

SYSTEM	EPOCH	FORMATION	GROUP	LITHOTYPE	MAX. THICKNESS
	Late	Imperial		Grey shale, silt, sandstone	850 m
		Canol		Black bituminous, cherty shale	100 m
		Ramparts		Platform + reefal limestone	400 m
		Hare Indian		Grey-green shale, siltstone	230 m
DEVONIAN	Middle	Bluefish Mbr		Black, bituminous shale	20 m
		Hume		Fossiliferous limestone	100 m
		Landry		Brown pelletoid limestone	570 m
Early	Arnica			Brown dolomite	
		Tatsieta		Green shale, limestone	165 m
~~	~~~~~~~~~	~~~~~~~~~~~~~	~~~~~~~~~	~~~~~~~~~~~~ Unconformity ~~	~~~~~~~~~~~~~~~~~
	Late	Peel	R	Pale dolomite	390 m
SILURIAN			o		
	Early		n		
		Mount Kindle	n	Brown dolomite	500 m
	Late		i		
ORDOVICIAN	Middle ~~~	~~~~~~~~~~~~~	~~ n ~~~	~~~~~~~~~~~ Unconformity ~~	~~~~~~~~~~~~~~~~
	Early	Franklin Mtn	g	White cherty dolomite	900 m
	Late	Saline River		Evaporite, shale, dolomite	470 m
CAMBRIAN	Middle	Mount Cap		Shale, dolomite	180 m
	Early	Old Fort Island		White sandstone	70 m
~~	~~~~~~~~~	~~~~~~~~~~~~~	~~~~~~~~	~~~~~~~~~~~~ Unconformity ~~	~~~~~~~~~~~~~~~~~
		Katherine Gp		Quartzite	>160 m
PRECAMBRIAN		Tsezotene		Black argillite	>800 m
		H1		Cherty dolomite	>250 m
		Sub H1		Shale	>200 m

of grey, quartzose, coarse siltstone and fine sandstone and is over 160 m thick. The upper part of the unit may grade into a siliceous dolomite.

Basalt underlies the Paleozoic rocks in a number of boreholes. Its age is unknown, preventing correlation to basalt found in outcrop.

Paleozoic strata

The complete succession of Paleozoic strata underlying the northwestern part of the Northern Interior Plains can be broadly subdivided into lower clastic, middle carbonate, and upper clastic units, each comprising several formations.

Lower clastic unit

The lower clastic unit consists entirely of Cambrian age sequences. The formations thin toward the north and west, and become dominated by carbonate toward the north. Locally, evaporitic strata constitute a large part of the succession. The reader is referred to Williams (1987) for up-to-date cross-sections and distribution maps of the Cambrian formations.

Old Fort Island Formation

At the base is Lower Cambrian, white, clear quartzose sandstone of the Old Fort Island Formation, or the equivalent Mount Clark Formation. It reaches a maximum thickness of 70 m in the Colville area and thins rapidly to a zero edge westward (about 25 km west of Tedji Lake, based on well-log correlations) and probably northward (no well control). The formation unconformably overlies the Proterozoic beds or basalt. The sandstone is generally friable, but locally is well indurated by extensive silicification.

Mount Cap Formation

The Old Fort Island Formation is conformably overlain by the Lower to Middle Cambrian Mount Cap Formation, which consists of a glauconitic succession of varicoloured shale, interbedded with siltstone and dolomite, and may reach a thickness of up to 180 m in the Colville area. The Mount Cap thins northward and becomes dominated by dolomite. Westward it reaches a zero edge on the Mackenzie Arch (Aitken et al., 1973) at a position farther west than the underlying Old Fort Island Formation. Where not bioturbated, the shale is an organic-rich, potential source rock (Wielens et al., 1990).

Saline River Formation

The Mount Cap is succeeded by the (possibly Middle to) Upper Cambrian, evaporitic Saline River Formation. The latter consists of an upper and usually lower unit of varicoloured shale with interbedded anhydrite, which may envelop a middle salt unit. The thickness of the salt varies tremendously from well to well; the complete formation reaches 470 m in thickness in the Colville Area, but northward decreases to zero before the Old Fort Island reaches its zero edge, while westward it stretches far beyond the zero edge of the Old Fort Island Formation. The top of the Saline River Formation is picked at the highest red shale under thick Paleozoic carbonate; the bottom is at the lowermost presence of evaporite (generally in the lower shale unit).

Carbonate unit

The Carbonate unit comprises a thick succession of platform carbonate with minor shale and overlies the lower clastic unit. Dolomite is the dominant rock type. Limestone is present in the upper part of the unit and where the dolomite changes to a basinal facies.

Franklin Mountain Formation

Conformably overlying the Saline River is the Upper Cambrian to Lower Ordovician Franklin Mountain Formation. It has been subdivided into three informal members (Macqueen, 1969, 1970): the lower cyclic member with microcrystalline to aphanitic, cream dolomite, which near the base of the member is grey and interbedded with grey shale; the middle rhythmic member, composed of fine to medium crystalline, usually cream coloured dolomite; and the upper cherty member, of cream-white to pale brown, fine to medium crystalline dolomite with, in its upper part, abundant white coloured chert, silicified oolites and stromatolites, and euhedral quartz crystals. The cherty member can be up to 400 m thick. The formation is not very fossiliferous and reaches a thickness of up to 920 m in the Northern Interior Plains (Pugh, 1983). Only the cherty member is important to this study for correlation purposes. The underlying members are difficult to distinguish in the subsurface and the characteristics that allow subdivision vanish to the north and west.

Mount Kindle Formation

The Franklin Mountain Formation is unconformably overlain by the Upper Ordovician to Silurian Mount Kindle Formation, which contains very fine to coarse crystalline, light to dark brown dolomite with only small amounts of white chert and quartz crystals. The formation commonly contains silicified fossils. A thickness of 500 m has been reported in the Northern Interior Plains area (Pugh, 1983). Middle Ordovician rocks are absent from the Northern Interior Plains, and this period of time is represented by an unconformity, which diminishes in importance west toward the Richardson Trough where the Middle Ordovician is represented by basinal shale. Although a major unconformity, the contact with the underlying Franklin Mountain Formation is difficult to pick in the subsurface. In many areas in the Northern Interior Plains where it has been identified, it is characterized by a gamma-ray wireline log kick, and/or the presence of green shale, and/or floating, rounded quartz grains (Wielens and Williams, 1988). Locally in the Peel area, there even may be a sandstone present (unpublished data), equivalent to the Little Doctor sandstone of the basal Mount Kindle Formation in the area northwest of Great Slave Lake (Meijer Drees, 1975). Identification of brachiopods found in this sandstone suggest an age range of Middle to Late Ordovician (Norford, *in* Meijer Drees, 1975, p. 55).

Peel Formation

The Mount Kindle Formation is conformably to discomformably overlain by the Upper Silurian to possibly Lower Devonian Peel Formation (Pugh, 1983), which is composed of pale grey to buff, microcrystalline dolomite, locally silty or argillaceous; its thickness varies from 0 to 390 m in the Northern Interior Plains.

The Franklin Mountain, Mount Kindle and Peel formations form the Ronning Group according to Pugh (1983); he revived this name [after Norford and Macqueen (1975) had abandoned it for outcropping formations] for convenience of use in the subsurface. The Ronning Group is retained in this paper. Separation of the carbonate formations within the Ronning Group on the basis of wireline logs in the area north of the 68th parallel is very difficult, because they consist of a succession of very similar and monotonous lithotypes. The dolomite of the group changes facies to the black shale and carbonate of the Road River Formation in the Richardson Trough to the west, at the location of the Richardson Mountains.

Tatsieta Formation

The Tatsieta Formation (Pugh, 1983), which is of probable Early Devonian age, is a pale buff limestone with interbedded green shale and usually one or more intraformational, conglomeratic beds. It overlies the Peel Formation with sharp contact and can be up to 165 m thick in the Northern Interior Plains.

The Tatsieta is equivalent to the lower limestone member of Tassonyi's (1969) Gossage Formation. No age determinations are available for the Tatsieta. It is a unit with evidence of several phases of erosion/deposition, and many internal gaps; the conglomerate may represent main phases in the sub-Devonian transgression (G.K. Williams and D. Morrow, pers. comm., 1987).

Arnica Formation

The Lower Devonian Arnica Formation, consisting of light to dark brown, medium to fine (respectively) crystalline dolomite, overlies the Tatsieta conformably and represents the transition from shallow to open marine conditions (Pugh, 1983). Its thickness is a function of dolomitization processes, and the contact with the overlying Landry Formation is diachronous. The fossil-poor Arnica increases in thickness westward at the expense of the overlying formation, and the contact can be sharp or gradual.

Landry Formation

The upper Lower to lower Middle Devonian Landry Formation is a brown, aphanitic limestone with pellets and fossil debris. The usual presence of crinoid ossicles with twin canals indicates a middle Emsian to early Eifelian age.

The combined Arnica and Landry formations in the Northern Interior Plains increase in thickness toward the west, reaching a maximum of about 570 m.

Hume Formation

The Middle Devonian Hume Formation consists of dark grey to black, argillaceous, bioclastic, fossiliferous limestone and interbedded shale and has a remarkably consistent thickness of about 100 m throughout the Northern Interior Plains. The contact with the underlying Landry Formation is sharp and easy to pick on wireline logs. Strata of the Hume Formation represent a drowning event. In general, the lower part of the formation is quite argillaceous, while the upper part is limestone. The top of the Hume Formation marks the end of platform carbonate deposition in the area. Locally, reefal carbonate developed later in the Ramparts Formation.

Carbonate rocks of the Tatsieta, Arnica, Landry and Hume formations change facies toward the Richardson Trough, where they grade into shale of the Road River Formation (Pugh, 1983).

Upper clastic unit

Hare Indian Formation

The Hume Formation is overlain with a sharp contact by the upper clastic unit. The base of the unit is a succession of Middle Devonian, radioactive, black, bituminous, basinal shale of the Hare Indian Bluefish Member (Pugh, 1983). The shale is quite characteristic, easily picked on gamma-ray wireline logs, and has source rock potential (Feinstein et al., 1988). The shale is about 20 m thick throughout the area. Locally it is overlain by Hare Indian interbedded grey shale, siltstone, and occasional limestone, which form a monotonous succession up to 250 m thick (including the Bluefish Member). The upper part of the formation with the grey shale thins rapidly to zero toward the north and west. The lower Bluefish Member remains consistent in thickness until 131W longitude, west of which it thins. The Hare Indian black or grey shale is overlain by the black, basinal shale of the Canol Formation in locations where the Ramparts Formation is absent.

Ramparts Formation

The Middle Devonian Ramparts Formation is present only locally, on the thicker parts of the Hare Indian Formation. The contact is gradational. The Ramparts consists of a lower, platformal limestone, locally overlain by reefal facies limestone which forms the chalkified reservoir in the Norman Wells field. A thin, bituminous and shaly limestone bed, the Carcajou marker (Tassonyi, 1969), may separate the platformal and reefal units. Adjacent to the reef area, a quartzose sandstone, named the Sandy member by Pugh (1983), is present and correlative to the Ramparts in age (Mackenzie et al., 1975). Reefal growth was terminated by drowning. The Ramparts is conformably overlain by the Canol Formation.

Canol Formation

The Early Frasnian Canol Formation consists of radioactive, siliceous shale, the high organic content of which makes it an excellent potential source rock (Snowdon et al., 1987). The maximum thickness of the Canol is about 100 m; the formation is much thinner where it overlies the Ramparts. Where the Ramparts Formation and the Hare Indian grey shales are absent due to a period of non-deposition in a starved basin, the Upper Devonian Canol Formation directly overlies the Middle Devonian Bluefish Member.

Imperial Formation

The youngest Upper Devonian formation in most of the area is the Imperial Formation (Braman, 1981; Williams, 1986a). It consists of interbedded, marine shale and siltstone with minor sandstone, and conformably overlies the Canol Formation with a gradational contact. The formation forms a west and northwest thickening wedge 0 to 1900 m thick, which is partly depositional and partly erosional. The Imperial Formation in most of the Northern Interior Plains is overlain by Cretaceous formations, which are distinguishable from the Imperial only by micropaleontological determination. The large, erosional hiatus is extremely difficult to pinpoint in both subsurface and outcrop, although it represents a gap of about 250 million years.

Carboniferous and Permian clastic rocks are only present at the northeastern edge of the Richardson Mountains and on Eagle Plain, west of the Richardson Mountains.

Unconformities

Three major unconformities are widespread and recognized in and above the subsurface Paleozoic suite: the sub-Cambrian, the sub-Devonian (Tatsieta), and the major, but difficult to recognize, sub-Mesozoic. In the literature, other unconformities are described or inferred from surface or subsurface data. One of these is the important Middle Ordovician unconformity found between the Mount Kindle and Franklin Mountain formations (Norford and Macqueen, 1975), which, as previously noted, is difficult to recognize within the subsurface Ronning Group of the area.

PRE-MESOZOIC STRATIGRAPHY OF THE TUKTOYAKTUK AREA

At the time of writing, 52 wells have penetrated pre-Mesozoic rocks on the Tuktoyaktuk Peninsula. A large cluster of wells is located on the southwestern part of the peninsula near Parsons Lake and another on the northwest coast near Atkinson Point (Fig. 1). The East Reindeer wells in the south have recently been renamed by COGLA. As most readers will be more familiar with the old names, these are retained in parenthesis in the text. The changes are as follows:

East Reindeer A-01 to Ikhil A-01
East Reindeer C-38 to Onigat C-38
East Reindeer G-04 to Atigi G-04
East Reindeer P-60 to Sholokpaqak P-60.

Total drilling depths range from 905 m to 4447 m, and the penetrated intervals of pre-Mesozoic rocks range from 1 m to 1767 m (Tables 2, 3). The pre-Mesozoic lithotypes vary considerably, even within areas of limited extent.

The pre-Mesozoic strata on Tuktoyaktuk Peninsula were examined to obtain a subcrop pattern. The results are displayed as generalized lithological columns for each well on a 1:500 000 scale base-map (Fig. 2; numerical information regarding depth, thickness, etc., is available from Tables 2 through 5). An extensive description of the lithotypes of core and drill cuttings from each well can be found in Appendix A. This Appendix is subdivided into Clastic and Carbonate sections, with the wells in each section sorted alphabetically within subgroups according to their geographic location. To display the lithotype, depth of penetration, and pertinent information, lithological columns for each well are presented (Fig. 3), categorized according to the different lithotype areas and alphabetically ordered. To obtain ages for the lithotype groups observed, both paleontological and absolute dating have been attempted. The reports of fossil determinations are contained in Appendix B.

Trending obliquely northeast across the Tuktoyaktuk Peninsula is a horst structure, the Eskimo Lakes Arch, as described by Young et al. (1976). These authors give no precise definition of the boundaries of this Mesozoic structure, but, according to their figures, it includes a central horst and adjacent downfaulted blocks. The Arch

TABLE 2

Wells with Pre-Mesozoic penetration (metric units)

			DEPTH (m)							CORES IN PRE-MESOZOIC STRATA					
WELL NAME		R.R.	KB	TD	QUA	FM	UNCONF.	DELTA	UNC.SS	FROM	TO	REC.	FROM	TO	REC.
AKKU	F14	1973	40.2	1522.8		C?	1364.6	158.2	-1324.4	—					
AMAGUK	H16	1973	20.1	1257.6		DIM	955.9	301.8	-935.7	1253.3	1257.6	3.4			
AMAROK	N44	1974	19.2	2332.3		DIM	1163.7	1168.6	-1144.5	2326.8	2332.3	5.5			
ATIGI	G04	1971	52.1	3733.8		RO	3591.8	142.0	-3539.6	—					
ATKINSON	A55	1974	9.1	2232.7		DGSG	2061.7	171.0	-2052.5	2226.6	2232.7	6.1			
ATKINSON	H25	1970	8.5	1810.8		C	1803.2	7.6	-1794.7	1798.3	1807.5	0.0			
ATKINSON	L17	1982	13.9	2480.0	**	M.OR	2331.0	149.0	-2317.1	2337.0	2350.2	13.1	2411.5	2430.2	18.7
ATKINSON	M33	1970	12.8	1928.5		C	1895.9	32.6	-1883.1	1912.3	1915.7	3.4	1924.2	1928.5	4.3
ESKIMO	J07	1969	27.1	905.6		PC	827.2	78.3	-800.1	841.2	844.3	2.1	868.4	881.5	13.1
IKHIL	A01	1971	190.5	2954.4		C-PC	2822.4	132.0	-2631.9	2905.4	2908.7	3.00			
IMNAK	J29	1975	18.3	3404.6		RO	3304.0	100.6	-3285.7	—					
INUVIK	D54	1969	42.1	1562.4		RO	320.0	1242.4	-278.0	711.4	719.3	7.0	1559.1	1562.4	1.5
KAMIK	D48	1976	33.2	3235.1	*	RO	3212.6	22.6	-3179.4	—					
KANGUK	F42	1973	7.9	1545.3		DIM	1469.1	76.2	-1461.2	—					
KANGUK	I24	1971	11.3	1601.4		DIM	1394.5	207.0	-1383.2	1390.2	1404.2	14.0	1596.8	1601.4	4.6
KANNERK	G42	1977	12.2	2480.5		M.OR	2387.2	93.3	-2375.0	—					
KAPIK	J39	1975	13.4	1466.7		DIM	1232.9	233.8	-1219.5	—					
KILANNAK	A77	1981	12.8	2966.0	**	DIM	1267.0	1699.0	-1254.2	—					
KILIGVAK	I29	1973	17.4	1965.0		DIM	198.1	1766.9	-180.7	1801.7	1806.2	2.7			
KIMIK	D29	1972	18.6	2657.9		M.OR	2581.7	76.2	-2563.1	2579.5	2585.3	4.3	2601.8	2608.5	
KUGALUK	N02	1969	215.8	2452.1		DIM	51.8	2400.3	164.0	246.0	2452.1				
LOUTH	K45	1975	8.5	2217.1		C	2118.4	98.8	-2109.8	—					
MAGAK	A32	1971	35.1	1572.8		C	1522.8	50.0	-1487.7	1525.2	1531.3	5.5	1567.3	1572.8	4.9
MAYOGIAK	J17	1971	22.6	3686.3		DGSG	2856.6	829.7	-2834.0	2854.8	3685.9	Many cores, see Table 3			
MAYOGIAK	L39	1974	14.3	4446.7		RO	4424.8	21.9	-4410.5	—					
MAYOGIAK	M16	1980	18.9	3093.0	**	DGSG	2867.0	226.0	-2848.1	2887.3	2894.3	6.2			
NATAGNAK	H50	1970	6.4	1951.3		C	1929.4	21.9	-1923.0	1930.6	1931.5	0.6	1939.7	1951.3	11.6
NATAGNAK	K23	1970	26.8	1517.0		M.OR	1481.3	35.7	-1454.5	1510.0	1517.0	6.7			
NATAGNAK	K53	1973	20.1	1751.7		C	1691.6	60.0	-1671.5	—					
NATAGNAK	O59	1983	9.2	2120.0	**	C	2100.0	20.0	-2090.8	2101.3	2101.9	0.6			
NUNA	A10	1984	54.2	3250.5	**	RO?	3222.0	28.5	-3167.8	3243.0	3250.5	7.5			
NUVORAK	O09	1970	11.0	1157.6		DIM	1043.6	114.0	-1032.7	1046.7	1065.0				
OGEOQEOQ	J06	1975	81.1	1839.2		C-PC	1787.7	51.5	-1706.6	—					
ONIGAT	C38	1970	71.6	2594.5		C-PC	1280.2	1314.3	-1208.5	1439.9	1446.6	6.7	1769.4	1776.4	6.7
PARSONS	A44	1975	63.1	3535.7		RR	3450.3	85.3	-3387.2	—					
PARSONS	D20	1976	70.4	4130.0		RO	4104.1	25.9	-4033.7	—					
PARSONS	F09	1972	63.1	3547.3		ORD	3313.2	234.1	-3250.1	—					
PARSONS	L37	1977	46.6	3965.4	*	RO-RR	3944.1	21.3	-3897.5	—					
PARSONS	L43	1976	57.9	3305.3		RO-RR	3279.6	25.6	-3221.7	—					
PARSONS	N10	1973	67.7	3205.0		ORD	3077.0	128.0	-3009.3	3432.0	3435.1	0.9			
PARSONS	O27	1974	42.1	3570.4	*	RO-RR	3569.2	1.2	-3527.1	—					
PARSONS	P41	1977	71.3	3555.5	*	RO-RR	3542.4	13.1	-3471.1	—					
PARSONS	P53	1974	51.2	3435.1		ORD	3185.2	249.9	-3134.0	3432.0	3435.1	2.7			
PIKIOLIK	E54	1972	24.4	3118.1		DGSG	2738.6	379.5	-2714.2	2757.8	2776.1	18.3			
PIKIOLIK	G21	1983	74.8	1429.6	**	RO	1378.0	51.6	-1303.2	—					
PIKIOLIK	M26	1972	24.1	1984.2		RO	1709.3	274.9	-1685.2	1716.9	1720.6	3.5			
RUSSELL	H23	1974	10.7	1831.8		DIM	1100.9	730.9	-1090.3	1821.2	1831.8	2.4			
SHOLOKPAQAK	P60	1970	115.8	1920.2		C-PC	1039.4	880.9	-923.5	1389.9	1399.9	10.1	1579.5	1585.3	5.0
SIKU	A12	1976	64.6	3287.9		ORD	3234.5	53.3	-3169.9	—					
SIKU	C11	1976	63.1	3294.9		ORD	3215.6	79.2	-3152.5		no cuttings				
SIKU	E21	1977	64.6	3427.5		ORD	3393.9	33.5	-3329.3	—					
TUK	M09	1984	31.2	3030.0	**	RO	2966.5	63.5	-2935.3	3008.0	3009.0	0.9			
TUKTU	O19	1971	30.5	2315.6		DGSG	2199.4	116.1	-2169.0	2240.3	2252.5	12.2	2311.0	2315.6	4.6
WAGNARK	C23	1976	30.5	4251.0		RO	4179.4	71.6	-4148.9	—					

R.R., rig release date; KB, Kelly Bushing depth; TD, total depth; QUA, indicator for deviated hole or depths in metric units: *deviated hole, **well with all data in metric units; FM, formation underlying sub-Mesozoic unconformity; UNCONF., depth of sub-Mesozoic unconformity; DELTA, thickness of pre-Mesozoic sequence penetrated; UNC.SS, depth of sub-Mesozoic unconformity below sea level; REC., amount of core recovered; C, Cambrian; DIM, Imperial Formation; RO, Ronning Group; DGSG, Landry and Arnica formations; M.OR, Middle Ordovician; PC, Precambrian; C-PC, Cambrian or Precambrian; RR, Road River equivalent; RO-RR, Ronning Group equivalent in Road River Formation.

TABLE 3

Wells with Pre-Mesozoic penetration (original units)

		DEPTH (* in feet; ** in metres)								CORES IN PRE-MESOZOIC STRATA					
WELL NAME		R.R.	KB	TD	QUA	FM	UNCONF.	DELTA	UNC.SS	FROM	TO	REC.	FROM	TO	REC.
AKKU	F14	1973	132	4996		C?	4477	519	-4345	—					
AMAGUK	H16	1973	66	4126		DIM	3136	990	-3070	4112	4126	11			
AMAROK	N44	1974	63	7652		DIM	3818	3834	-3755	7634	7652	18			
ATIGI	G04	1971	171	12250		RO	11784	466	-11613	—					
ATKINSON	A55	1974	30	7325		DGSG	6764	561	-6734	7305	7325	20			
ATKINSON	H25	1970	28	5941		C	5916	25	-5888	5900	5930				
ATKINSON	L17	1982	13.9	2480.0	**	M.OR	2331.0	149	-2317.1	2337.0	2350.2	13.1	2411.5	2430.2	18.7
ATKINSON	M33	1970	42	6327		C	6220	107	-6178	6274	6285	11	6313	6327	14
ESKIMO	J07	1969	89	2971		PC	2714	257	-2625	2760	2770	7	2849	2892	43
IKHIL	A01	1971	625	9693		C-PC	9260	433	-8635	9532	9543	10			
IMNAK	J29	1975	60	11170		RO	10840	330	-10780	—					
INUVIK	D54	1969	138	5126		RO	1050	4076	-912	2334	2360	23	5115	5126	5
KAMIK	D48	1976	109	10614	*	RO	10540	74	-10431	—					
KANGUK	F42	1973	26	5070		DIM	4820	250	-4794	—					
KANGUK	I24	1971	37	5254		DIM	4575	679	-4538	4561	4607	46	5239	5254	15
KANNERK	G42	1977	40	8138		M.OR	7832	306	-7792	—					
KAPIK	J39	1975	44	4812		DIM	4045	767	-4001	—					
KILANNAK	A77	1981	12.8	2966	**	DIM	1267.0	1699.0	-1254.2	—					
KILIGVAK	I29	1973	57	6447		DIM	650	5797	-593	5911	5926	9			
KIMIK	D29	1972	61	8720		M.OR	8470	250	-8409	8463	8482	14	8536	8558	
KUGALUK	N02	1969	708	8045		DIM	170	7875	538	807	8045	continuous core			
LOUTH	K45	1975	28	7274		C	6950	324	-6922	—					
MAGAK	A32	1971	115	5160		C	4996	164	-4881	5004	5024	18	5142	5160	16
MAYOGIAK	J17	1971	74	12094		DGSG	9372	2722	-9298	9366	12093	Table 3, many cores			
MAYOGIAK	L39	1974	47	14589		RO	14517	72	-14470	—					
MAYOGIAK	M16	1980	18.9	3093.0	**	DGSG	2867.0	226	-2848.1	2887.3	2894.3	6.2			
NATAGNAK	H50	1970	21	6402		C	6330	72	-6309	6334	6337	2	6364	6402	38
NATAGNAK	K23	1970	88	4977		M.OR	4860	117	-4772	4954	4977	22			
NATAGNAK	K53	1973	66	5747		C	5550	197	-5484	—					
NATAGNAK	O59	1983	9.2	2120.0	**	C	2100.0	20	-2090.8	2101.3	2101.9	0.6			
NUNA	A10	1984	54.2	3250.5	**	RO?	3222.0	28.5	-3167.8	3243.0	3250.5	7.5			
NUVORAK	O09	1970	36	3798		DIM	3424	374	-3388	3434	3494	58			
OGEOQEOQ	J06	1975	266	6034		C-PC	5865	169	-5599	—					
ONIGAT	C38	1970	235	8512		C-PC	4200	4312	-3965	4724	4746	22	5805	5828	22
PARSONS	A44	1975	207	11600		RR	11320	280	-11113	—					
PARSONS	D20	1976	231	13550		RO	13465	85	-13234	—					
PARSONS	F09	1972	207	11638		ORD	10870	768	-10663	—					
PARSONS	L37	1977	153	13010	*	RO-RR	12940	70	-12787	—					
PARSONS	L43	1976	190	10844		RO-RR	10760	84	-10570	—					
PARSONS	N10	1973	222	10515		ORD	10095	420	-9873	11260	11270	3			
PARSONS	O27	1974	138	11714	*	RO-RR	11710	4	-11572	—					
PARSONS	P53	1974	168	11270		ORD	10450	820	-10282	11260	11270	9			
PARSONS	P41	1977	234	11665	*	RO-RR	11622	43	-11388	—					
PIKIOLIK	E54	1972	80	10230		DGSG	8985	1245	-8905	9048	9108	60			
PIKIOLIK	G21	1983	74.8	1429.6	**	RO	1378.0	51.59	-1303.2	—					
PIKIOLIK	M26	1972	79	6510		RO	5608	902	-5529	5633	5645	11.5			
RUSSELL	H23	1974	35	6010		DIM	3612	2398	-3577	5975	6010	8			
SHOLOKPAQAK	P60	1970	380	6300		C-PC	3410	2890	-3030	4560	4593	33	5182	5201	16.5
SIKU	A12	1976	212	10787		ORD	10612	175	-10400	—					
SIKU	C11	1976	207	10810		ORD	10550	260	-10343			no cuttings			
SIKU	E21	1977	212	11245		ORD	11135	110	-10923	—					
TUK	M09	1984	31.2	3030.0	**	RO	2966.5	63.51	-2935.3	3008.0	3009.0	0.9			
TUKTU	O19	1971	100	7597		DGSG	7216	381	-7116	7350	7390	40	7582	7597	
WAGNARK	C23	1976	100	13947		RO	13712	235	-13612	—					

R.R., rig release date; KB, Kelly Bushing depth; TD, total depth; QUA, indicator for deviated hole or depths in metric units: *deviated hole, **well with all data in metric units; FM, formation underlying sub-Mesozoic unconformity; UNCONF., depth of sub-Mesozoic unconformity; DELTA, thickness of pre-Mesozoic sequence penetrated; UNC.SS, depth of sub-Mesozoic unconformity below sea level; REC., amount of core recovered; C, Cambrian; DIM, Imperial Formation; RO, Ronning Group; DGSG, Landry and Arnica formations; M.OR, Middle Ordovician; PC, Precambrian; C-PC, Cambrian or Precambrian; RR, Road River equivalent; RO-RR, Ronning Group equivalent in Road River Formation.

belongs to the much larger Aklavik Arch (Jeletzky, 1961; Norris, 1974), which comprises the Campbell Uplift and structural components beyond the scope of this paper. The present study enabled the subdivision of the ancestral Eskimo Lakes Arch into components which are named to simplify their characterization.

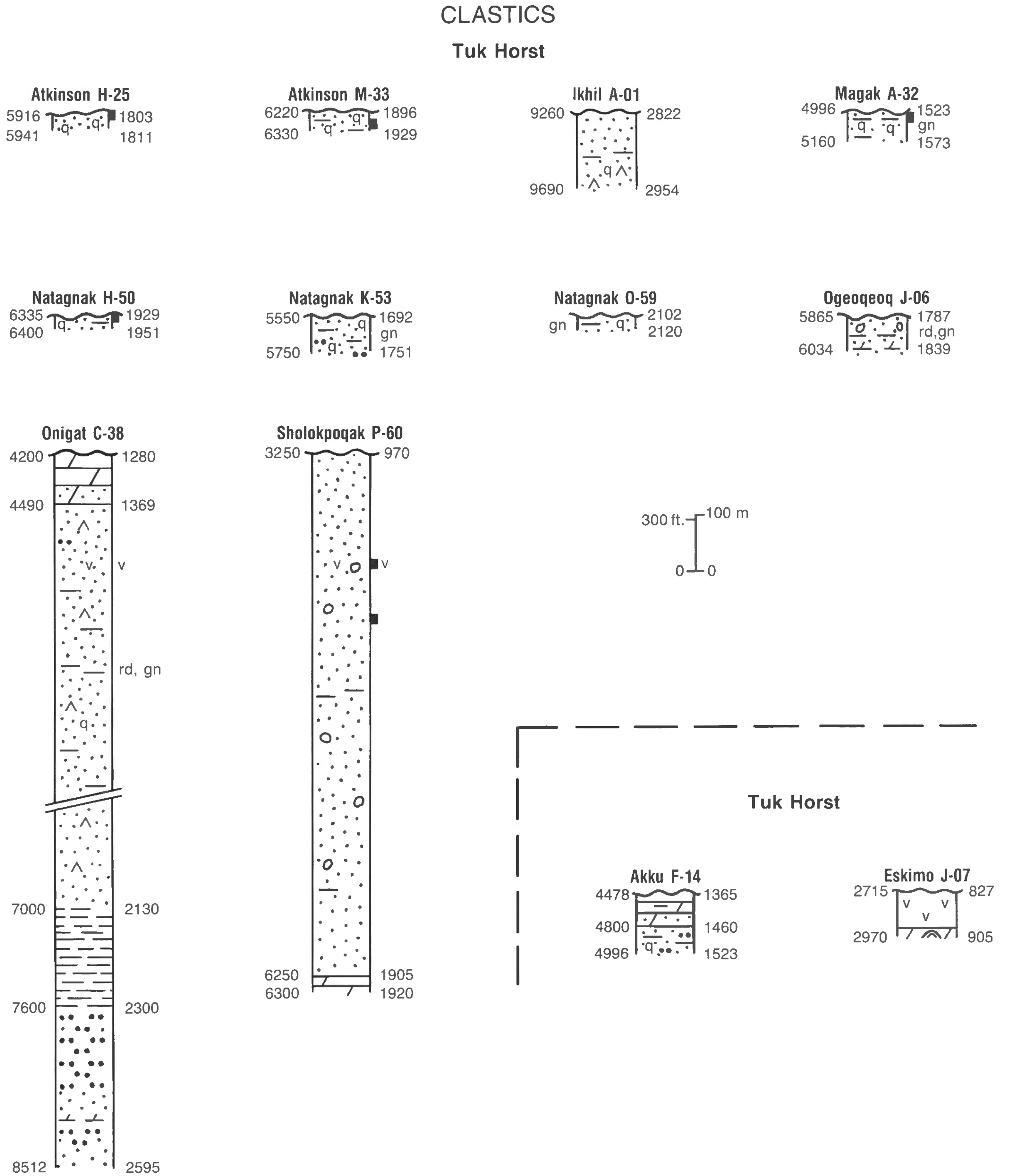

Figure 3. Lithology columns for each well.

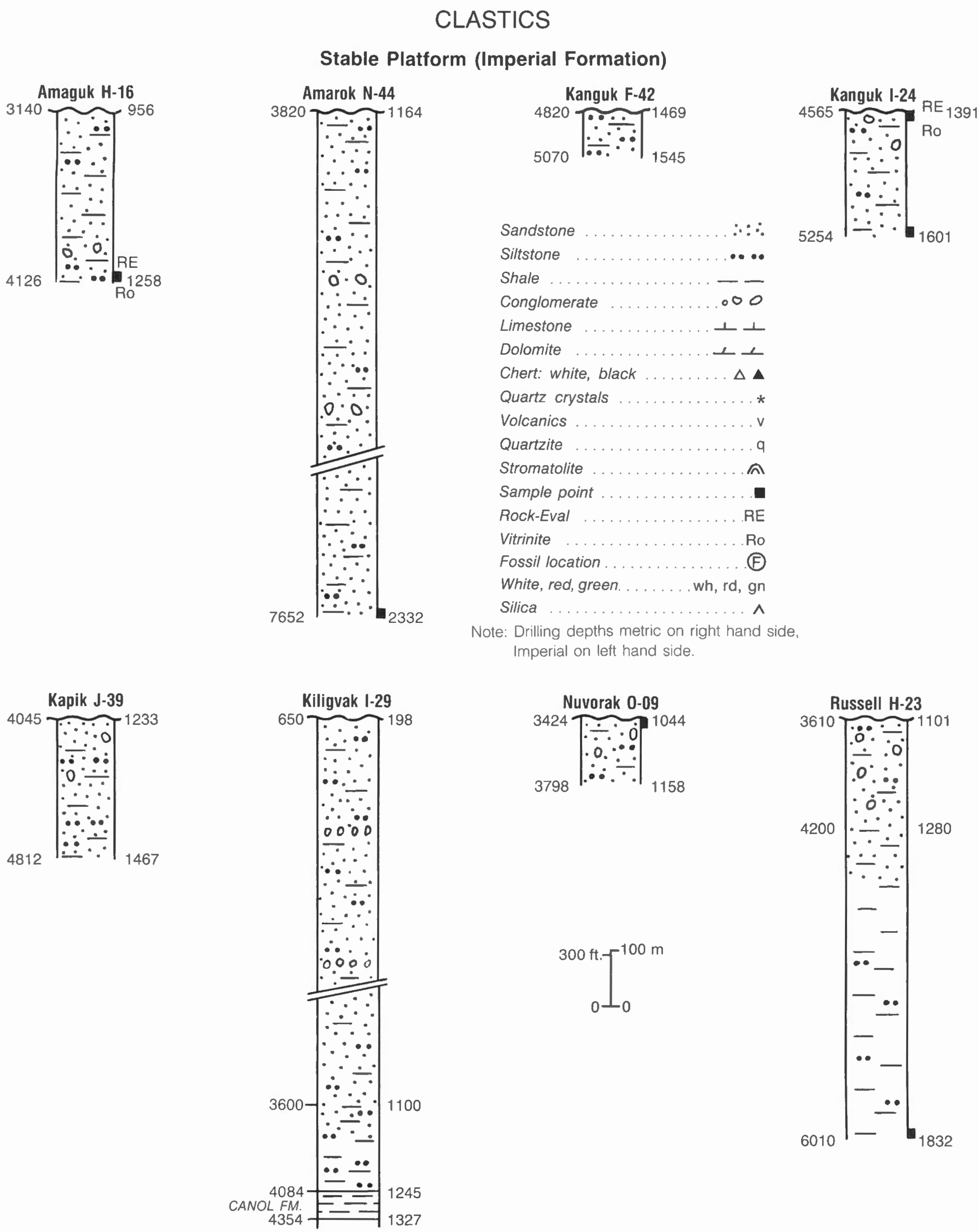

Figure 3. cont'd.

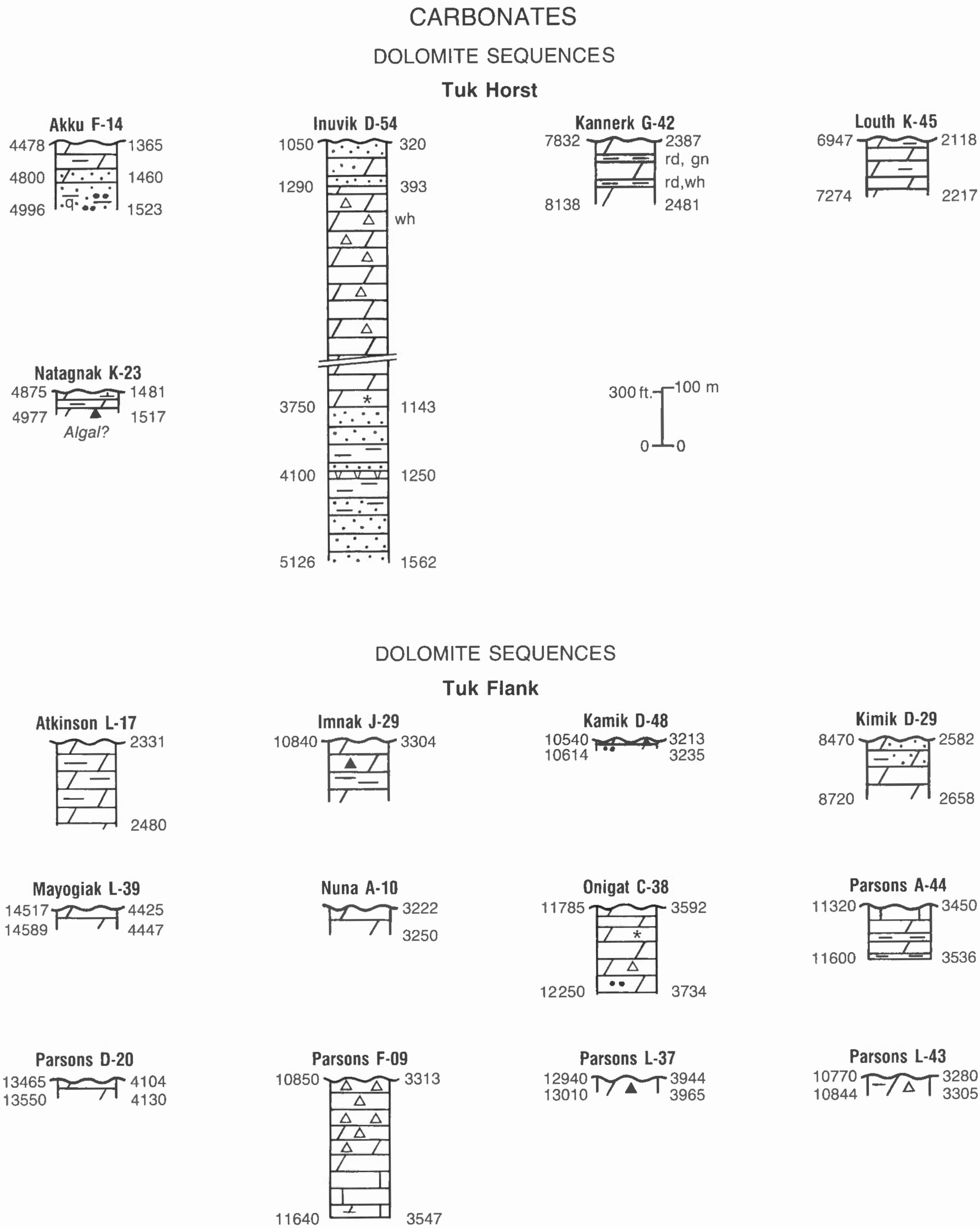

Figure 3. cont'd.

CARBONATES

DOLOMITE SEQUENCES (cont.)

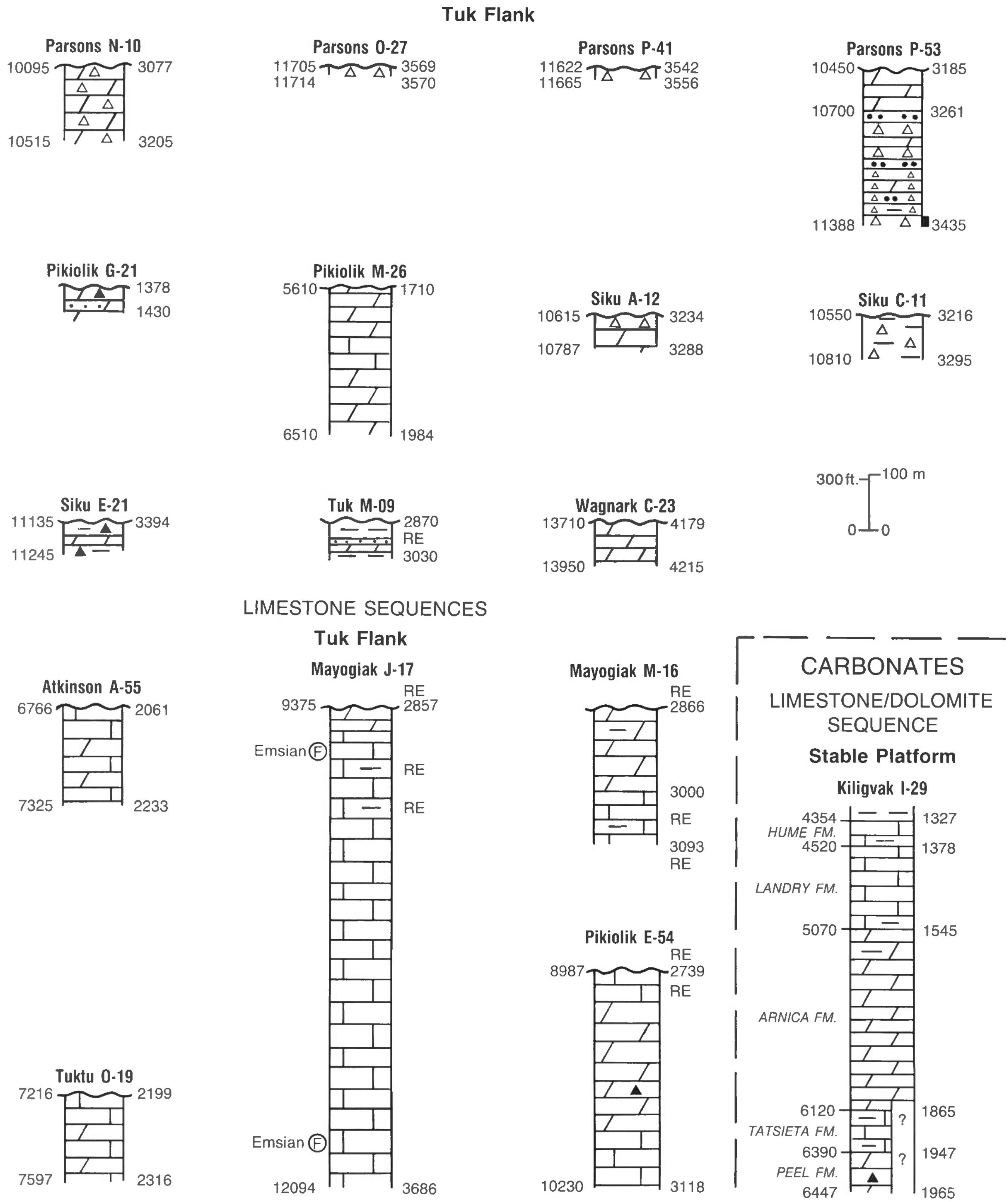

Figure 3. cont'd.

The sub-Mesozoic geology varies among four large areas, each characterized by particular rock types (Fig. 4): the Tuk Horst; the Tuk Flank, to the northwest of the Horst; the Stable Platform to the southeast of the Horst; and the Permian Wedge at the southwestern extension of the Tuk Flank. The first two of these areas can be subdivided on the basis of smaller lithotype units. The Campbell Uplift is a segment of the Tuk Horst visible in outcrop.

Each of the lithotype units in the four areas will be described in this chapter according to rock type, age, and possible correlation.

The Tuk Horst

The backbone of the ancestral Eskimo Lakes Arch is formed by an area underlain by white quartzite, sandstone, siltstone, shale, dolomite, and volcanic rocks, each of which has been penetrated by a number of wells. Seismic evidence indicates that these lithotypes occupy a pre-Mesozoic horst structure; this area will therefore be referred to as the "Tuk Horst" (Fig. 3). This new name is introduced for the area to stress that this is a more precise subdivision of the ancestral part of the Eskimo Lakes Arch of Young et al. (1976), and that the arch as defined by Young et al. is a Mesozoic feature. Each of the

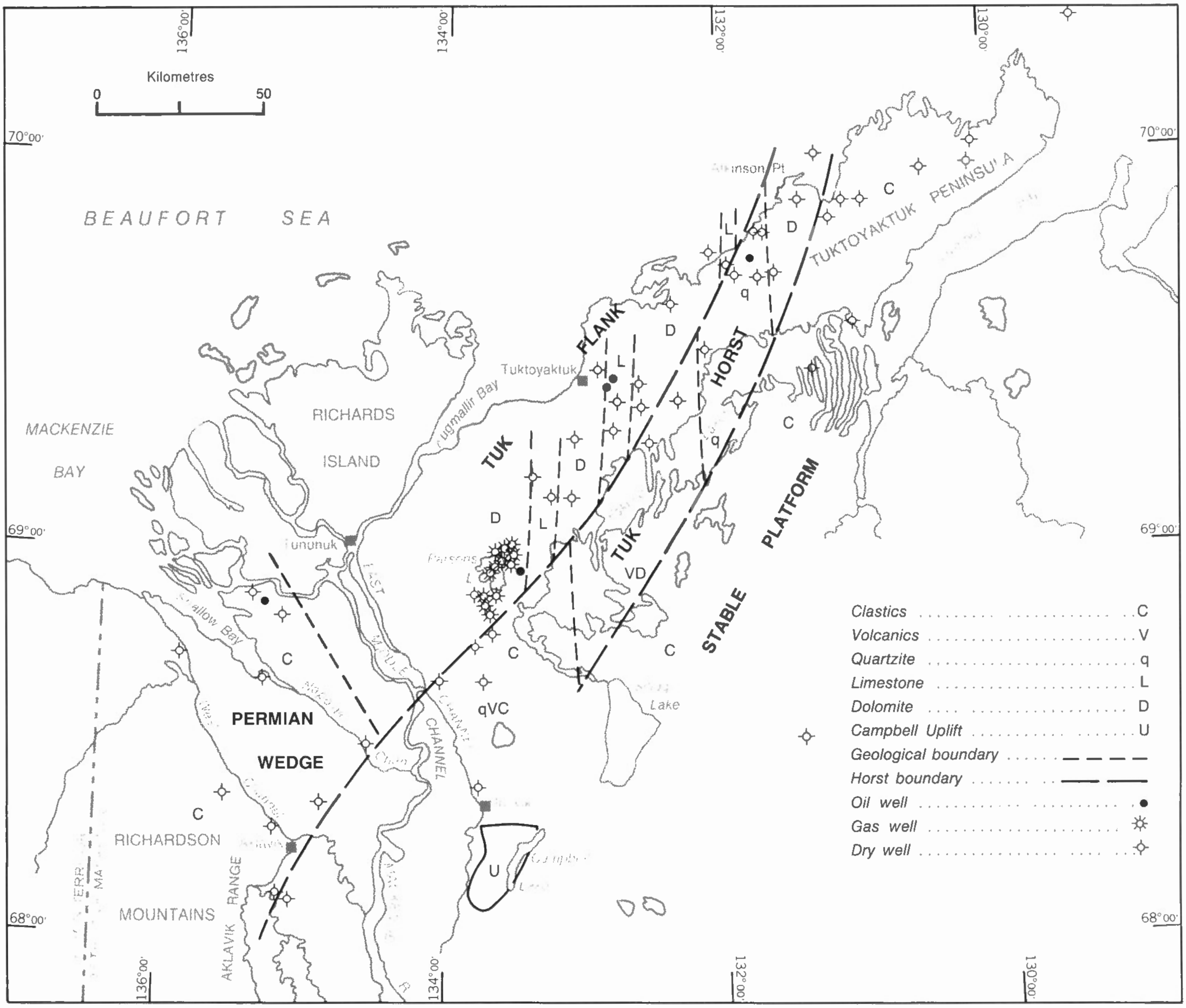

Figure 4. Lithology subcrop pattern.

TABLE 4

Cores in Mayogiak J-17

DEPTH (ft.)			DEPTH (m)		
FROM	TO	REC.	FROM	TO	REC.
9366	9383	17	2854.8	2859.9	5.2
9394	9397	3	2863.3	2864.2	0.9
9407	9410	0.8	2867.3	2868.2	0.2
9426	9429	3	2873.0	2874.0	0.9
9450	9453	3	2880.4	2881.3	0.9
9462	9465	3	2884.0	2884.9	0.9
9481	9632	149	2889.8	2935.8	45.4
9634	9656	13	2936.4	2943.1	4.0
9659	9692	24	2944.1	2954.1	7.3
9692	9705	11	2954.1	2958.1	3.4
9787	9817	30	2983.1	2992.2	9.1
10321	10347	23	3145.8	3153.8	7.0
10596	10602	5.5	3229.7	3231.5	1.7
10940	10947	6	3334.5	3336.6	1.8
11238	11251	12	3425.3	3429.3	3.7
11499	11521	22	3504.9	3511.6	6.7
12070	12093	23	3678.9	3685.9	7.0

REC., amount of core recovered.

components in the Tuk Horst will be described from oldest to youngest. With the description, a trend becomes apparent of successively older formations from Middle Ordovician to Cambrian or Precambrian subcropping toward the south; the Campbell Uplift is the exception, where the youngest, Devonian formations outcrop. This pattern reflects the complicated tectonic history.

Onigat clastic sequence

In the southwestern part of the Tuk Horst, Cambrian or Precambrian formations subcrop in the area with the cluster of wells including Sholokpaqak (East Reindeer) P-60, Ikhil (East Reindeer) A-01, Onigat (East Reindeer) C-38, and Ogeoqeoq J-06 (Fig. 1). The age relationship with the carbonate and volcanic rocks described in the next chapter remains unresolved, but the rocks in these wells appear to be older than the volcanic rocks.

Lithology

The succession in Sholokpaqak (East Reindeer) P-60 consists of nearly 1000 m of green-grey shale, with interbedded siltstone, sandstone and conglomerate. The shale overlies 15 m of cherty dolomite near the bottom of the well. The siltstone and sandstone are indurated into

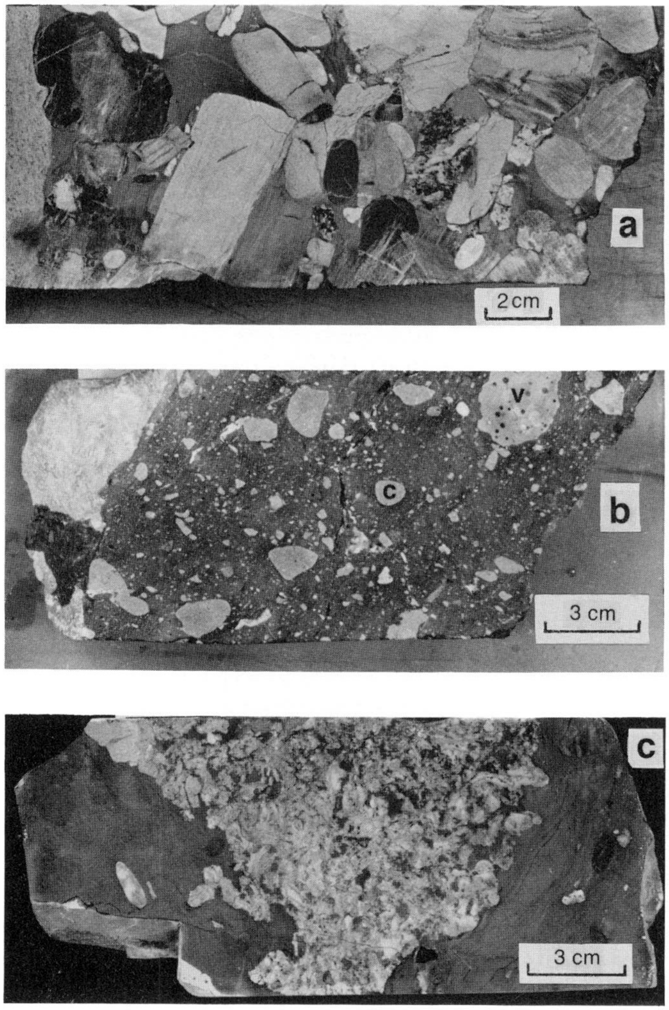

Figure 5. *Core photographs from Sholokpaqak (East Reindeer) P-60. a) 4561 ft., conglomerate in very fine matrix, sand in protected areas, and indentation of clasts (ISPG photo. 2740-74); b) 5187 ft., debris flow with vesicular basaltic (v) and rounded chert (c) clasts (ISPG photo. 2740-22); c) 4563 ft., clast of possible travertine with irregular outline (ISPG photo. 2740-78).*

quartzite and have a salt and pepper appearance. Although the Onigat clastic sequence is to some degree similar to the Imperial Formation, and the underlying dolomite has been correlated to the Silurian-Ordovician by Canadian Stratigraphic Services Ltd. (henceforth called Can-Strat), it is probably significantly older, because, unlike the Imperial Formation elsewhere, these clastic rocks are characterized by the absence of plant remains and carbonaceous flakes, and mica is rare. Moreover, the total amount of sandstone is unusually large for the Imperial Formation, although this could be explained by proximity to a source, as is indicated also by the presence of conglomerate in the P-60 well (Fig. 5a-c).

TABLE 5

Wells with probable Permian penetration, on and to the southwest of Tuktoyaktuk Peninsula

										CORES IN PRE-MESOZOIC STRATA					
WELL NAME		R.R.	KB	TD	QUA	FM	UNCONF	DELTA	UNC.SS	FROM	TO	REC	FROM	TO	REC
METRIC UNITS															
AKLAVIK	A37	1970	10.1	2584.4		P	1758.7	825.7	-1748.6	2579.2	2584.4	5.2			
AKLAVIK	F17	1973	8.2	891.5		C?	771.1	120.4	-762.9	890.6	891.2	0.6			
AKLAVIK	F38	1973	12.2	2056.5		P	1626.7	429.8	-1614.5	—					
BEAVERHOUSE	H13	1971	74.7	3747.5		P	1176.5	2571.0	-1101.9	2085.1	2085.7	0.2	2515.2	2524.0	8.8
KILANNAK	A77	1981	12.7	2996.0	*	DIM	1260.0	1736.0	-1247.3	—					
KUGPIK	L24	1975	12.2	2817.0		P	2731.0	86.0	-2718.8	2257.0	2267.7	10.1	2494.8	2505.8	10.1
KUGPIK	O13	1973	10.4	3689.0		P?	3240.0	449.0	-3229.7	3095.2	3102.3	6.7	3651.5	3654.6	2.4
NAPOIAK	F31	1974	13.1	1528.6		P	1264.3	264.3	-1251.2	1514.9	1525.5	10.7			
NAPARTOK	M01	1969	15.8	1960.0	*	P?	1683.0	277.0	-1667.2						
TULLUGAK	K31	1977	9.8	2926.1		P???	1802.9	1123.2	-1793.1						
ULU	A35	1976	11.3	3919.7		P?	2772.5	1147.3	-2761.2	2939.2	2947.4	8.8			
UNAK	B11	1974	9.2	2120.0	**	P???	2100.0	20.0	-2090.8	2101.3	2101.9	0.6			
IMPERIAL UNITS															
AKLAVIK	A37	1970	33	8479		P	5770	2709	-5737	8462	8479	17			
AKLAVIK	F17	1973	27	2925		C?	2530	395	-2503	2922	2924	2			
AKLAVIK	F38	1973	40	6747		P	5337	1410	-5297	—					
BEAVERHOUSE	H13	1971	245	12295		P	3860	8435	-3615	6841	6843	0.5	8252	8281	29
KILANNAK	A77	1981	12.7	2996	*	DIM	1267	1729	-1254.3	—					
KUGPIK	L24	1975	40	9242		P	8960	282	-8920	7405	7440	33	8185	8221	33.3
KUGPIK	O13	1973	34	12103		P?	10630	1473	-10596	10155	10178	22	11980	11990	8
NAPOIAK	F31	1974	43	5015		P	4148	867	-4105	4970	5005	35			
NAPARTOK	M01	1969	15.8	1960	*	P?	1683	277	-1667.2	—					
TULLUGAK	K31	1977	32	9600		P???	5915	3685	-5883	—					
ULU	A35	1976	37	12860		P?	9096	3764	-9059	9643	9670	29			
UNAK	B11	1974	33	10975		P???	8180	2795	-8147	9495	9525	30			

R.R., rig release date; KB, Kelly Bushing depth; TD, total depth; QUA, indicator for deviated hole or depths in metric units: * deviated hole, ** well with all data in metric units; FM, formation underlying sub-Mesozoic unconformity; UNCONF, depth of sub-Mesozoic unconformity; DELTA, thickness of pre-Mesozoic sequence penetrated; UNC.SS, depth of sub-Mesozoic unconformity below sea level; REC., amount of core recovered; P, Permian; C, Cambrian; DIM, Imperial Formation.

In core, the shale is far more indurated than is typical of the Imperial Formation and contains extensive vertical fractures cemented by quartz. In common with the Imperial Formation, distal-source turbidite beds with De Bouma sequences are evident in the shale and soft-sediment deformation is extensive. Many of the pebbles in the conglomerates are composed of weathered, amygdaloidal, ophitic volcanic rocks (Fig. 5b).

Similar, but more strongly deformed clastic rocks have been penetrated in the Ikhil (East Reindeer) A-01 (Fig. 6a, b), Onigat (East Reindeer) C-38 (Fig. 7a, b), and Ogeoqeoq J-06 wells. In A-01, the well indurated sandstone is very white and composed of clear quartz (both characteristics are very unlike those of the Imperial Formation), but it is less indurated than the quartzite on the Tuk Horst and is interbedded with a few, up to 3 m thick, dark grey shale beds. In Onigat C-38, as in Akku F-14, dolomite overlies the clastic rocks. The succession in Ogeoqeoq J-06 contains interbedded sandstone, shale and dolomite, and the shale is grey or red. None of the cores from these wells shows any sign of bioturbation.

Age and correlation

The Onigat clastic sequence is essentially unfossiliferous, and not even a limestone bed in Onigat (East Reindeer) C-38 (Fig. 7b), and shale in Sholokpaqak P-60 contain any fossils. Only a few black fragments were recovered from the shale (Appendix B, GSC Rep. 3-JU-87) and these showed no reaction to oxidation. This indicates that the fragments are not coal and are probably inorganic. A total absence of palynomorphs and such paucity in carbonaceous material is highly unlikely for the Imperial Formation. The absence of graptolites, conodonts and brachiopods, as well as the lithotype, rule out a Road River Formation equivalence. The Onigat clastic beds contain volcanic debris beds, and volcanic rocks are not present in any of Pugh's (1983) four

Precambrian units. However, a large gap exists between the youngest of his units and the oldest Cambrian rocks. Cambrian correlatives are present at considerable distances from the study area. Middle Cambrian volcanic rocks are present in the Slats Creek equivalent in the Bonnet Plume area (Green, 1972). The Middle Cambrian Slats Creek Formation of the Richardson Trough (Fritz, 1974) is similar in lithotype and bedding style. If equated to the Slats Creek Formation, the rocks would have been deposited as a clastic wedge in a northern extension of the Richardson Trough, similar to the wedge of Cambrian clastics found in the northwestern Misty Creek Embayment (Cecile, 1982). If they were derived by erosion from the volcanic units (described in the following chapter) present in the Eskimo J-07 well, these clastic rocks would be younger than the volcanic rocks and dolomite in J-07. The apparent northeast dip of the rocks, as outlined by the tentative correlations in Figure 16, makes this unlikely; they dip under the Eskimo J-07 penetrated succession, and are thus older. Therefore, the Onigat clastic sequence is tentatively assumed to be

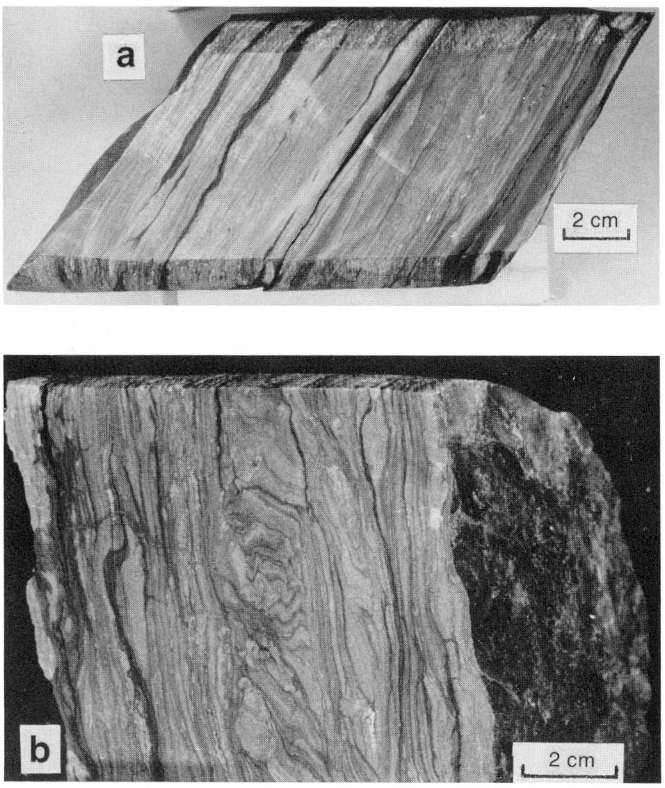

Figure 6. Core photographs from Ikhil (East Reindeer) A-01. a) 9533 ft., deformation of interbedded siltstone and shale (ISPG photo. 2740-46); b) 9534 ft., enterolithic appearance resulting from soft-sediment deformation (ISPG photo. 2740-71).

Precambrian. Also, the lithotype strongly resembles that of the Katherine Group. If the Onigat clastic sequence is Precambrian, it reinforces the impression that the formations subcropping along the Tuk Horst are successively older from northeast to southwest (Fig. 8).

The Tuk Horst volcanic rocks and stromatolites

Likely Cambrian or Precambrian rocks subcrop in a significant, 100 m thick succession consisting of volcanic rocks and underlying brecciated dolomite in the Eskimo J-07 well. Minor other appearances include a few metres of volcaniclastic rocks found in the Inuvik D-54, Onigat (East Reindeer) C-38, and Sholokpaqak (East Reindeer) P-60 wells.

Lithology

In the Eskimo J-07 well (Figs. 1, 2), there is a 30 m thick dolomite succession, overlain by 70 m of basalt. The dolomite is a dense, partly mottled, partly laminated, fine crystalline, grey to orange-pink rock with some solid

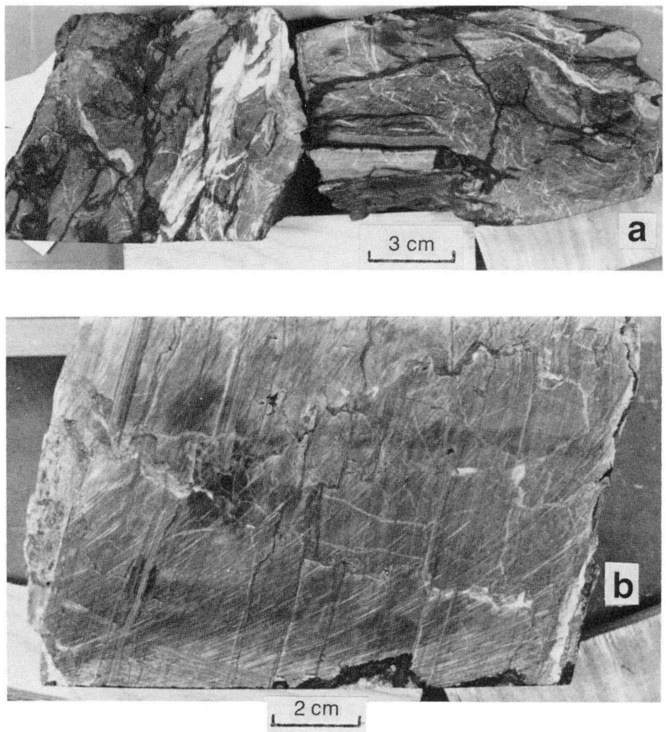

Figure 7. Core photographs from Onigat (East Reindeer) C-38. a) 5874 ft., deformed and recemented shale and siltstone (ISPG photo. 2740-28); b) 6351 ft., fractured and recemented limestone (ISPG photo. 2740-37).

hydrocarbon (black, soft) in vugs. The major fraction of the dolomite is stromatolitic (Fig. 9). Many of the stromatolites appear to be in growth position and usually contain pink laminae. The absence of active branching and walls prevents identification and thus dating. Part of the dolomite is a breccia with rounded, laminated clasts floating in a pinkish sandy matrix.

The basalt is dark grey, hydrothermally altered rock with local green or red patches. It is best described as an amygdaloidal, aphanitic to porphyritic rock. Locally it contains olivine. The presence of zeolite minerals testifies to later hydrothermal alteration.

The thick basalt in Eskimo J-07 [and volcaniclastic nodules in the Onigat (East Reindeer) C-38 and Sholokpaqak (East Reindeer) P-60 wells] have been subjected to X-ray analysis (Table 6). The data are presented in Table 7 (elemental analysis and mineral composition). The results do not provide any clue to possible correlation or age. The Eskimo J-07 and Onigat (East Reindeer) C-38 basalts are alkalic; those in Sholokpaqak (East Reindeer) P-60 just tholeitic (almost alkalic). All samples have concentrations of the major elements generally considered normal for basalt, with the exception of those from P-60, which have a high silica content. All of the iron and titanium values in the samples are below, while potassium

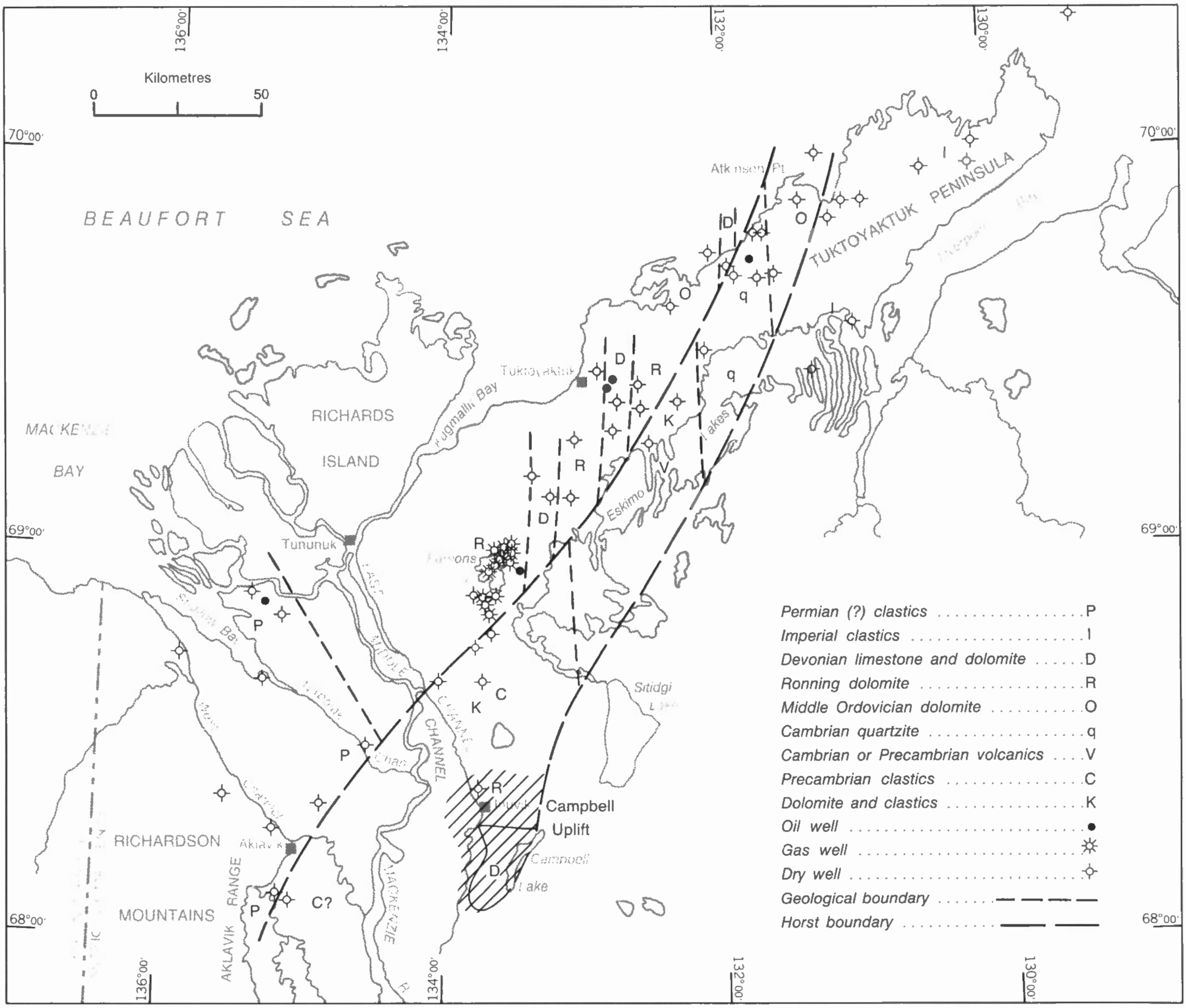

Figure 8. *Subcrop pattern of lithology in relation to formation ages.*

Figure 9. Stromatolites in carbonate in core from the Eskimo J-07 well (ISPG photo. 2823-1).

and silica are slightly above, normal values for alkalic basalt. Calcium values are quite variable, probably an effect of the younger hydrothermal phase. The barium content is normal and not comparable to the elevated barium values reported by Cecile (1982) for early Paleozoic basalt in the Misty Creek Embayment in the Selwyn Basin. They are similar in composition to the early Paleozoic alkalic basalt described by Moore (1987) in the central and eastern Brooks Range.

Age

The dolomite is barren of conodonts. According to J.D. Aitken (pers. comm., 1987), the stromatolites in this unit do not have a Phanerozoic appearance, nor do they resemble those that can be observed in the Precambrian Little Dal Formation. However, they have several similarities to stromatolites in the Precambrian Map-unit H1, where bitumen is also present. The spotty orange colour of the dolomite is typical in Map-unit H1, as are crystals of quartz. Conversely, pseudomorphic gypsum crystals, characteristic of Map-unit H1, were not observed in this well.

The basalt in the Eskimo J-07 well was sampled for absolute dating. Thin section study revealed that the rock underwent severe hydrothermal alteration with introduction of large amounts of calcite and epidote. The K-Ar method for whole-rock or mineral dating is useless in such rocks, because the K-bearing minerals did not remain closed systems. Rb-Sr dating of minerals is unreliable for this type of basalt and has not been attempted. As an alternative, samples were crushed and concentrates of the heavy minerals, possibly containing apatite and zircon, were submitted for fission track dating. However, these attempts to obtain absolute dates for the hydrothermally altered volcanics in Eskimo J-07 have been unsuccessful so far.

Correlation

The dolomite, which underlies the basalt, is composed of largely massive, but undatable stromatolites (Fig. 9). On the basis of the characteristics of the stromatolites, a Precambrian, possibly H1-equivalent age for the dolomite is likely.

Basic igneous rocks are present in the Mackenzie Mountains as sills and dikes intruded at levels as high as the Grainstone member of the Proterozoic Little Dal Formation (Aitken, 1981); as flows in the Proterozoic Copper Cycle (Aitken, 1981); in the Lower Cambrian of the British Mountains in northern Yukon (Norris, 1981a); and in the Paleozoic Marmot Formation of the Mackenzie and Selwyn mountains (Cecile, 1982). On Victoria Island, similar volcanic rocks from the Late Proterozoic Natkusiak Formation (Young, 1981; Jefferson et al., 1985), were dated at about 700 Ma (Rb-Sr, Baragar and Loveridge, 1982). Thus, basalt extrusion and volcaniclastic deposition could have occurred from the Precambrian to the middle Paleozoic. There are no clues to their age in the Eskimo, Onigat, Sholokpaqak, and Inuvik wells. In the Colville area, basalt underlies the Old Fort Island Formation. It appears to rest on a peneplain overlying Precambrian formations, rather than being intercalated in them. Considering the presence near by of Lower Cambrian quartzite (see "The Tuk Horst quartzite" section below) and the structural relationship with the Onigat clastic sequence described above, a Late Precambrian or, less likely, Early Cambrian age is tentatively assumed for the volcanic rocks in Eskimo J-07. A Precambrian age is consistent with an overall pattern of younging to the northeast along the axis of the Tuk Horst.

The Tuk Horst quartzite

Northward, beyond the area with the volcanic rocks and dolomite, Lower Cambrian rocks were penetrated in the Atkinson M-33, H-25, Magak A-32, and Natagnak H-50, K-53, and O-59 wells. These are the oldest dated rocks in the study area.

TABLE 6

Sampling

WELL NAME		CORE	CUTTINGS	
		Depth/Anal.	Depth/Anal.	Comments
AKKU	F-14		4500-4600/con	
AKKU	F-14		4600-4700/con	
AKKU	F-14		4700-4800/con	
AMAGUK	H-16	4113/gech		
AMAGUK	H-16	4123/gech		
AMAROK	N-44	7641/gech		
AMAROK	N-44	7650/gech		
AMAROK	N-44	7651-7652/pln		
ATIGI	G-04		1800-12100/con	
ATIGI	G-04		12100-12250/con	
ATKINSON**	L-17	2337.0-2340.6/con		
ATKINSON**	L-17	2340.6-2344.4/con		
ATKINSON**	L-17	2344.4-2350.2/con		
ATKINSON**	A-55	7305-7325/con	6770-7300/con	
ESKIMO	J-07	2765/XRF		
ESKIMO	J-07	2865/XRF		
ESKIMO	J-07	2891/XRF		
ESKIMO	J-07	2919/K-Ar		
ESKIMO	J-07	2919/XRF		
ESKIMO	J-07	2929/XRF		
ESKIMO	J-07	2945/XRF		
ESKIMO	J-07	2945-2954/con		
ESKIMO	J-07	2954-2963/con		
ESKIMO	J-07	2955-2968/gech		
ESKIMO	J-07	2963-2971/con		
IMNAK	J-29		10860-11170/con	
INUVIK	D-54		1900-2150/con	
INUVIK	D-54		3100-3350/con	
KANGUK	I-24	4560/pln		
KANGUK	I-24	4595-4599/gech		
KANGUK	I-24	4607/pln		
KANGUK	I-24	5246-5248/gech		
KILLANAK**	A-77		2100.0-2160/con	
KILLANAK**	A-77		2165.0-2230/con	
KILLANAK**	A-77		2235.0-2350/con	
KILLANAK**	A-77		2310.0-2360/con	
KILLANAK**	A-77		2365.0-2460/con	
KILLANAK**	A-77		2750.0-2850/con	
KIMIK	D-29	8466/gech	8480-8720/con	
KIMIK	D-29	8476/gech		
KIMIK	D-29	8613-8624/con		
KIMIK	D-29	8602-8613/con		
LOUTH	K-45		6970-7270/con	
MAGAK	A-32	5004-5007/pal		*Salterella*
MAGAK	A-32	5007/pal		*Salterella*
MAGAK	A-32	5007.7/pal		*Salterella*
MAGAK	A-32	5008-5011/pal		*Salterella*
MAGAK	A-32	5020-5022/pal		*Salterella*
MAYOGIAK	J-17	9371/gech		
MAYOGIAK	J-17	9375/gech		
MAYOGIAK	J-17	9533-9610/con		
MAYOGIAK	J-17	9638/gech		
MAYOGIAK	J-17	9681/gech		
MAYOGIAK	J-17	9686/gech		
MAYOGIAK	J-17	9813/gech		
MAYOGIAK	J-17	10596-10602/con		
MAYOGIAK	M-16	2850/gech		
MAYOGIAK	M-16	2920/gech		
MAYOGIAK	M-16	2990/gech		
MAYOGIAK	M-16	2866-3005/con		
MAYOGIAK	M-16	3005-3093/con		
NATAGNAK	H-50	6388-6394/FT		
NATAGNAK	K-23	4954-4965/con	4900-4970/con	
NATAGNAK	K-23	4965-4977/con		
NATAGNAK	H-50	6119-6127/FT		
NUNA**	A-10	3243.0-3245.0/con		
NUNA**	A-10	3245.0-3248.0/con		
NUNA**	A-10	3248.0-3250.5/con		
NUVORAK	O-09	3460/gech		
NUVORAK	O-09	3482/gech		
PARSONS	A-44		11330-11440/con	
PARSONS	P-53		10450-10820/con	
PARSONS	N-10		10120-10515/con	
PARSONS	F-09		11000-11240/con	
PARSONS	F-09		11240-11450/con	
PARSONS	F-09		11450-11650/con	
PIKIOLIK	M-26	5620-6470/con		
PIKIOLOIK	G-21		1380-1428.0/con	
PIKIOLOIK	E-54	9048-9078/con		
PIKIOLOIK	E-54	9101/pal		corals
PIKIOLOIK	E-54	9102/pal		corals
PIKIOLOIK	E-54	9102/pal		corals
RUSSELL	H-23	5978/gech		
RUSSELL	H-23	6008/gech		
SHOLOKPAQAK	P-60	5187/XRF	3260/gech	pickedSHC
SHOLOKPAQAK	P-60		3270/gech	
SHOLOKPAQAK	P-60		3280/gech	
SIKU	E-21		11160-11245/con	
TUK**	M-09	3008.5/gech	2860.0/gech	
TUK**	M-09	3008.0-3009.0/pln	2865.0/gech	
WAGNARK	C-23		13720-13950/con	

Measurements are in original units; depths are in feet, except for wells denoted ** , which are metres.

Anal., type of analysis; con, conodonts; gech, Rock-Eval; XRF, X-ray fluorescence; K-Ar, potassium-argon dating; pln, palynology; pal, paleontological dating; FT, fission-track dating; SHC, solid hydrocarbon (bitumen).

TABLE 7

XRF-analyses of volcanic rocks in Eskimo J-07, Sholokpaqak (E. Reindeer) P-60, and Onigat (E. Reindeer) C-38 wells

	WELL (depth in feet)								
	J-07 (2765)	J-07 (2865)	J-07 (2891)	J-07 (2919)	J-07 (2929)	J-07 (2945)	C-38 (5187)	P-60 (6127)	P-60 (6399)
A. Percent, normalized									
Fe_2O_3	6.24	12.53	7.84	9.39	10.56	5.53	9.58	3.59	1.59
MnO	0.15	0.09	0.30	0.14	0.14	0.01	0.03	0.06	0.11
TiO_2	0.90	0.66	0.53	0.60	0.58	0.86	0.72	0.55	0.17
BaO	0.04	0.04	0.01	0.03	0.03	0.03	0.03	0.03	0.04
CaO	0.14	0.85	12.98	7.33	6.27	0.09	3.10	9.33	0.04
K_2O	6.62	7.14	1.19	3.36	4.19	8.22	2.72	2.42	2.39
P_2O_5	0.10	0.06	0.06	0.08	0.07	0.08	0.10	0.06	0.02
Al_2O_3	17.27	16.28	14.51	14.06	14.28	20.72	18.71	7.91	3.89
SiO_2	55.11	50.59	48.43	49.44	48.95	51.79	47.50	63.58	90.49
MgO	7.06	5.16	9.30	9.47	10.27	2.93	6.09	0.57	0.26
Na_2O	2.16	1.61	2.12	1.51	0.75	0.28	3.53	0.16	0.05
SO_3	0.01	0.09	0.00	0.00	0.00	3.85	2.00	2.71	0.36
LOI	4.20	4.90	2.90	4.60	3.90	5.61	5.90	9.01	0.60
BASALT	Alkl	Alkl	Alkl	Alkl	Alkl	Alkl	Alkl	Thol	Thol
B. Parts per million (ppm)									
F	—	—	—	—	—	—	—	—	—
Zn	99	30	44	60	63	1	67	26	0
Cu	67	8	48	54	38	27	114	4	21
Pb	0	0	5	0	0	0	0	7	8
Ni	84	107	119	128	157	67	77	38	28
Ag	—	—	—	—	—	—	—	—	—
Mo	—	—	—	—	—	—	—	—	—
As	—	—	—	—	—	—	—	—	—
Hg	—	—	—	—	—	—	—	—	—
Sb	—	—	—	—	—	—	—	—	—
Rb	67	117	20	62	78	144	72	56	46
Cs	—	—	—	—	—	—	—	—	—
Sr	40	46	311	102	122	35	54	95	36
Ba	380	415	126	393	439	253	380	311	304
U	—	—	—	—	—	—	—	—	—
Ce	—	—	—	—	—	—	—	—	—
Cr	76	349	384	424	478	643	394	185	294
V	231	101	203	202	212	226	172	75	20
Y	13	18	10	15	15	17	13	11	5
La	—	—	—	—	—	—	—	—	—
Zr	69	61	110	65	66	64	75	220	118
Th	—	—	—	—	—	—	—	—	—
Mn	1018	628	1034	1009	1017	24	163	476	803

— = below detection limit of 5-10 ppm; Alkl., alkaline basalt; Thol., tholeiitic basalt; LOI, loss on ignition.

Lithology

Conspicuous on the horst is well indurated, white to light grey, nearly pure quartzite. It consists of coarse to fine, angular to rounded, clear quartz grains, tightly cemented by milky silica. The rocks are thin bedded, display faint sorting within the beds, crossbedding, and prograding ripples, suggesting a fluvial origin. Thin, ochre-coloured shale bands are intercalated.

Age

In the Magak A-32 well, the upper part of core through the top of the quartzite formation contains several bioturbated (Fig. 10a), ochre-coloured, millimetre- to centimetre-thick shale layers, interbedded with the quartzite. The shale appears to dip parallel to the enveloping quartzite and, therefore, is probably in succession with it. In two of these shale beds, poorly preserved, silicified fossils are present (Fig. 10b), which have been identified tentatively by W.H. Fritz (pers. comm. 1987; Appendix B) as Lower Cambrian *Salterella*? (Fig. 11a–e). Fritz and Yochelson (1988) commented that *Salterella* normally is restricted to the middle part of the Lower Cambrian *Bonnia–Olenellus* Zone. *Salterella* was a marine organism that lived in shallow lagoons (Reinhardt and Wall, 1975). If the interpretation is correct, the quartzite cannot be fluvial in origin. An Early Cambrian age is assigned to the quartzite.

Quartzite samples crushed and subjected to heavy mineral separation to obtain apatite and zircon for fission track dating did not yield enough material for further analysis.

Correlation

Prior to the identification of Lower Cambrian fossils in the Tuk Horst, the quartzite was considered to be Precambrian. Similar quartzite in the Northern Interior Plains is present in outcrops of the Lower Cambrian Old Fort Island Formation, and widely in the subsurface. The maximum penetration on the Tuk Horst is only about 30 m and, consequently, nothing is known about the beds underlying the quartzite. The degree of induration of the quartzite (drilling times of up to 6 h/m while coring these rocks are mentioned in the well history reports) suggests complete cementation; low-grade metamorphism is not evident in the intercalated shale. The fossils found in the shale in the Magak A-32 well indicate an Early Cambrian age for the quartzite. In addition, the composition of the quartzite is similar to that of the marine sandstone of the Early Cambrian Old Fort Island Formation in Anderson Plain. In some of the wells around the Tedji Lake area and in outcrop in the Brock Inlier on Coppermine Arch, the white, quartzose, mature, and typically friable Lower Cambrian sandstone is well cemented, and may represent the finer grained lithological correlatives. The sandstone, however, pinches out not far to the west of the Tedji Lake area and appears to do so to the north. This zero edge is poorly defined by well control. Thus, if the Tuk Horst quartzite is correlative with the Lower Cambrian Tedji Lake sandstone, it belongs to a basin separated by a large threshold from the one in the Northern Interior

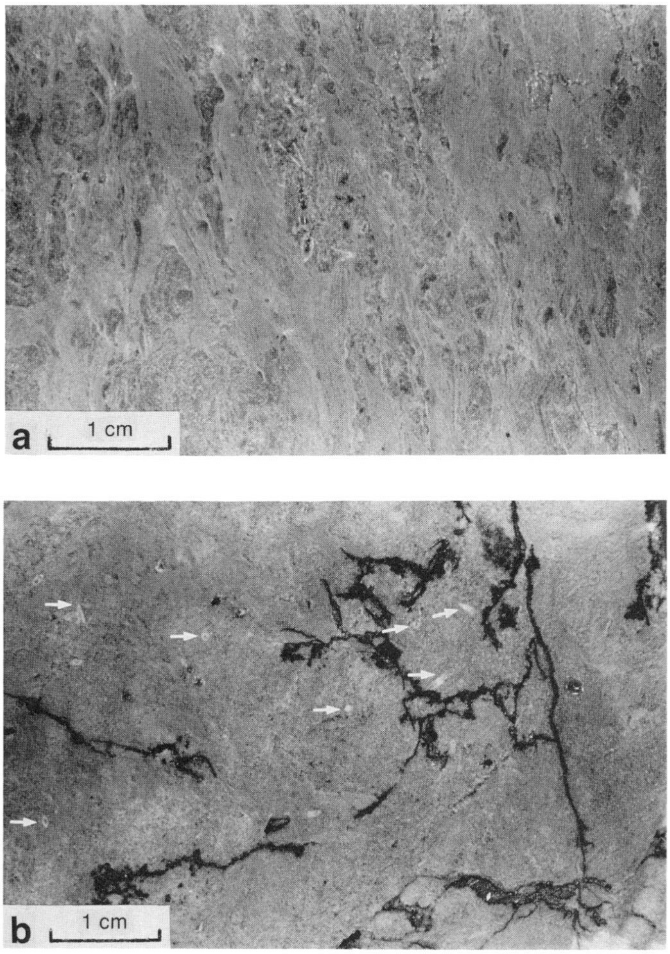

*Figure 10. Core photographs from Magak A-32. a) 5007 ft., bioturbation in shales (ISPG photo. 2790-4); b) 5007.7 ft., **Salterella**? sp. cones (indicated by arrowheads) in shale (ISPG photo. 2790–7).*

Plains. The Old Fort Island zero edge is poorly defined by well control. Therefore, another possibility is a single depositional basin, with the areas separated by a large peninsula. The basin is limited to the southwest by the absence of quartzite from the Campbell Uplift (see "Campbell Uplift" section below).

The Tuk Horst dolomite

Farther north, at the northern end of the Tuktoyaktuk Peninsula, three closely spaced wells (Kannerk G-42, Louth K-45, and Natagnak K-23; Fig. 1) contain Middle Ordovician dolomite. They are near the northwestern edge of the Tuk Horst. To the north the horst extends offshore and is visible on seismic lines (J. Dietrich, pers. comm. 1988), but has not been penetrated by wells.

Lithology

The Tuk Horst dolomite is fine to medium crystalline and mainly white, light buff to flesh coloured, with varying amounts of varicoloured (green, red, purple), phyllitic, interbedded shale. In one well, Kannerk G-42, the shale is red and green. In the other two wells part of the dolomite is orange to yellow and pink. The dolomite may be laminated and contains fenestrae.

Age

Middle Ordovician conodonts (Table 8; Appendix B) (Uyeno and Nowlan, pers. comm., 1988; Appendix B) have been recovered from the dolomite in the Natagnak K-23 well. Non-diagnostic Ordovician to Triassic conodont elements were found in the Louth K-45 well. Kannerk G-42 was not sampled because of contamination from shale caving.

Correlation

The Middle Ordovician age is very significant, because rocks of this age are absent from the entire Northern Interior Plains. This time interval is represented there by the sub-Mount Kindle unconformity. Dolomite of this age is reported only in the Porcupine, Ogilvie, and Mackenzie mountains; it is inferred to be present under the westernmost Peel area. The Tuk Horst dolomite is much younger than the quartzite, and the juxtaposition of wells with these lithotypes makes a regular stratigraphic succession less likely. A normal fault contact could be interpreted, with the dolomite forming a separated, faulted sliver lying on the Tuk Horst; an unconformity could also explain the observed pattern, although it is considered less likely.

The Middle Ordovician rapidly thins to zero. For example, the Stable Platform area to the southeast of the Tuk Horst contains a normal stratigraphic succession, as found in the adjacent Anderson Plains. In the Stable Platform, the Kiligvak I-29 well is closest to the area underlain by the Middle Ordovician Tuk Horst dolomite, but penetrated no Middle Ordovician rocks. Farther to the north, in the offshore Kilannak A-77 well, the dolomite about 500 m above total depth has a non-diagnostic Silurian to Middle Devonian conodont age (Table 8; Appendix B) (T.T. Uyeno, pers. comm., 1988); an interval deeper in the well is barren. In addition, the carbonate in these two wells does not match the lithology of the Tuk Horst dolomite. Thus, it appears that the Middle Ordovician is absent along the southeast side of the Tuk Horst; it is also absent from the Kugaluk N-02 and Wolverine H-34 wells in the nearby Anderson Plains.

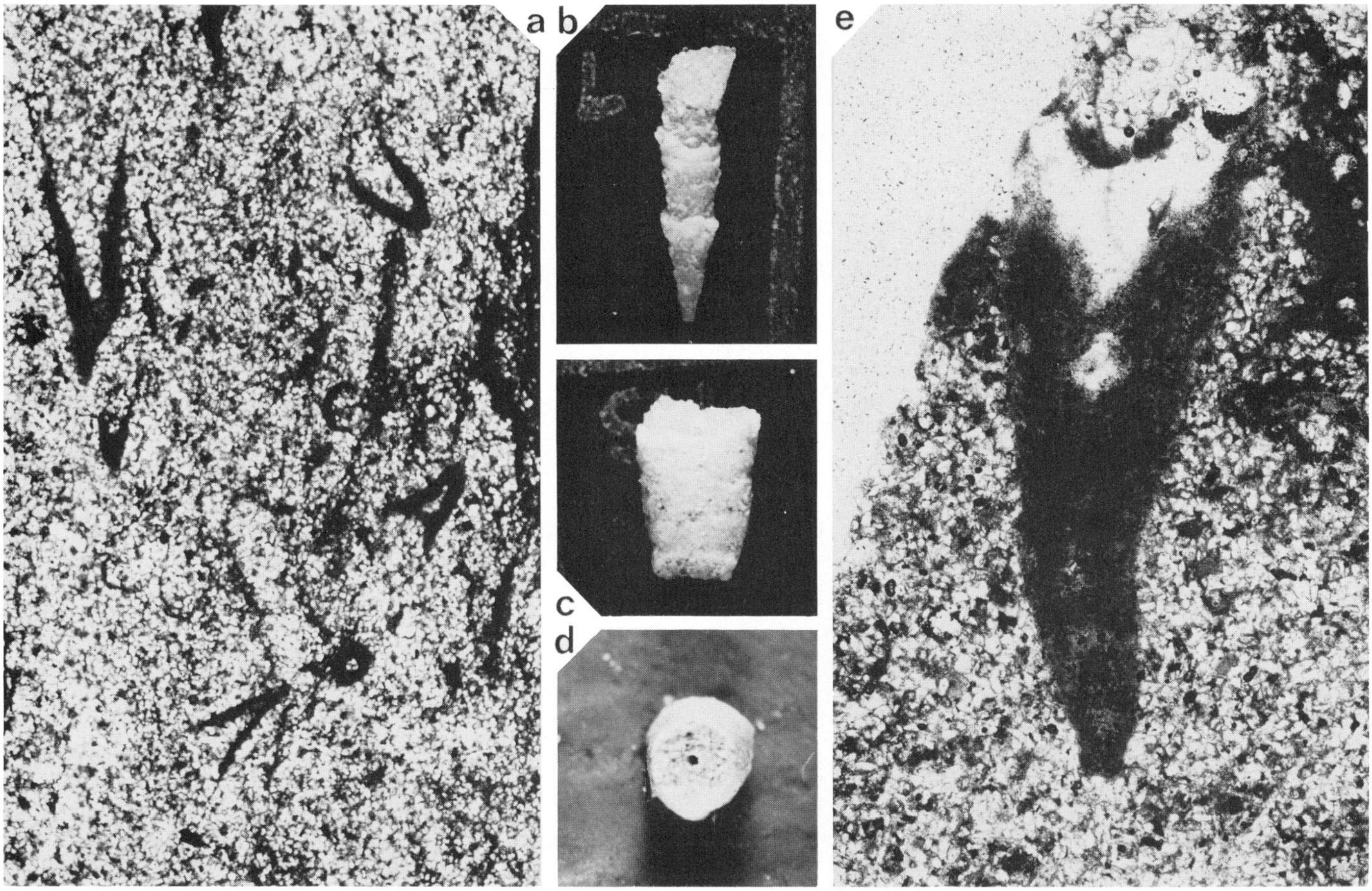

*Figure 11. **Salterella**? sp. from Magak A-32 well. a, e) Thin sections from interval 5007.0 to 5007.3 ft., GSC loc. C-104132a, show the outer wall of various specimens (a, x36.0, GSC no. 99550) and an axial plane view of a nearly complete specimen (e, x36.0, GSC no. 99551). Specimens arranged in the middle of the figure (b, c, d) are silicified replacements of inner laminar cones. b) a nearly complete replacement in side view (b, x13.9, GSC no. 99552); c, d) segment of a replacement (c, d x13.3, GSC no. 99553) in side and end views. The central tube is visible in the end view. All the silicified specimens are from interval 5020 to 5022 ft., GSC loc. C-104132d.*

If the Middle Ordovician carbonate was unconformably deposited on the Tuk Horst quartzite, then the emergence of the Tuk Horst must have lasted until immediately after the time of Franklin Mountain Formation deposition at the latest. The amount of normal Franklin Mountain dolomite without sand in the adjacent Tuk Flank suggests an earlier submerging of the horst, but there is no conclusive evidence.

Enigmatic rocks on the Tuk Horst

Rocks of unknown, but possible Paleozoic age, are present on the southwest part of the horst in the Akku F-14 (Fig. 1) well.

Lithology

The pre-Mesozoic succession in Akku F-14 consists of buff to pink, finely crystalline dolomite with a few laminae, interbedded with green and red phyllitic shale. Small amounts of buff chert are present. Near the bottom of the succession, the dolomite grades into quartzite, which differs from the quartzite described above in that it contains black minerals, is finer grained, and is stained red or yellow by iron in the matrix.

Age and correlation

One smooth conodont cone was recovered from carbonate rocks in the Akku F-14 well. Although indeterminate, it indicates an age no older than Late Cambrian and no younger than late Paleozoic. The sample was taken from drill cuttings and could represent cavings from higher in the well.

Dolomite similar in colour to that in the Akku F-14 well is found in wells in the area of the Tuk Horst dolomite (in which conodont identifications indicate a Middle Ordovician age), although no quartzite was penetrated in those wells.

TABLE 8
Conodont sampling and results

WELL NAME		CORE DEPTH	CUTTING DEPTH	RESULTS
AKKU	F-14		4500-4600	post Cambrian through Devonian
AKKU	F-14		4600-4700	barren
AKKU	F-14		4700-4800	barren
ATKINSON	A-55	7305-7325	6770-7300	barren, brachiopod fragments: E. Paleozoic
ATKINSON	L-17	2337.0-2340.6		early M. Ordovician (Whiterockian)
ATKINSON	L-17	2340.6-2344.4		early M. Ordovician (Whiterockian)
ATKINSON	L-17	2344.4-2350.2		early M. Ordovician (Whiterockian)
ATIGI	G-04		11800-12100	barren
ATIGI	G-04		12100-12250	barren
ESKIMO	J-07	2945-2954		barren
ESKIMO	J-07	2954-2963		barren
ESKIMO	J-07	2963-2971		barren
IMNAK	J-29		10860-11170	barren
INUVIK	D-54		1900-2150	barren
INUVIK	D-54		3100-3350	barren
KILANNAK	A-77		2100.0-2160.0	indeterminate
KILANNAK	A-77		2165.0-2230.0	M.Ord - M.Dev, probably Early to early M. Devonian
KILANNAK	A-77		2235.0-2305.0	Late Emsian
KILANNAK	A-77		2310.0-2360.0	Late Silurian to Middle Devonian
KILANNAK	A-77		2365.0-2460.0	Late Silurian to Middle Devonian
KILANNAK	A-77		2750.0-2850.0	barren
KIMIK	D-29		8480-8720	barren
KIMIK	D-29	8602-8613		probably Middle to Late Ordovician
KIMIK	D-29	8613-8624		probably Middle to Late Ordovician
LOUTH	K-45	6970-7270		Ordovician through Devonian
MAYOGIAK	J-17	9533-9610		late Emsian
MAYOGIAK	J-17	10596-10602		late Emsian
MAYOGIAK	M-16	2866-3005		barren
MAYOGIAK	M-16	3005-3093		probably Middle Devonian
NATAGNAK	K-23		4900-4970	barren
NATAGNAK	K-23	4954-4965		indeterminate
NATAGNAK	K-23	4965-4977		early M. Ordovician (Whiterockian)
NUNA	A-10	3243.0-3245.0		barren
NUNA	A-10	3245.0-3248.0		barren
NUNA	A-10	3248.0-3250.5		barren
PARSONS	A-44		11330-11440	barren
PARSONS	F-09		11000-11240	Lower Ordovician (early to mid Canadian)
PARSONS	F-09		11240-11450	barren
PARSONS	F-09		11450-11650	barren
PARSONS	N-10		10120-10515	Lower Ordovician (early to mid Canadian)
PARSONS	P-53		10450-10820	probably Middle to Late Ordovician
PIKIOLOIK	E-54	9048-9078		Middle Ordovician to Middle Devonian
PIKIOLOIK	G-21		1380.0-1428.0	barren
PIKIOLIK	M-26	5620-6470		barren
SIKU	E-21		11160-11245	barren
TUKTU	O-19	7352-7371		probably Early to early Middle Devonian
WAGNARK	C-23		13720-13950	barren

NOTE: Depths in decimals are in metres, the others are in feet.

Considering the lithology of the Akku F-14 rocks and the conodont age, a Middle Ordovician age is assumed. If so, we may actually be seeing in this well the quartzite underlying the Middle Ordovician dolomite to the northeast; the strata in this well do not fit the pattern of increasing age to the south on the horst.

The Campbell Uplift

The Campbell Uplift, at the southernmost end of the Tuk Horst (southwest of Inuvik), is a tectonic window through Cretaceous clastic rocks that exposes Paleozoic carbonate with minor clastic units, unconformably overlying Precambrian argillite, sandstone, and dolomite. The youngest Paleozoic rocks of the Tuk Horst outcrop locally in this area, while elsewhere older formations underlie the Cretaceous. North of Inuvik, the Inuvik D-54 well penetrated a similar succession with carbonate overlying argillite and sandstone. Although part of the Eskimo Lakes Arch, the exact relationship of the uplift to the Tuk Horst remains unclear.

Lithology

In the Campbell Uplift, the pre-Mesozoic succession consists of carbonate overlying clastic rocks. The uppermost carbonate is Devonian limestone, underlain by Silurian to Ordovician dolomite of the Vunta Formation (Dyke, 1975). The contact of the Vunta dolomite with the underlying clastic strata is covered, but on the basis of dip measurements, appears to be unconformable (Norris and Calverley, 1978). No good measured sections of the dolomite in this area have been published. The underlying Proterozoic clastic units are a succession of interbedded, varicoloured argillite, quartzite, and dolomite (Norris and Calverley, 1978).

The pre-Mesozoic succession in the nearby Inuvik D-54 well (Fig. 1) consists of sandy dolomite overlying a thick clastic sequence of shale with some interbedded sandstone. These clastic rocks overlie a thin volcanic unit at a depth of 4100 ft. (1250 m). The volcanic interval is underlain by black, slightly dolomitic shale, white quartzite, red and green shale, and finally a thick sequence of white quartzite. In a core cut at 5120 ft. (1561 m), the earliest quartzite is composed of clear, white, well cemented sandstone with angular grains.

Age and correlation

Outcrop. One of the youngest limestone units exposed in the uplift contains crinoid ossicles with twin canals, indicating a middle Emsian to earliest Eifelian age (Norris, 1985) equivalent to the Landry Formation. In addition, conodonts from the uppermost exposed unit have an age equivalent to the Hume Formation (Uyeno and Mason, 1975). The contact with the formations below the Emsian limestone is a fault, as deduced from field relationships in one of the exposures. The underlying dolomite was assigned by Norris and Calverley (1978) to the Vunta Formation, of Ordovician to Silurian age (Norris, 1967). Thus, equivalents of Hume, Landry and older carbonates are present here.

The contact with underlying clastic rocks of Proterozoic age appears to be unconformable according to dip measurements. Thus, the Mount Kindle-equivalent Vunta appears to rest directly on the Precambrian, and the Cambrian and Early Ordovician are absent. This would be the deepest erosion anywhere beneath the Middle Ordovician unconformity. Norford (1964, Section 23) reports undated dolomite at the base of the Vunta farther west in the uplift and assumed that it is equivalent to the Cambrian–Lower Ordovician Franklin Mountain Formation. Also, M. Cecile (pers. comm., 1990) maintains that undated dolomite, which is likely Franklin Mountain equivalent, is exposed on the uplift. Even so, the total thickness of the Franklin Mountain carbonate, as compared to that in the Anderson Plain, was dramatically reduced by the Middle Ordovician erosion. The absence of Lower Cambrian quartzite is also significant if Cambrian dolomite is present on the uplift. It marks a southwestward limit to the Lower Cambrian area of quartzite deposits.

A palaeomagnetic study of the varicoloured Precambrian clastic rocks found that the geomagnetic dipole corresponds to an age between 1020 Ma and 1220 Ma on the mean polar wandering curve for North American Precambrian rocks (Norris and Black, 1964). These rocks would thus correlate with the Shaler Group (*op cit.*), which in turn has been correlated with the informal Mackenzie Mountain supergroup (Aitken, 1981).

Subsurface. The pre-Mesozoic sequence in the Inuvik D-54 well (Fig. 1) is anomalous. It may indicate a Cambrian or Proterozoic tectonic uplift event on the Campbell Uplift.

Dolomite subcrops immediately below the sub-Mesozoic unconformity, and, on the basis of lithotype, is tentatively assigned here to the Mount Kindle Formation. The rocks have little in common lithologically with Devonian formations. Pugh (1983, Appendix) quoted a report by T.P. Chamney (Report number MES-Paleoz-7-TPC-1972) on fossils in drill cutting samples in D-54. (?)Middle Devonian algal oögonia and cricoconarids are present in the interval between 1050 and 1110 ft. (320–338 m). Most of the fossil identifications are qualified by question marks. The presence of fossils is not questioned, but their Devonian age is tentative, and therefore is disregarded in favour of a Silurian age.

The contact with the underlying Franklin Mountain Formation is picked on the basis of the wireline gamma-ray log pattern. In addition, sand grains (Wielens and Williams, 1988) are present, although here they are not really diagnostic of the contact, owing to the presence of sand throughout dolomites of the Franklin Mountain and Mount Kindle formations in this well. Samples collected for conodonts in the Franklin Mountain interval between 2334 and 2360 ft. (711–719 m) proved barren. It should be noted that the abundance of sand in this well is atypical of the Ronning Group, whereas chert is relatively sparse. The shaly and sandy dolomite near the bottom of the Ronning carbonate section between 3500 and 3780 ft. (1067–1152 m) is clearly related to the widely recognized shaly basal Franklin Mountain Formation (Norford and Macqueen, 1975), where sand is atypical. Sand is found only on the crest of the Mackenzie Arch. The restriction of sandstone abundance in this area to just this well suggests that it is a locally derived accumulation, perhaps associated with a lower Paleozoic emergent area, which could include the area of the Campbell Lake Uplift. It may also have included those parts of the Tuk Horst where quartzite is present.

According to Norris and Calverley (1978), the covered interval between the outcropping Vunta dolomite and Proterozoic rocks is represented in the subsurface in Inuvik D-54 by red or green shale and sandstone. Although the authors do not indicate the exact interval in the well, it probably lies between 3780 and 4080 ft. (1152–1244 m). The weathered volcanic unit at 4100 ft. (1250 m) is similar to that in the Eskimo Lakes J-07 well on the Tuk Horst to the north, but no age is available and the volcanic rocks could have been derived from anywhere. Cambrian rocks appear to be absent from the Campbell Uplift 12 km to the south; therefore, the clastic rocks in this well are probably Precambrian in age. One piece of conflicting age evidence involves ostracodes from the interval below the volcanic rocks, mentioned by C. Yorath on the GSC litholog of the Inuvik D-54 well at 4260 ft. (1298 m) and 4300–4320 ft. (1311–1317 m). No specimens were curated. Careful study of the drill cuttings from these intervals did not reveal any ostracodes. The author found only several ostracode-like impressions, moulds of a round, olive-green, translucent, crystalline material. Thus, no proof could be found of a Paleozoic age for this interval.

The clastic Proterozoic sequence underlying the volcanic unit and consisting of black dolomitic shale, red and green shale, and white quartzite, does not compare with any of the four Precambrian units of Pugh (1983) or the formations described by Aitken and Pugh (1984). It does have similarities with both the Shaler Group [Kilian or Reynolds Point formations (Young, 1981)] on Victoria Island and the upper Tsezotene Formation (Aitken, 1981) of the Mackenzie Mountains.

The substantial difference in thickness of the Franklin Mountain Formation between this well and exposure in the uplift indicates significant differences in vertical movement during the Cambrian to Middle Ordovician in this area.

The Tuk Flank

Northwest of the Tuk Horst is an area where carbonate rocks of Ordovician to Devonian age subcrop, including remarkable Middle Ordovician dolomite. Most of the rocks are dolomite, but some wells contained limestone; locally the section contains shale rich in chert. Each of the two carbonate lithotypes will be discussed separately. Owing to the complexity of this area, it was decided to describe the area by lithotype units rather than strictly stratigraphically. The lithotypes are depicted in Figure 4.

Conodonts provided the key age information, particularly for the dolomite. The carbonate was sampled where possible from cores as well as drill cuttings to obtain these fossils (Figs. 12, 13; Tables 6, 8). The conodonts were identified by T.T. Uyeno and G.S. Nowlan, and the relevant reports are listed in Appendix B.

Dolomite succession

Lower Ordovician to Lower Devonian dolomite, black shale and chert are present in the Atkinson L-17, Imnak J-29, Kimik D-29, Mayogiak L-39, Nuna A-10, Pikiolik G-21 and M-26, Tuk M-09, and Wagnark C-23 wells, and in a large cluster of wells near Parsons Lake, consisting of the Atigi (East Reindeer) G-04; Kamik D-48; Parsons A-44, D-20, F-09, L-37, L-43, N-10, O-27, P-41, and P-53; and Siku A-12, C-11, and E-21 wells (Fig. 1).

Lithology

The dolomite can be subdivided into several subgroups on the basis of lithotype and likely correlation.

The dolomite in some of the Parsons wells displays the characteristics of both formations of the Ronning Group: the presence of large amounts of chert and the absence of recognizable fossils. The dolomite is fine to medium crystalline and ranges from white to dark grey or brown in colour; clear quartz crystals and pyrite are present in small amounts. Dolomite interbedded with shale is limy. The chert is varicoloured, but mainly brown, and has a pelletal character. Other wells interspersed in this densely drilled area contain interbedded black dolomitic limestone, chert, and shale. These strata appear to represent the transition to Road River Formation. The Ronning dolomite contains dolomitized, non-diagnostic fossils and locally fenestral pores in the Kimik D-29, Nuna A-10, Pikiolik M-26, and Tuk M-09 wells. The vuggy dolomite is fine to medium crystalline, extensively fractured, and may contain clastic interbeds; the main colour is light grey, but may grade to black. Some of the cores appear to be composed of carbonate debris flows. A small amount of chert is present.

Middle Ordovician dolomite is present in the Atkinson L-17 well. The heavily fractured dolomite is mainly light grey to dark brown and mottled and contains ghosts of fossils. Rounded, frosted, and clear euhedral quartz crystals are present. Chert is absent; thin beds of claystone are intercalated.

Dark grey, fine crystalline, sucrosic to white, coarse, possible Lower Devonian dolomite in the Wagnark C-23 and Imnak J-29 wells contains only rare chert pebbles

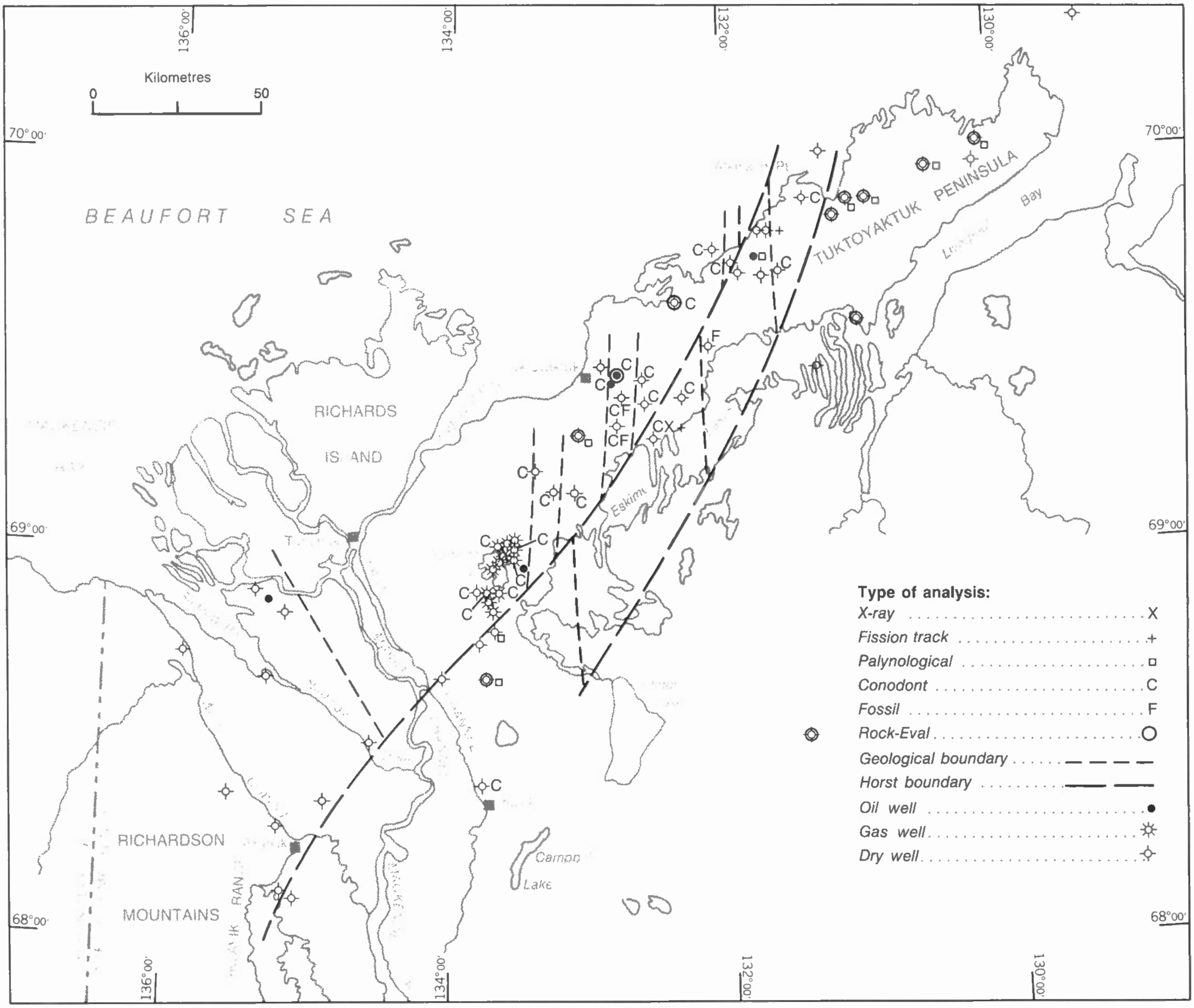

Figure 12. Sample localities and types of analysis performed.

(instead of the large quantities of chert found in the rocks of the Parsons area), and rounded, frosted quartz grains (instead of the euhedral crystals). Minor dark brown to black shale bands are present. The dolomite does not contain fossils.

Age

Out of the 27 samples processed for conodonts from dolomite successions in the carbonate area, 18 were barren (Table 8). Conodonts recovered from the remaining dolomite indicate an early Middle Ordovician age in the Atkinson L-17 well, and Early Ordovician (early to middle Canadian) ages in the Parsons F-09 and N-10 wells. A probable Middle to Late Ordovician age is indicated for the same rocks in the Kimik D-29 and Parsons P-53 wells. Most of the dolomite is substantially older than the limestone to be discussed below.

Correlation

The cherty dolomite of the Parsons area is Early Ordovician (Franklin Mountain Formation equivalent) and in at least one well, Parsons P-53, probably Late Ordovician (Mount Kindle Formation equivalent). Rocks from other wells in this same area are extensively

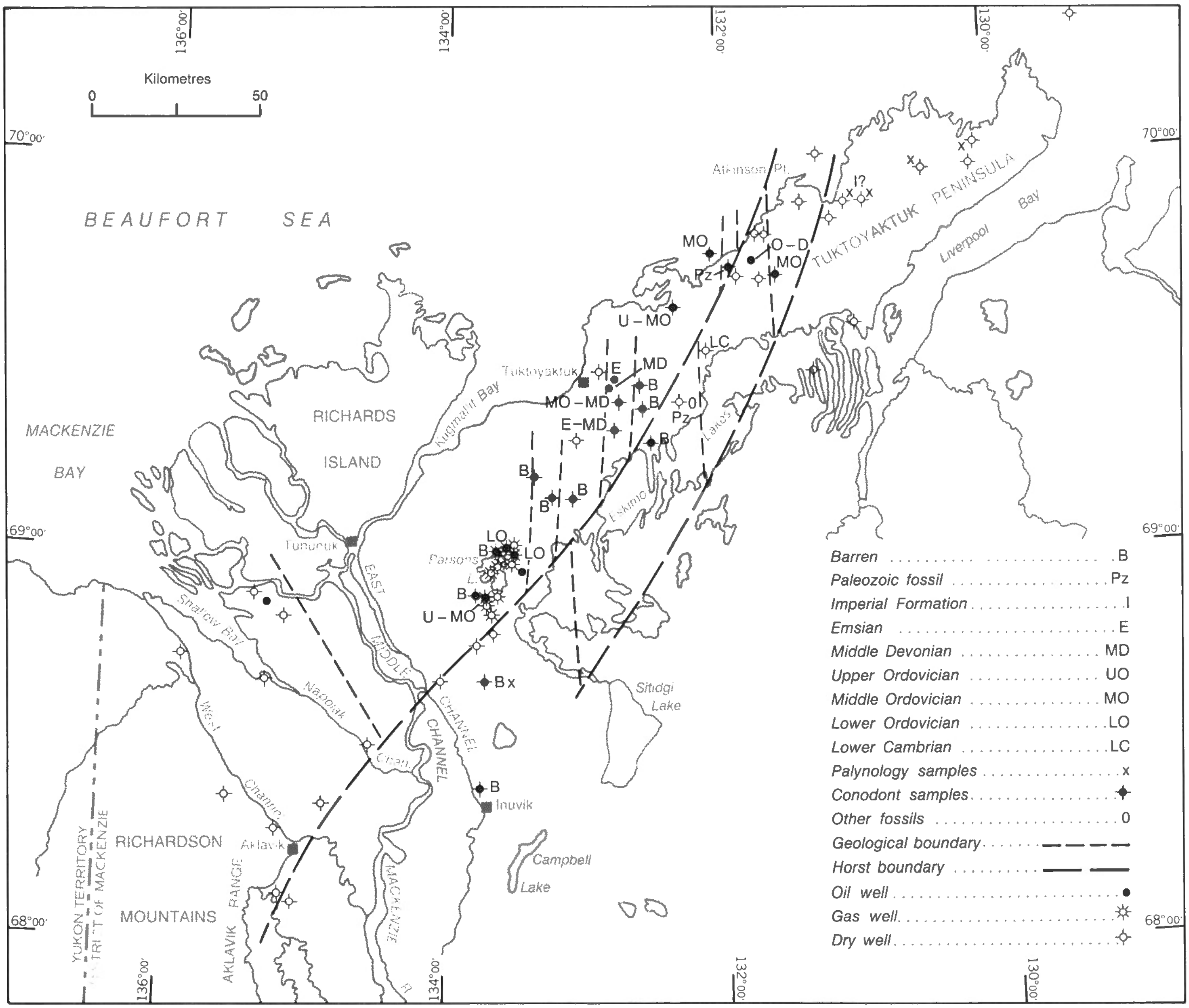

***Figure 13.** Fossil localities and ages of collections.*

stratified with chert and black shale or even limestone, indicating a position in or proximal to the carbonate-shale transition, a position analogous to that of the dolomite in the westernmost Peel area. They thus represent either a northeastward extension of the Richardson Trough or a southwestward extension of the Franklinian Geosyncline. They lie in the southwesternmost Ronning area shown in Figure 8. The few interbedded, black, dolomitic limestone and shale beds in this area also suggest a proximity to the transition into shale, especially in this heavily drilled area, where neighbouring wells with dolomite or chert are usually not more than one kilometre apart. In addition, the age of the conodonts (Early Ordovician) in dolomite overlying limestone in the Parsons F-09 well proves that the limestone belongs to the Franklin Mountain Formation equivalent. Although strictly speaking the limestone should have been described under the "limestone succession" section, it is included in the "dolomite succession" section, because of its genetic relationship.

The northernmost Ronning carbonate is found in the area indicated by O in Figure 8. Two wells are located in the southwestern part of this block, Pikiolik G-21 and M-26 (Fig. 1). The G-21 well contains dark to light grey, fine crystalline dolomite with light buff to dark brown chert and red quartz grains. This lithotype is typical of the cherty member of the Franklin Mountain Formation in the Northern Interior Plains. The M-26 well contains a mainly micritic to fine crystalline, laminated, dark to light grey dolomite with oolites (silicified?) and coloured chert pellets, and interbedded limestone. Although the characteristic white chert is absent, these rocks belong to the upper part of the Franklin Mountain Formation, based on lithological correlation.

The Atkinson L-17 and Kimik D-29 wells are located in the northeastern part of the same block. As mentioned when discussing the Middle Ordovician dolomite of the Tuk Horst, this time interval is represented by a hiatus in the Interior Plains; dolomite of this age is reported only in the Porcupine, Ogilvie, and Mackenzie mountains, and in the Tuk Horst, as described above; it may be present under the westernmost Peel area. The area around Atkinson L-17 is the only one on the Tuk Flank to contain carbonate of this age. The carbonate in Kimik D-29 has an age range of possibly Middle to Late Ordovician. The Pikiolik M-26 and G-21 wells were barren of conodonts.

It appears that the block is tilted so that the older carbonate subcrops to the southwest. Therefore, the stratigraphic succession in the block would be the top of the Franklin Mountain Formation overlain by Middle Ordovician carbonate.

The dolomite in the Nuna A-10 well (Fig. 1) in comparison is lighter coloured and contains dolomitized, but non-diagnostic fossils. It is lithologically very similar to the Upper Ordovician Mount Kindle Formation in the Northern Interior Plains, and thus separate from the block containing Devonian rocks penetrated by the Imnak and Wagnark wells.

The debris flow and black shale in the Tuk M-09 well (Fig. 1) are similar to lithotypes in the Road River Formation in the Richardson and Mackenzie mountains, and the rocks encountered in the Parsons area, although chert is not present in abundance in this well.

The position of the coarse crystalline, white dolomite in Mayogiak L-39 (Fig. 1) is unclear. The shallow, 20 m, penetration and extremely heavy caving render the samples unrepresentative. The rocks do not match the Arnica Formation because they are coarsely crystalline and white; their white colour separates them from the Mount Kindle Formation and they differ from the Franklin Mountain Formation because chert and coarse crystallinity are not present in that formation. My interpretation is that this specific area is probably underlain by formations equivalent in age to the Ronning Group and forms the middle of the Ordovician–Silurian blocks enclosed by bands of Devonian carbonate (Fig. 8).

The age of the remainder of the dolomite has not been established. Lithotype correlation suggests an age equivalent to that of the Arnica Formation (Early Devonian) for the dolomite in the Imnak J-29 and Wagnark C-23 wells (Fig. 1). The dark grey to white, fine sucrosic dolomite in these wells is non-fossiliferous, does not contain chert other than in rare, small, well rounded pebbles, and may contain a few shale beds. In particular, the absence of large quantities of chert and the darker colours point to the Arnica Formation of the Northern Interior Plains as an equivalent. Based purely on lithological correlation, these wells define the southwesternmost band with Devonian carbonate (dolomite), as is indicated in Figure 8.

Limestone succession

Lower to Middle Devonian limestone was penetrated in five wells on the Tuk Flank: Atkinson A-55, Mayogiak J-17 and M-16, Pikiolik E-54, and Tuktu O-19 (Fig. 1). Both Mayogiak wells contain a minor amount of dolomite. In addition, the offshore well Kilannak A-77 penetrated a succession of limestone underlying the clastic units of the Imperial and Canol formations. For correlation purposes, the carbonate in this well will also be discussed in this chapter. (In A-77 the Imperial

Formation subcrops below the sub-Mesozoic unconformity and it will be described as part of the Stable Platform.) The wells containing limestone define two of the narrow, north trending Devonian bands on the subcrop map (Figs. 4 and 8; one band is based on only one control point). The third Devonian band contains dolomite and has been discussed above.

Limestone is present in minor amounts in the Parsons Lake wells, where it is always dark in colour and interbedded with black shale and chert. Those wells with dolomitic limestone are interspersed in an area where most of the wells contain dolomite of Ordovician age. They were discussed under the "dolomite succession" section.

Lithology

The limestone in this subgroup is generally dark grey to black, pelitic, micritic, nodular, and has mottling caused by dolomitization. The nodules can be rounded or angular. The limestone is generally fractured, both horizontally and vertically, with the fractures filled by calcite spar. Locally, it is fossiliferous.

The limestone strata are lithologically similar to those of the Landry Formation in the Northern Interior Plains.

Age and correlation

The limestone in the Kilannak A-77, Mayogiak J-17, Pikiolik E-54, and Tuktu O-19 wells contains crinoid ossicles with twin or even four central canals, and corals, all indicating an Emsian to earliest Eifelian age (Norris, 1985), corresponding to the age of the Landry, but not the Hume Formation. Conodonts confirm this age in Mayogiak J-17, Tuktu O-19, and Kilannak A-77 (T.T. Uyeno, pers. comm., 1988; Table 8, Appendix B). In Pikiolik E-54, the conodonts indicate an age range from Middle Ordovician to Middle Devonian. The limestone/dolomite successions in the Pikiolik M-26, Mayogiak M-16, and Atkinson A-55 wells did not contain the twin-canal crinoid ossicles, but could correlate to Early Devonian rocks of the Landry and Arnica formations on the basis of their lithotype. No conodonts were recovered from Atkinson A-55, but tiny, fragmented, brachiopod shells were present. These shells are not indicative of a specific age. One sample from Mayogiak M-16, between 916 and 943 m (3005–3093 ft.), contained a single conodont fragment of probable Middle Devonian age. This would place the interval in the Hume, but fossil-poor limestones are atypical of the Hume Formation. A slightly greater age appears more probable.

The fossil content of the rocks in the Atkinson A-55 well is thus not very diagnostic. Poor preservation of the imprints of fossils, which suggest *Amphipora*, *Thamnopora*, etc. (see Appendix A), preclude their identification. Pelletal material is present and the total assemblage is similar to that found in rocks of the Landry Formation in the Northern Interior Plains, but distinctly darker in colour. This darker colour may indicate the proximity to the transition zone where the carbonate changes facies to Road River shale. Thus, this well has penetrated a northernmost, north-trending band of probable Devonian limestone, while the other limestone-containing wells define the middle band (Figs. 4, 8). The southernmost band of Devonian age is composed of dolomite, as described in the preceding section.

The Stable Platform

Southeast of the Tuk Horst the Imperial Formation subcrops and is composed of shale, with interbedded siltstone, sandstone and conglomerate. This part of the study area belongs to the stable platform of the Northern Interior Plains. The name "Platform" is used here to indicate that all tectonic movement of the Tuk Horst and Flank was anchored to this stable block. Wells with deeper penetration, such as Kiligvak I-29 and Kilannak A-77 (offshore between the Tuktoyaktuk Peninsula and Banks Island, Fig. 1), encountered a deeper sequence, from Hare Indian Bluefish Member or Hume Formation to Ronning carbonate, comparable to the Paleozoic sequence found in wells in the Northern Interior Plains (e.g., Kugaluk N-02, Wolverine H-34, located about 80 km SE from the Tuk Horst). Other wells in the Stable Platform area are Amaguk H-16, Amarok N-44, Kanguk F-24 and I-24, Kapik J-39, Nuvorak O-09, and Russell H-23 (Fig. 1).

Imperial succession

Lithology

The clastic rocks in the flysch-like Imperial Formation consist of salt and pepper siltstone, sandstone and conglomerate, interbedded with dark to medium grey shale. The pebbles mainly consist of carbonate and chert. The sandstone and siltstone are composed of quartz with mica flakes and irregularly distributed carbonaceous flakes. The lower part of the succession generally consists of shale.

Kugaluk N-02 in the Anderson Plain (Fig. 1) was cored from 818 ft. (249 m) to total depth of 8045 ft. (2452 m). The following observations from this well are common to the Imperial Formation and pertain to the wells in the study area:

1. Plant remains and carbonaceous flakes are present in every sample.
2. The sand and siltstone have a salt and pepper appearance, mainly caused by the presence of detrital mica.
3. The shale is indurated, but not enough to keep it from splitting in the core box.
4. The sandstone contains crossbedding and does not display soft-sediment deformation.
5. Laminae are usually present in the argillaceous beds.
6. No evidence of burrowing was found in the sandstone.
7. Scouring features are present, as well as Bouma sequences in the more shaly parts.
8. The sandstone beds are usually thicker than those in the cores of the Onigat, Ikhil, and Sholokpaqak wells.

Age and correlation

Core samples for palynological dating from the Imperial Formation in the Nuvorak O-09, Kanguk I-24, Amarok N-44, and Russell H-23 wells on the northernmost part of the peninsula (Figs. 1, 14) yielded sparse pollen, which indicates a probable Givetian age (J. Utting and D.C. McGregor, pers. comm., 1988; Appendix B).

Carbonate-clast and chert-clast conglomerate was encountered within this siliciclastic sequence in several wells. The presence of the conglomerate, together with an unusually large proportion of sandstone, indicates that there was a proximal source. Because the conglomerate is carbonate- and chert-rich, the Paleozoic carbonate of the Tuk Flank is the most likely origin. Probable sources of the carbonate clasts are erosional truncation of uplifted carbonate blocks on the Tuk Flank and/or erosion of carbonate from the crest of the horst. The wells with deeper penetration within the Anderson Plain record an undisturbed succession of rocks as old as the Mount Kindle Formation, and, in Kugaluk N-02 and Wolverine H-34, the Franklin Mountain Formation (Fig. 15). A similar sequence was encountered in the Kilannak A-77 well, offshore to the north of the Peninsula. Thus, these last two areas cannot have been the source of the conglomerate.

The stable platform is part of, and geologically similar to, the northwestern Anderson Plain, where Mesozoic strata rest directly upon a westward thickening wedge of Imperial Formation; some thinning of the formation close to the Tuk Horst is visible on seismic lines (J. Dietrich, pers. comm., 1988) and was probably caused by pre-Cretaceous erosion. Thus, below the unconformity, Upper Devonian rocks in the Stable Platform area are juxtaposed with Cambrian or older rocks on the Tuk Horst. To accommodate the amount of missing section (a few kilometres), a major fault is necessary. Unpublished seismic lines (COGLA) in the Eskimo Lakes area indicate that there is only a restricted area where faulting could have occurred, and that a series of stepfaults, as on the Tuk Flank, does not appear to be present.

The Permian Wedge

The Permian Wedge is located near Aklavik in the westernmost part of the Mackenzie Delta and at the southwestern extension of the Tuk Flank. The name selected stresses a northward thinning wedge, apparently unconformably overlying the much older Paleozoic carbonate of the Tuk Flank. Another, less likely interpretation is a contact along a fault of unknown nature. The wedge lies outside the boundaries of the study area and the rock samples were given only a cursory examination. The pre-Mesozoic was penetrated in the wells Aklavik A-37 and F-38, Beaverhouse H-13, Kugpik L-21 and O-13, Napartok M-01, Napoiak F-31, Ulu A-35, and Unak B-11 (Fig. 1; Table 5). The area is underlain by a succession of clastic rocks with sparse interbedded carbonate.

Permian succession

Lithology

The clastic rocks consist of interbedded varicoloured shale, siltstone, sandstone, conglomerate and chert beds, and the intercalated carbonate is mainly limestone, rich in chert.

Age and correlation

The clastic rocks in the Permian Wedge area are lithologically very similar to Carboniferous and Permian rocks in northern Yukon described by Bamber and Waterhouse (1971). The few Permian palynological ages mentioned in well-history reports corroborate this lithotype correlation.

Cross-sections

To illustrate the characteristics of the different lithotype areas, four stratigraphic cross-sections have been constructed (Fig. 1). Three of them are essentially parallel in a southwesterly to northeasterly direction; one section (A–A′, Fig. 14) covers the wells on the Stable Platform that penetrate the regular successions including the Imperial and older formations, and is connected through the offshore Kilannak A-77 well to Orksut I-44 on Banks Island. The other two sections parallel the Tuk Horst (section B–B′, Fig. 16) and the Tuk Flank (section C–C′, Fig. 17). Along the southwestern end, a more-or-less east–west section (D–D′, Fig. 15) crosses and connects the areas covered by the other sections, and also connects the area of the GSC deep-reflection seismic line, which extends northwesterly, at the southwest termination of Tuktoyaktuk Peninsula (Fig. 1).

The log sections show the stratigraphic relationships. Stick sections show the pre-Mesozoic configuration for each of the stratigraphic sections and contain the tectonic position as interpreted. Both types of section have the pre-Mesozoic erosional surface as a datum. On the stick sections, the sea-level line represents the inverse of the post-Mesozoic structural component.

Section A–A′, through the Stable Platform, from Anderson Plain to Banks Island

The stratigraphy of Tuktoyaktuk Peninsula on the Stable Platform southeast of the Tuk Horst is similar to that encountered in the Northern Interior Plains (see section A–A′, Fig. 14). Regrettably, only one well on the Peninsula, Kiligvak I-29, penetrates the carbonate rocks underlying the clastic section of the Imperial Formation. The only other well in this general area with a more complete regular succession is the offshore Kilannak A-77, which permits correlation of the stratigraphy of Anderson Plain with that of the Banks Island well Orksut I-44.

Kugaluk N-02

The southeasternmost well on section A–A′ (Fig. 14) is Kugaluk N-02, on Anderson Plain. It is also included on section D–D′ (Fig. 15), to be discussed below. This well has a typical Northern Interior Plains succession, except that the Imperial Formation is thin due to erosion at the sub-Mesozoic unconformity. Truncation of pre-Mesozoic formations close to the Tuk Horst is visible on seismic lines. The amount of missing Imperial section demonstrates significant post-Imperial and pre-Mesozoic erosion in this area. The upper part of the Imperial contains mostly the usual siltstone and rare sandstone sequence, while the lower part is predominantly shale. The underlying Canol Formation directly overlies the Bluefish Member of the Hare Indian Formation; the grey shale of the Hare Indian and the Ramparts Formation carbonate are absent. The Hume Formation, although thin, comprises the normal upper limestone and lower shale sequence. The underlying Landry Formation is fairly thick in this area and changes gradually with depth into the Arnica dolomite. The Tatsieta Formation below the Arnica Formation consists of the typical limestone. The stratigraphy of the Ronning dolomite deeper in Kugaluk N-02 is tied down by several conodont ages: conodonts recovered between 5590 and 5614 ft. (1704–1711 m) and at 5819 ft. (1774 m) indicate a Silurian age. Between 6111 and 6126 ft. (1863–1867 m) and at 6491 ft. (1978 m) conodonts indicate a late Middle Ordovician to Late Silurian age, equivalent to the Mount Kindle Formation (Norford et al., 1973). The unconformable contact between the Franklin Mountain and Mount Kindle formations is marked by floating sand grains (see Wielens and Williams, 1988). The well bottoms in the Franklin Mountain Formation.

Kiligvak I-29

The next well on the section, Kiligvak I-29, at a distance of 106 km from Kugaluk N-02, also penetrated some of the carbonate underlying the Paleozoic upper clastic unit. The Imperial Formation, in contrast to the previous well, contains conglomerate with pebbles of carbonate and chert, and a large proportion of sandstone. No internal correlation of the Imperial Formation is apparent between this well and Kugaluk N-02. The Canol Formation again directly overlies the Bluefish Member and both are, together with the underlying Hume Formation, quite similar in lithotype and thickness to the sequence in Kugaluk N-02. The Landry Formation is somewhat thinner, and changes gradually downward into the dolomite of the Arnica; lack of samples from this interval forces a correlation based on only the wireline logs for the bottom part of the penetrated succession.

Amaguk H-16, Amarok N-44, and Russell H-23

The next three wells on the section are, in order, Amaguk H-16, Amarok N-44, and Russell H-23. The first two wells contain conglomerate and a large proportion of sandstone. None of the three penetrates the complete Imperial Formation. The nearly pure shale section that is observed elsewhere in the lower Imperial Formation, is present only in Russell H-23. Beyond Russell H-23, the section extends off the Tuktoyaktuk Peninsula.

Kilannak A-77

The next well is Kilannak A-77, in which the basal Imperial is not as shaly as is common in the previous wells: cherty sandstone underlies a shaly and silty sequence. This lithotype change is a reflection of the fact that, at this locality, formations begin to display similarities to the stratigraphy of both the Northern Interior Plains and the Arctic Islands. Therefore, the Arctic Islands Nomenclature (henceforth indicated as AIN) will be given where possible. The AIN equivalent of the Imperial is the Cape de Bray Formation, and the siliceous sandstone in the AIN is the Blackly Formation, which does not have an equivalent in the Plains. The Imperial Formation overlies a thin, silicious, black shale —the Canol Formation and possibly the Bluefish Member (AIN: Kitson Formation). The underlying Hume limestone is still quite similar to that in the Northern Interior Plains, and contains the usual lower shaly limestone member. It is equivalent to the upper limestone of the AIN Blue Fiord Formation, the top of which may be lowermost Eifelian in age and the bottom not older than Emsian. Conodonts in the sequence directly underlying the Hume Formation in this well indicate a late Emsian age (T.T. Uyeno, pers. comm., 1988; Appendix B), which correlates with the Landry Formation. The presence of crinoids with multiple central canals confirms this age. The formation gradually becomes more dolomitic with depth, and changes into the Arnica dolomite. Here the Tatsieta is not recognizably limestone, and is therefore tentatively assigned to the dolomitic sequence with "noisier" gamma-ray and sonic wireline logs. The related unconformity may be less prominent in this area. The AIN equivalent is the Unnamed shaly dolomite. The lowermost sequence of light brown dolomite may be equivalent to the Peel Formation, but contains floating quartz crystals and could be Mount Kindle or even upper Franklin Mountain Formation.

Orksut I-44

The final well on the section is Orksut I-44 on Banks Island. The pre-Mesozoic succession starts with the Cape de Bray clastic rocks, equivalent to the Imperial Formation. It is underlain by the radioactive, black, siliceous shale of the Kitson Formation, which has a similar thickness to that of the equivalent Canol Formation in the Northern Interior Plains. It is underlain by limestone and dolomite of the Blue Fiord Formation. The limestone unit is fairly thin, compared with that of the combined Hume and Landry formations, but the equivalent of the lower Hume shaly limestone is still evident near the upper part of the Blue Fiord Formation. A conodont from the dolomite of the Blue Fiord Formation is indicative of a late Emsian to early Eifelian age (T.T. Uyeno, pers. comm., 1988; Appendix B). The somewhat shalier, underlying Unnamed shaly dolomite has a Middle Ordovician to Middle Devonian conodont age. The well terminates in the cleaner Unnamed dolomite, which is here tentatively correlated with the Peel Formation.

Section B–B′, on the Tuk Horst

Sholokpaqak P-60, Onigat C-38

The southwest-northeast section B–B′ (Fig. 16) illustrates the relationships of the pre-Mesozoic rocks on the Tuk Horst. The section starts in the southwest with the Sholokpaqak (East Reindeer) P-60 and Onigat (East Reindeer) C-38 wells. Both contain a clastic sequence of Precambrian age, as has been discussed above. The clastic succession in Sholokpaqak P-60 overlies cherty, grey dolomite at the very base. Clastic beds in Onigat C-38 are overlain by white sandy dolomite. A few tentative correlations between wells are indicated. The differences between the dolomite in both wells render it unlikely that the dolomites in Sholokpaqak P-60 and Onigat C-38 are equivalent. In addition, there appear to be some similarities in the log traces of the clastic succession. There is no evidence that the dolomite in C-38 could belong to the Ronning Group carbonate. One could argue that the dolomite has the same wireline-log characteristics as the Franklin Mountain Formation, but according to the sand content it would have to be the top part of the formation; the lack of chert contradicts this.

Eskimo J-07

The next well, Eskimo J-07, contains volcanic rocks. They have been assigned a Precambrian to Cambrian age and overlie stromatolitic dolomite (Fig. 9), which has been assigned a Precambrian age. The dolomite cannot be dated, owing to the lack of active branching and walls in the stromatolites; it is dissimilar to that in the two previously described wells in this section, and, based on the apparent northeasterly dip from Sholokpaqak P-60 to Onigat C-38, is probably younger than the dolomite in Onigat C-38.

Akku F-14

In the next well, Akku F-14, dolomite overlies a clastic succession of black sandstone, siltstone and shale, but probably does not correlate with the dolomite in Onigat C-38, because it is more shaly and has a more radioactive wireline-log response than in Onigat C-38. The increase in shale content is not part of a regional trend in the Precambrian dolomite, which regionally is consistent in lithology. Also, a conodont fragment from the drill cuttings indicates a Paleozoic, probably post Middle Cambrian age (T.T. Uyeno, pers. comm., 1988; Appendix B). The clastic succession contains a fair amount of black minerals such as amphibole and biotite. It has a unique appearance and thus does not appear correlatable to the much lighter coloured clastic rocks in the Sholokpaqak P-60 and Onigat C-38 (East Reindeer) wells.

Magak A-32, Atkinson M-33, and Natagnak H-50

The next wells on the section are, in order, Magak A-32, Atkinson M-33, and Natagnak H-50. All three contain the white, well indurated quartzite of the Tuk Horst. Based on the fossils in Magak A-32, the quartzite is dated as Early Cambrian.

Louth K-45

The final well, Louth K-45, penetrated the shaly Tuk Horst dolomite and contains non-diagnostic conodonts (Ordovician to Triassic range). The conodonts in the neighbouring Natagnak K-23 well indicated a more precise Middle Ordovician (Whiterockian) age, which probably also applies to K-45. It is possible that the carbonate overlies the Tuk Horst quartzite unconformably. More probable is a fault contact; normally the entire Franklin Mountain succession is overlain by the Middle Ordovician strata, as is apparent on the O-block of the Tuk Flank (see discussion under "dolomite succession").

If the succession in the Sholokpaqak P-60 and Onigat C-38 (East Reindeer) wells is Precambrian in age, it indicates a general northward dipping plunge of the Tuk Horst during erosion, whereby the southwest end of the horst was truncated to a lower stratigraphic level than the northeast end. Local tectonics complicated this simple concept in the Campbell Uplift. This plunge is corroborated on a local scale by the northeasterly dip (Fig. 16) derived from the tentative correlations between the two wells. According to this dip, the carbonate and volcanic rocks dip below those found in Eskimo J-07 and thus must be older.

Section C–C′, the Tuk Flank

Parsons P-53 and F-09

Section C–C′ (Fig. 17) displays the relationships of pre-Mesozoic sediments on the Tuk Flank. Two wells, Parsons P-53 and F-09, at the southwesternmost end of the section, display cherty dolomite of Middle to Late and Early Ordovician age, respectively, equivalent to the older part of the Ronning Group. The presence of chert and black shale reflects proximity to a facies change into the Road River Formation and indicates that the Richardson Trough extended northward to include this area.

Imnak J-29

The dolomite in the next well, Imnak J-29, has been assigned a probable age equivalent to that of the Arnica Formation. This well lies in the southernmost of the Devonian carbonate bands (Fig. 8).

Pikiolik E-54 and Mayogiak J-17

The next two wells are Pikiolik E-54 and Mayogiak J-17; both contain dolomite and limestone of the Arnica and Landry formations, and Emsian crinoids and conodonts. The wells are located on the middle band of Devonian carbonate (Fig. 8); no well on the line of section is located in the intervening area of Ronning carbonate.

Kimik D-29

The section continues with Kimik D-29, which contains Middle to Late Ordovician conodonts, indicating correlation with the Mount Kindle Formation or older strata. In this dolomite, an interval of grey shale and floating quartz grains causes a gamma-ray kick on the wireline logs and could represent the contact between the Mount Kindle Formation and the Middle Ordovician dolomites.

Atkinson A-55

From this Middle Ordovician carbonate area, the section continues into the northernmost Devonian limestone area as shown by Atkinson A-55. The sequence of interbedded limestone and dolomite is quite similar to the transition zone between the Landry and Arnica formations, and precludes correlation with the Ronning carbonate. The reported early Paleozoic fossil age is based on tiny, broken brachiopod fragments and is very tentative.

On the stick section, the contacts correlated between Pikiolik E-54 and Mayogiak J-17 are terminated by faults (Figs. 17, 18). Many faults in the pre-Mesozoic sequence are visible on seismic data for this area, but their nature and stratigraphic displacement are difficult to ascertain. Another explanation for the difficulty in correlating the strata could be the presence of an unconformity.

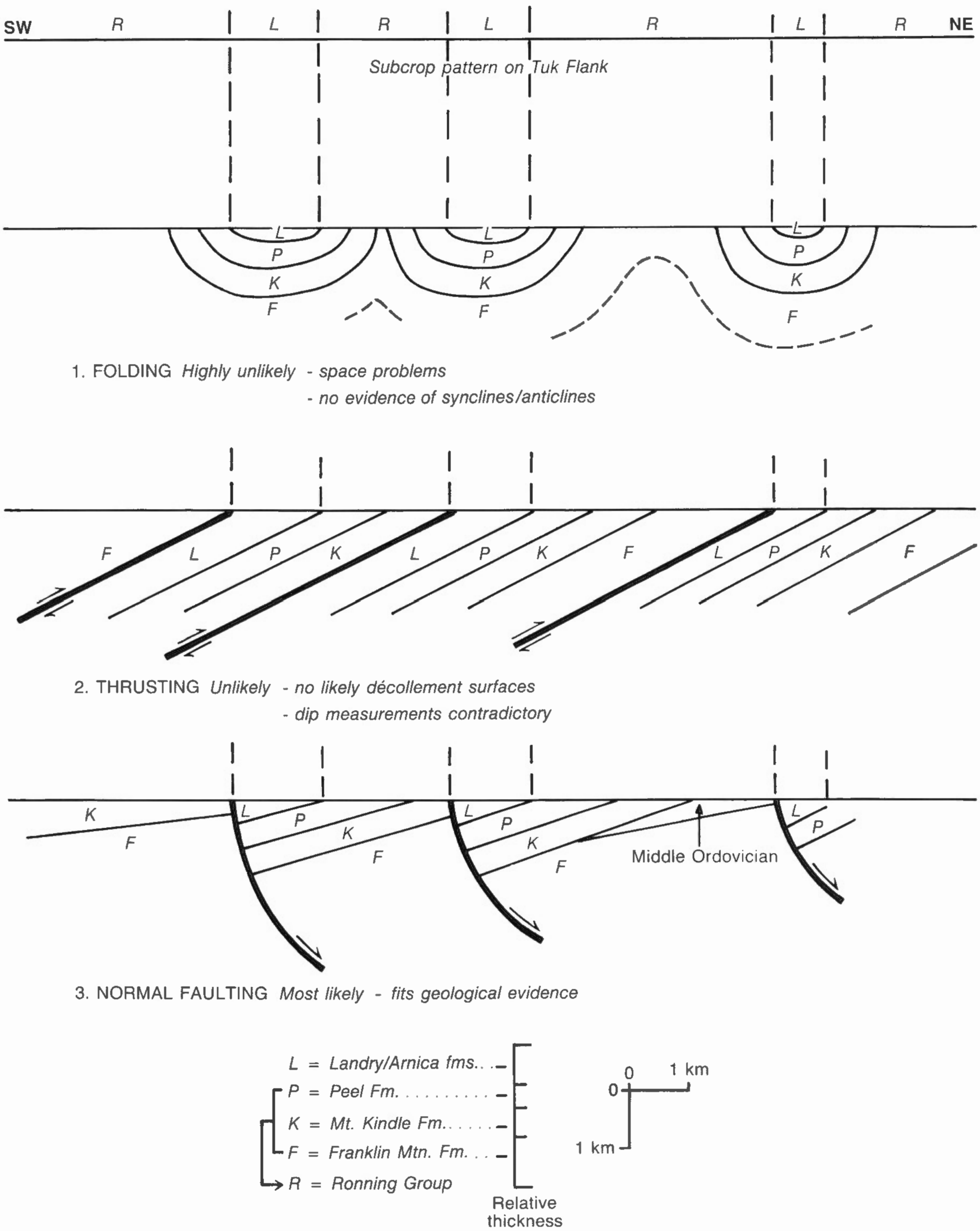

Figure 18. Hypothetical cross-sections to explain the pattern of geological outcrops in the Tuk Flank area.

Connecting section D–D′

Section D–D′ (Fig. 15), in the Inuvik area, crosses Tuk Horst from the Stable Platform (Anderson Plain) into the Tuk Flank.

Wolverine H-34 and Kugaluk N-02

From east to west, the first wells on the section are Wolverine H-34 and Kugaluk N-02; the latter has already been described under section A–A′. Both wells contain a typical Northern Interior Plains succession. The Imperial Formation underlies the sub-Mesozoic unconformity in both wells; it thickens from Wolverine H-34 to Kugaluk N-02 and then thins to zero in Inuvik D-54 on the Tuk Horst. The thickness of the Imperial Formation normally increases westward as a result of the homoclinal westward dip of the Paleozoic formations; the missing section indicates significant post-Imperial and pre-Mesozoic erosion in this area, in part related to the Campbell Uplift. This, together with some truncation below the sub-Mesozoic unconformity, suggests pre-Mesozoic tilting and erosion of Imperial and older strata, as is visible on seismic sections. Noteworthy is the presence of a thin interval of Hare Indian Formation grey shale in Wolverine H-34 that is absent in Kugaluk N-02. The shale has a limited distribution in the Northern Interior Plains.

Inuvik D-54

The sequence in Inuvik D-54, to the west of the previous two wells, is peculiar and is indicative of a Cambrian and Ordovician history of the Campbell Uplift area. Rocks assigned tentatively to the Mount Kindle Formation (as discussed above) subcrop immediately below the sub-Mesozoic unconformity and are underlain by Franklin Mountain Formation dolomite.

The lithology of the Ronning Group is atypical here in that there is an abundance of sandstone throughout both the Mount Kindle and Franklin Mountain formations, whereas chert is relatively sparse. The shaly dolomite near the bottom of the Ronning carbonate section, between 3500 and 3780 ft. (1067–1152 m) depth, represents the widely recognized shaly basal Franklin Mountain Formation (Norford and Macqueen, 1975), but the sand content is abnormal. The source of the sand in this well is unknown. Its abundance suggests that it was locally derived, perhaps indicating that (part of) the Eskimo Lakes Arch first emerged as a positive element during the Cambrian and Ordovician.

The interval with shale and some interbedded sandstone between 3780 and 4080 ft. (1152–1244 m) is considered to be Precambrian, based upon the detrital volcanic rocks found near 4100 ft. (1250 m) depth that are thought to be Proterozoic in other wells on the Tuk Horst. In addition, Paleozoic carbonate overlies Precambrian clastic rocks on the Campbell Uplift 12 km to the south of this well, making the presence of Cambrian formations unlikely.

The detailed sequence underlying the detrital volcanic rocks contains, from top to bottom: black, slightly dolomitic shale; white quartzite; red and green shale; and another thick succession of white quartzite, all of which are considered to be Proterozoic.

Sholokpaqak P-60 and Ogeoqeoq J-06

From Inuvik D-54, on the northwest edge of the Campbell Uplift, the section changes direction to the north. Direct correlation to the strata in the next well, Sholokpaqak (East Reindeer) P-60, is impossible. A thick sequence of clastic rocks overlies dolomite found near the bottom of the well. As discussed above, a Precambrian age is assigned to the clastic formations in P-60, as well as to those in the next well on the section, Ogeoqeoq J-06, where a succession of interbedded white and grey sandstone, red and grey shale and a small amount of grey dolomite has been penetrated. The information available for both wells does not allow any correlation within the clastic package.

Parsons P-53

The northwesternmost well in the section, Parsons P-53, cannot be correlated to Ogeoqeoq J-06, and contains dolomite with interbedded black shale and large amounts of chert, and probable Middle to Upper Ordovician conodonts. Chert is absent in Middle Ordovician dolomite found to the north in the study area; the large amount of chert present in this well thus points to Franklin Mountain Formation equivalence. The lithological characteristics equate the rocks with the Road River Formation (transitional to basin facies). Wells in the immediate neighbourhood, such as Parsons F-09 and N-10, have Lower Ordovician conodonts in the dolomite, while others contain cherty dolomite only, suggesting that the whole area lies close to the shale-out edge of the Paleozoic carbonate and is in part equivalent to the upper part of the Franklin Mountain Formation. Following the reasoning above, the Middle Ordovician is absent in this area, limiting the extent of the basin of this age. The presence of subcropping Paleozoic carbonate in these wells indicates that they are downfaulted on the Tuk Flank with respect to the Tuk Horst; on the other hand, they are uplifted with respect to the Stable Platform. A substantial amount of anhydrite nodules is present in P-53. Their presence is anomalous because this mineral is normally absent in the lower Paleozoic formations in this area. The appearance of the anhydrite nodules points to localized, restricted, small basins, related to tectonism and the proximity of the Middle Ordovician unconformity to the south and the basin to the north.

Thermal maturity

Wherever possible, samples were collected from shales in cores for geochemical analysis. Most samples were analyzed for maturity and total organic carbon (TOC) on the Rock-Eval instrument; a few samples were processed for measurement of reflectance on coaly or bituminous material. Thermal Alteration Indices (TAI) and conodont Colour Alteration Indices (CAI) were determined from paleontological samples. Not enough data were available to present a coherent picture of the maturity pattern in the study area. The data are presented in Tables 9–12. Most maturities are fairly high for the sample depths and indicate either anomalously high heat flows, or, more probably, erosion of a thick succession from this area. The TOC, S_2, and Hydrogen Index values of a number of the immature samples indicate that they have source rock potential. Kanguk I-24 has fair, gas-prone source potential, but has an anomalous T_{max} value. Good to excellent, oil-prone, immature source potential is indicated in Kimik D-29 around 8470 ft. (2580 m). In

TABLE 9

Results of Rock-Eval analysis

WELL NAME		CORE DEPTH	T_{max}	S_1	S_2	S_3	PI	S_2/S_3	TOC	HI	OI
AMAGUK	H-16	4113	522	0.07	0.11	0.13	0.39	0.85	0.82	16	13
AMAGUK	H-16	4123	497	0.12	2.27	0.15	0.05	15.13	4.78	3	47
AMAROK	N-44	7641	300	0.00	0.01	0.05	0.00	0.20	0.73	7	1
AMAROK	N-44	7650	0	0.00	0.00	0.03	0.00	0.00	0.67	4	0
ESKIMO	J-07	2955-2968	—	—	—	—	—	—	—	—	—
KANGUK	I-24	4560	349	0.21	0.08	0.14	0.72	0.57	0.76	18	11
KANGUK	I-24	4607	587	0.08	4.03	0.76	0.02	5.30	4.23	18	95
KIMIK	D-29	8466	431	0.61	11.37	0.53	0.05	21.45	2.78	19	409
KIMIK	D-29	8476	425	0.75	14.38	0.81	0.05	17.75	3.48	23	413
MAYOGIAK	J-17	9371	444	0.44	7.43	0.25	0.06	29.72	2.79	9	266
MAYOGIAK	J-17	9375	445	0.32	4.37	0.27	0.07	16.19	1.73	16	253
MAYOGIAK	J-17	9638	407	0.27	0.53	0.95	0.34	0.56	8.86	11	6
MAYOGIAK	J-17	9681	468	0.92	2.62	0.78	0.26	3.36	5.39	14	49
MAYOGIAK	J-17	9686	471	0.65	2.52	0.54	0.21	4.67	4.00	14	63
MAYOGIAK	J-17	9813	—	—	—	—	—	—	—	—	—
MAYOGIAK	M-16	2850	439	0.46	1.53	0.45	0.23	3.40	1.48	30	103
MAYOGIAK	M-16	2920	437	0.95	2.24	0.93	0.30	2.41	2.85	33	79
MAYOGIAK	M-16	2990	439	0.44	1.02	0.59	0.30	1.73	1.89	31	54
NUVORAK	O-09	3460	494	0.11	0.18	0.21	0.38	0.86	0.70	30	26
NUVORAK	O-09	3482	483	0.17	0.74	0.28	0.19	2.64	1.59	18	47
RUSSELL	H-23	5978	495	0.01	0.12	0.23	0.08	0.52	0.45	51	27
RUSSELL	H-23	6008	486	0.02	0.09	0.12	0.18	0.75	0.38	32	24
SHOLOKPAQAK	P-60	3260	—	—	—	—	—	—	—	—	—
SHOLOKPAQAK	P-60	3270	—	—	—	—	—	—	—	—	—
SHOLOKPAQAK	P-60	3280	—	—	—	—	—	—	—	—	—
SHOLOKPAQAK	P-60	4574	—	—	—	—	—	—	—	—	—
SHOLOKPAQAK	P-60	4587	340	0.14	0.06	0.2	—	0.17	—	—	—
SHOLOKPAQAK	P-60	4587	371	0.16	0.12	0.29	—	0.16	—	—	—
TUK	M-09	2860.0	436	0.33	1.06	0.94	0.24	1.13	1.67	56	63
TUK	M-09	2865.0	436	0.23	0.97	1.54	0.19	0.63	1.66	93	58
TUK	M-09	3008.5	366	0.47	0.60	0.38	0.44	1.58	1.29	29	47
PIKIOLIK	E-54	8980	444	0.40	3.90	0.31	0.09	12.58	2.95	11	132
PIKIOLIK	E-54	9300	444	0.79	5.14	0.59	0.13	8.71	2.37	25	217

NOTE: Depths in decimals are in metres, the others are in feet. T_{max}, temperature of highest hydrocarbon production; S_1, hydrocarbons present; S_2, hydrocarbons generated; S_3, carbon dioxide generated; PI, Production Index, TOC, total organic carbon content; HI, Hydrogen Index; OI, Oxygen Index.

TABLE 10

Results of palynological (TAI) analysis

WELL NAME		CORE DEPTH	TAI	COMMENTS
AMAROK	N-44	7634-7644	high	no pollen
KANGUK	I-24	4569	3+to 4-	
KANGUK	I-24	4594-4607	3+to 4-	
KANGUK	I-24	5244-5254	4-	
NUVORAK	O-09	3437-3460	2+	
NUVORAK	O-09	3481-3494	2+	
RUSSELL	H-23	5975-6010	2+	
SHOLOKPAQAK	P-60	4566-4577		barren
SHOLOKPAQAK	P-60	4578-4593		barren
SHOLOKPAQAK	P-60	5197-5201		barren

NOTE: Depths are in feet. TAI, Thermal Ateration Index of spores.

Mayogiak J-17, good, mature, oil-prone source rock is present at 9371 ft. (2855 m), while some fair oil- and gas-prone source material is found at 9375 ft. (2856 m) and at a deeper level around 9680 ft. (2950 m). Fair, low-mature, gas-prone source potential exists at 2920 m in Mayogiak M-16. Pikiolik E-54 contains mature, fair, oil- and gas-prone source beds around 9000 ft. (2750 m).

Structural implications—evidence of Ellesmerian orogenesis

The pre-Mesozoic subcrop-geological map (Fig. 8) shows a complex pattern of rock units of Precambrian to Late Devonian age. The pattern requires a major post-Devonian to pre-Cretaceous structural event(s).

In the Tuk Flank, there is an alternating pattern of subcropping Ronning Group (Cambrian–Silurian) dolomite and Devonian carbonate (dolomite and Emsian limestone of the Arnica and Landry formations). Contacts between these alternating formations trend north or northwest (Fig. 4) as defined by well data. This pattern could be produced in three ways: by folding, thrust faulting, or normal faulting (Fig. 18). It is interesting to note that "Ellesmerian" structures in the Barn Mountains (Dyke, 1974; Norris and Yorath, 1981), which are potentially of the same age as the Tuktoyaktuk sub-Mesozoic structures, also trend northerly. The "Ellesmerian" structures in the mountains are compressional; therefore thrusting and possibly folding are favoured as options for the structures in the carbonate to the northwest of the Tuk Horst. Cook et al. (1987) also interpreted potential major pre-Mesozoic deformational foreshortening from the GSC deep-reflection seismic line crossing the southwest part of the peninsula (Fig. 1). Dip measurements are compatible with either possibility.

TABLE 11

Results of conodont (CAI) analysis

WELL NAME		CORE DEPTH	CAI	COMMENTS
AKKU	F-14	4500-4600	3.5	
AKKU	F-14	4600-4700		barren
AKKU	F-14	4700-4800		barren
ATKINSON	A-55	7305-7325		barren
ATKINSON	L-17	2337.0-2340.6	5	
ATKINSON	L-17	2340.6-2344.4	5	
ATKINSON	L-17	2344.4-2350.2	5	
ATIGI	G-04	11800-12100		barren
ATIGI	G-04	12100-12250		barren
ESKIMO	J-07	2945-2954		barren
ESKIMO	J-07	2954-2963		barren
ESKIMO	J-07	2963-2971		barren
IMNAK	J-29	10860-11170		barren
INUVIK	D-54	1900-2150		barren
INUVIK	D-54	3100-3350		barren
KILLANAK	A-77	2100.0-2160.0	3	
KILLANAK	A-77	2165.0-2230.0	3	
KILLANAK	A-77	2235.0-2305.0	3.5	
KILLANAK	A-77	2310.0-2360.0	2.5	
KILLANAK	A-77	2365.0-2460.0	3	
KILLANAK	A-77	2750.0-2850.0		barren
KIMIK	D-29	8480-8720		barren
KIMIK	D-29	8602-8613	5	
KIMIK	D-29	8613-8624	5	
LOUTH	K-45	6970-7270	5	
MAYOGIAK	J-17	9533-9610	5	
MAYOGIAK	J-17	10596-10602	5	
MAYOGIAK	M-16	2866-3005		barren
MAYOGIAK	M-16	3005-3093	5	
NATAGNAK	K-23	4954-4965	5	
NATAGNAK	K-23	4965-4977	5	
NATAGNAK	K-23	4900-4970		barren
NUNA	A-10	3243.0-3245.0		barren
NUNA	A-10	3245.0-3248.0		barren
NUNA	A-10	3248.0-3250.5		barren
PARSONS	A-44	11330-11440		barren
PARSONS	F-09	11000-11240	4	
PARSONS	F-09	11240-11450		barren
PARSONS	F-09	11450-11650		barren
PARSONS	N-10	10120-10515	5	
PARSONS	P-53	10450-10820	4.5	
PIKIOLOIK	E-54	9048-9078	5	
PIKIOLOIK	G-21	1380.-1428.0		barren
PIKIOLIK	M-26	5620-6470		barren
SIKU	E-21	11160-11245		barren
TUKTU	O-19	7352-7371	5	
WAGNARK	C-23	13720-13950		barren

NOTE: Depths in decimals are in metres, the others are in feet. CAI, conodont Colour Alteration Index.

TABLE 12

Results of bitumen reflectance analysis

WELL NAME		CORE DEPTH	R_{max}	R_o equiv.
AMAGUK	H-16	6940	1.9	1.617
KANGUK	I-24	4607	3.2	2.451
KUGALUK	N-02	830	2.2	1.810
KUGALUK	N-02	2406	2.4	1.938
KUGALUK	N-02	2552	2.7	2.130
KUGALUK	N-02	2599	2.7	2.130
KUGALUK	N-02	2655	2.7	2.130
KUGALUK	N-02	2673	2.5	2.002
KUGALUK	N-02	2674	2.5	2.002
KUGALUK	N-02	2681	2.7	2.130

NOTE: Depths are in feet. R_{max}, maximum reflectance of bitumen; R_o equiv., bitumen reflectance recalculated to vitrinite reflectance.

The contacts of these formations with the Tuk Horst are problematic. They may either be abruptly truncated against a northeast trending major fault or change trend abruptly to swing parallel to the horst. The latter hypothesis is more attractive and will be discussed further under the section "Dipmeter data" below. The similarities of these rocks to formations found in the Richardson, Ogilvie, and Mackenzie mountains (e.g., shale transition of the Ronning Group; presence of Middle Ordovician rocks) and the differences with formations on Banks Island appear to preclude major left-lateral wrench displacements from the north (Arctic Islands); on the other hand, there is no evidence that the major fault in this area, the Eskimo Lakes Fault (Fig. 8), is a transcurrent fault. All available information points to a normal dip-slip fault (L.S. Lane, pers. comm., 1988).

The Imperial Formation subcrops on the Stable Platform to the southeast of the Tuk Horst. The abrupt, consistent change from Imperial Formation on the Stable Platform to early Paleozoic and older rocks on the Tuk Horst appears best explained by the presence of a fault (Fig. 19), with a possible reversal in the direction of movement during later stages. This southeastern fault, parallel to the Eskimo Lakes Fault, could be a strike-slip fault, a normal fault or a thrust fault. Two models are possible with regard to the time of faulting: the Tuk Horst could have become a high either during or after deposition of the Imperial; the former model is simpler and more attractive. The presence of conglomerate with chert and carbonate clasts in the upper, preserved part of the Imperial succession suggests that, whatever the nature of the fault, movement on it was in part contemporaneous with deposition of the upper part of the Imperial Formation. The conglomerate was derived from the erosion of Ronning Group cherty carbonate. The Tuk Horst itself is a likely source, but the tilted blocks of the Tuk Flank must also have provided debris.

A thinning and truncation of the Imperial Formation close to the Tuk Horst is evident on seismic sections. This requires a certain amount of uplift of the Stable Platform block (underlying the Imperial) in the neighbourhood of the Tuk Horst. Following the above reasoning on the timing of the reversal in direction, the presence of the Imperial conglomerate is not explained if the faulting was post-Imperial with subsequent pre-Mesozoic erosion of the area. If both models are considered in combination, the vertical movement along the fault must have been reversed after deposition of the Imperial Formation. Seismic sections (unpublished data) from the Eskimo Lakes area constrain the interpretation to a steep fault contact between Tuk Horst and the Stable Platform, with almost no space for step faults.

The peculiar nature of units in the Inuvik D-54 well suggests a Paleozoic high in the area of the Campbell Uplift. The anomalous abundance of sandstone throughout the carbonate section in this well, but not in other wells of the area, suggests that it was locally derived and that a local emergent area was present.

The Campbell Uplift and the Tuk Horst experienced a similar evolution. Both underwent pre-Cretaceous erosion and post-Cretaceous deformation with downdropping of the northwest side. It is virtually certain that earlier Paleozoic and Proterozoic structures played a major role in controlling the location and character of these younger uplifts. The Campbell Uplift appears to have undergone a more complex tectonic history than the Tuk Horst, possibly with more episodes of uplift and sinking.

Dipmeter data and structure

Dipmeter data were collected from available dipmeter wireline logs. The mean values of dip and strike above and below the pre-Mesozoic unconformity were recorded. With the help of a Wulff nomogram, the Mesozoic dip values were subtracted from the pre-Mesozoic data to determine the original dip of formations at the onset of Mesozoic sedimentation, assuming that no topography was present. The measured and recalculated data are presented in Appendix A at the heading paragraph for each well, and in Figure 20. After discarding the data with a wide variation or other uncertainties in the measurements, the remaining few data were plotted on a map (Fig. 21). The Imperial Formation dips westward, in accordance with the general trend in the Anderson Plain. The northeast dip in Amaguk H-16 (Fig. 20) is established from data with a wide scatter, and is therefore considered anomalous; it could, on the other hand, represent a reversal of the dip, from northwest to southeast, on approaching the Tuk Horst. The carbonate units on the Tuk Flank dip more or less eastward; strata in the

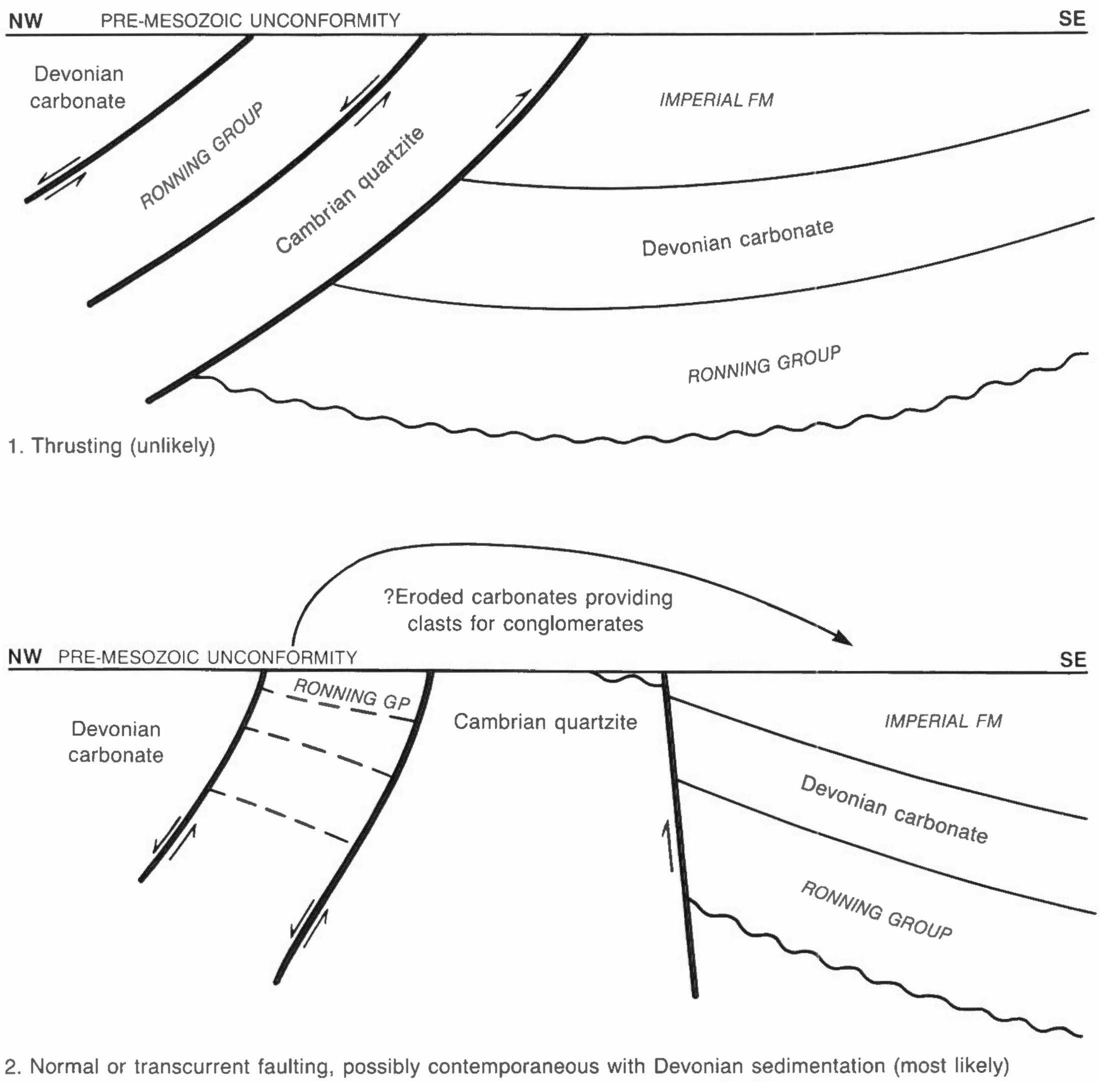

***Figure 19.** Hypothetical cross-sections from subcrop patterns around the Tuk Horst.*

northern part of the Tuk Horst have a northwest dip, and in the southern part a shallow southwest dip. This pattern appears to confirm the rotation of the carbonate normal fault blocks as depicted in Figure 18. Especially in the carbonate rocks, the rather wide variation in dip directions can be explained by the extensive faulting to which the units have been subjected. The faulting is evident from seismic information in COGLA Reports (which deal mainly with this segment of the study area).

In cross-section, a pattern similar to that in Figure 22 is visualized, in which the Imperial succession on the southeast side (Stable Platform) has westward dips similar to those on the mainland in Anderson Plain, but with some uplift close to the Tuk Horst. This uplift is deduced from the thinning of the Imperial seen on seismic sections. The quartzite and carbonate of the Tuk Horst have been uplifted, and appear to dip westward. The carbonate on the northwest side (Tuk Flank) dips eastward, due to rotation of the faulted blocks or folding. Strike measurements in wells very close to the Tuk Horst are consistently parallel to the fault bounding the Tuk Horst, and may indicate that the structures change trend to swing parallel to the Tuk Horst. The Tuk Horst extends a fair distance farther north into the Beaufort Sea, as is visible on seismic sections. Overall, the value of the dipmeter data is questionable due to the scarce datapoints, and because of dip values that appear to contradict the general trend in the area. It should be kept in mind, however, that seismic data indicate that the study area is heavily faulted. Slight rotation of the faulted blocks may explain the apparently inconsistent dip values.

Timing of the deformation and its relation to other areas

The Permian Wedge is underlain by probable Permian strata (Fig. 8). In the simplest model, the Permian rocks overlie Cambrian to Devonian carbonate in the

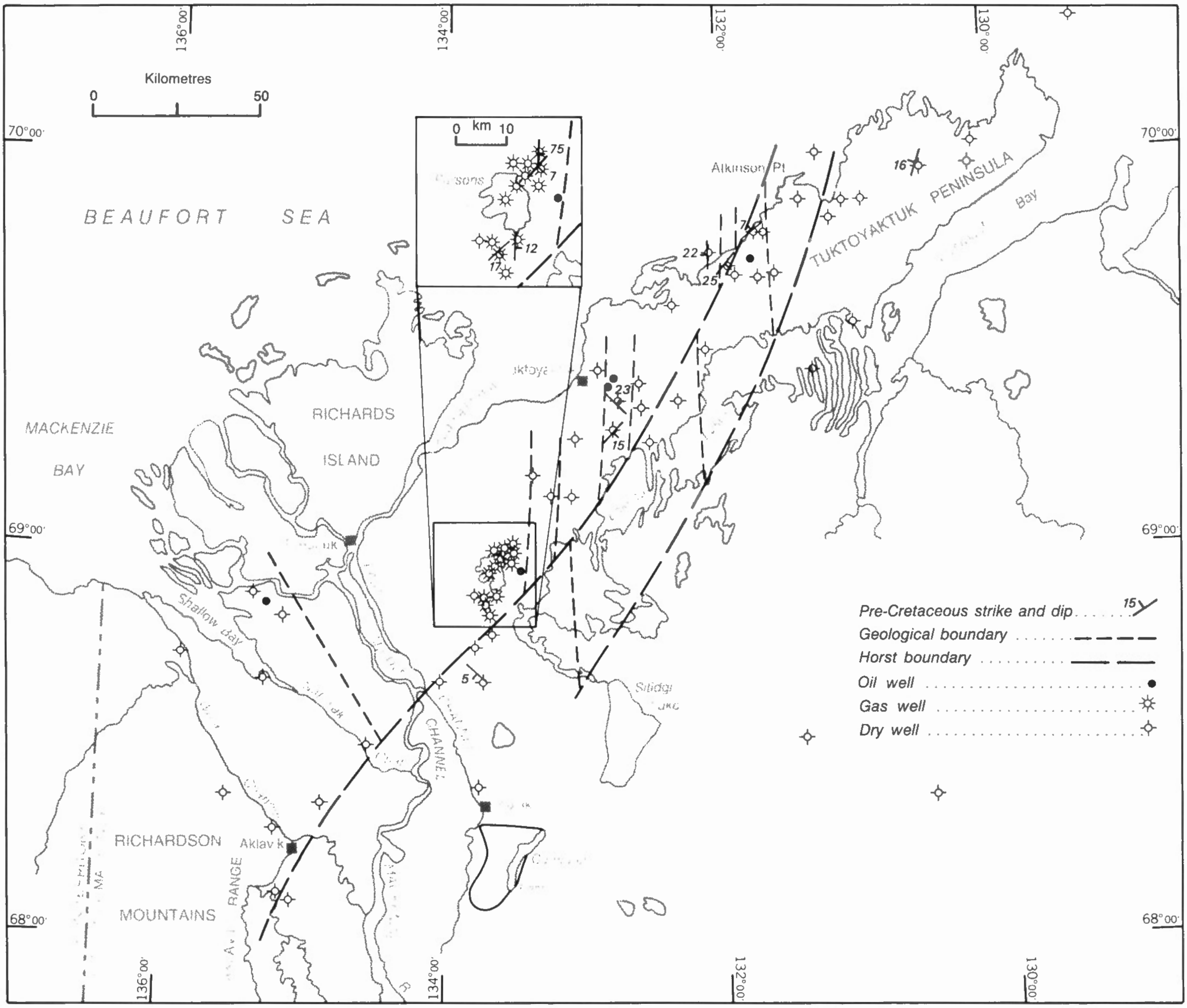

Figure 20. Dip measurements; all data.

southwest. If the Permian formations overlie the carbonate unconformably, as in the northern Richardson Mountains (Bamber and Waterhouse, 1971), it would indicate pre-Permian uplift and erosion. The "Ellesmerian" deformation would then predate the onset of Permian clastic deposition.

The pre-Mesozoic succession in the Aklavik F-17 well (southernmost well in Figure 1) is supposedly Cambrian in age and lies on the southward continuation of the Tuk Horst or Eskimo Lakes Arch. The absence of Permian in this well indicates that the Tuk Horst was still a positive feature during the Permian.

Evidence of "Ellesmerian" orogenic events is found in two adjacent areas: the Alaskan North Slope and the Arctic Islands. The general folding direction in both areas differs from that in the study area.

To the west, in the Alaskan North Slope area, the "Ellesmerian" orogeny climaxed in the Late Devonian and Early Carboniferous; the initial orogenic stages are probably related to the emplacement of Lower Devonian granitic intrusions with radiometric ages of 390-360 Ma (Hubbard et al., 1987). Synorogenic sediment derived from the fold belt (the clastic rocks of the Lower Carboniferous Endicott Group, containing the Kayak Shale, Itkilyariak Formation, and Kekiktuk Conglomerate), unconformably overlies formations ranging in age from Precambrian through Middle(?) Devonian (Reiser et al., 1980), a similar, but even more restricted time interval than is observed on Tuktoyaktuk Peninsula.

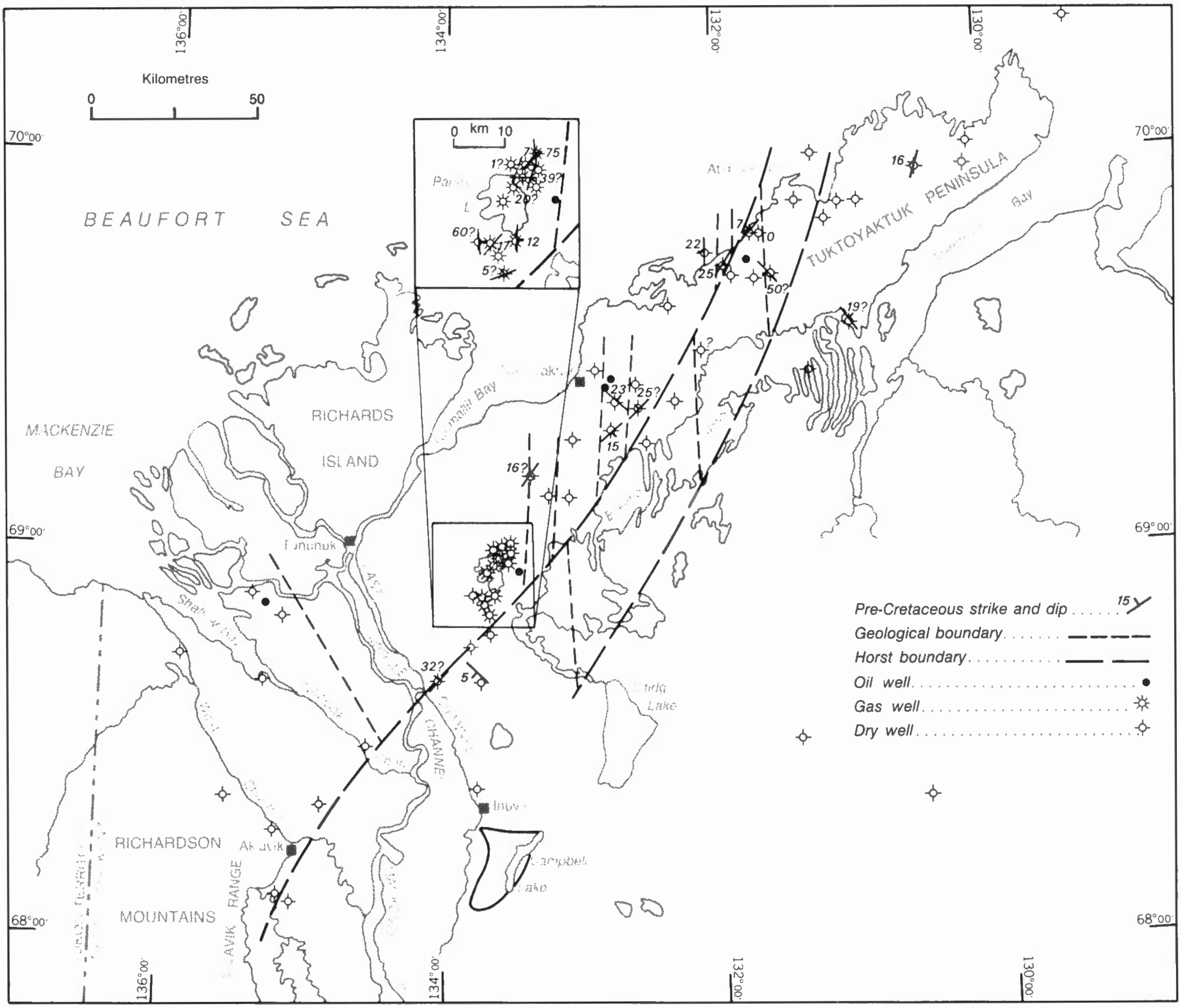

Figure 21. Dip measurements; uncertain data subtracted.

In the sedimentary basins of the Arctic Islands, "Ellesmerian" deformation has had a more prolonged history, and comprises several cycles, starting in the Late Silurian (Trettin and Balkwill, 1979; Trettin, 1987). The earliest phases occurred in the northernmost area and the Boothia Uplift, and appear to the south in successively later stages. A culmination appears to have been reached during the latest Devonian to Early Carboniferous, in a discrete event (H. Trettin, pers. comm., 1988), the effects of which can be observed from northern Greenland, through the Arctic Islands, Tuktoyaktuk Peninsula, and northern Yukon to the Alaskan North Slope. The orogeny was accompanied in the northern Arctic Islands by the intrusion of granites, some of which have Devonian radiometric ages (390 and 360 Ma, on Ellesmere and Axel Heiberg islands); other intrusions are older. Plutons of similar age have been observed in northern Yukon; no evidence of granitic intrusions has been found in the Tuktoyaktuk area.

Evidence of the Ellesmerian event is obvious in the subcrop pattern in the Tuktoyaktuk area as described in this study. It is corroborated by the interpretation of the GSC deep-reflection seismic line data (Fig. 1), indicating potential, major, pre-Mesozoic deformational foreshortening (Cook et al., 1987).

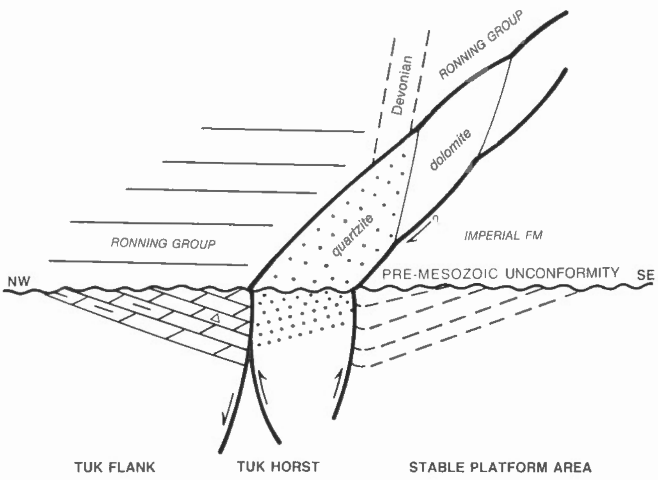

Figure 22. Schematic diagram of structural geology of Tuk Peninsula, based on dip measurements.

CONCLUSIONS

A pattern of regional lithotype groups that are correlatable to formations in the Northern Interior Plains is defined and these are tied to the stratigraphy of the southern Arctic Islands. In addition, the lithotype groups allow an accurate delineation of the elements of the ancestral Eskimo Lakes Arch. The Tuk Horst is the major structure, obliquely underlying the Tuktoyaktuk Peninsula and continuing offshore. Paleozoic rocks are present on both sides of the Tuk Horst and on a large part of the Tuk Horst itself. The two components, Tuk Horst and Tuk Flank, are the backbone and flank, respectively, of the ancestral Eskimo Lakes Arch. The Tuk Flank consists of a series of stepfaulted blocks. The Stable Platform is part of the mainland and remained stable relative to the movements of the other two elements of the Eskimo Lakes Arch.

The white quartzite and varicoloured dolomite on the Tuk Horst, previously thought to be Precambrian, have yielded fossils which identify them respectively as Early Cambrian and Middle Ordovician. This new dating has profound consequences for the area. First, it indicates that the Tuktoyaktuk Peninsula was underlain by a Cambrian basin, separated from the one in the Northern Interior Plains by a high located to the southeast of the Peninsula. Second, rocks of Middle Ordovician age were previously known from the Richardson, Ogilvie, and Mackenzie mountains, but are absent from the Northern Interior Plains, with the possible exception of the westernmost Peel area. This evidence, together with lithological characteristics, places the Ronning Group on the Tuktoyaktuk Peninsula in a position similar to that of the westernmost parts of the Plains area, fairly close to the zone of facies change from carbonate to Road River shale. The clastic beds in the area of the Onigat, Ikhil, and Sholokpaqak wells, at the south end of the Tuk Horst, are probably Precambrian, based on lithotypes and structural relationships. The Precambrian age corroborates a general northward plunge of the horst at the onset of Mesozoic deposition. Differential uplift of the horst juxtaposed Ronning Group, Middle Ordovician and Devonian carbonate rocks with Lower Cambrian quartzite on its northwest side and with Late Devonian clastic strata on the southeast side. This requires offsets in the order of hundreds of metres to kilometres, respectively, on both sides of the horst.

The Campbell Uplift is probably part of the Tuk Horst, but appears to be a separate unit that reacted slightly differently to the tectonic regime. It contains Ordovician to Devonian carbonate rocks overlying Proterozoic clastic and dolomitic rocks. These Paleozoic rocks contrast in lithology with the probable Precambrian rocks subcropping in the area of the Onigat, Ikhil and Sholokpaqak wells 40 km to the north. The Campbell Uplift is primarily a pre-Cretaceous structure, the nearby Inuvik well containing evidence of an emergent area during deposition of the Ronning carbonate.

The Paleozoic formations to the southeast of the Tuk Horst are part of the regular stratigraphic succession, common to the Northern Interior Plains, and can be followed all the way through to the southern Arctic Islands, where minor changes can be observed in the succession. Thus, this area formed part of one large basin, stretching from Sverdrup basin in the north to the Tathlina High in the south. The presence of conglomerate in the Imperial Formation indicates that the tectonic activity of the Tuk Horst had already started in the Late Devonian.

Evidence of ''Ellesmerian'' deformation is found in the Paleozoic carbonate strata to the northwest of the Tuk Horst. These rocks appear to be a normal lower to middle Paleozoic sequence with some structural complexities. Their subcrop pattern produces an alternating succession of areas underlain by older Ronning and Middle Ordovician dolomite and younger Lower and Middle Devonian limestone and dolomite, all of which have been deformed after the Devonian and before the onset of Mesozoic or perhaps Permian sedimentation. Part of the Ronning carbonate package in the southern part of the Peninsula is in a transitional facies into basinal shale of the Road River Formation, indicating that the Richardson Trough extended into this area. Hence, the Arch underlying Tuktoyaktuk Peninsula shares several features with the Mackenzie Arch and the Peel Arch, and the geology is closely related to that of the westernmost Northern Interior Plains.

Permian rocks appear to be present near the southwest side of the Peninsula, under and to the southwest of the Mackenzie Delta, southwest of the Tuk Flank. If the Permian rocks in the subsurface overlie the carbonate unconformably, as in the Northern Richardson Mountains, they restrict the time interval for the "Ellesmerian" deformation to post-Devonian and, based on the presence of several Permian conglomerate beds, intra-Permian.

The juxtaposition to the northwest of the Tuk Horst of blocks with a repetitive pattern of alternating ages, in which wells penetrated rocks that are age-equivalent to the Ronning Group and Landry or Arnica formations, has structural implications, however the pattern is explained. From the lithotype subcrop pattern, the presence of complex "Ellesmerian" structures involving Paleozoic and Precambrian rocks is evident. The pattern may represent folding or faulting, or a combination of both. Evidence of this "Ellesmerian" deformation phase has rarely been observed within the Northern Interior Plains. It is evident in the Barn Mountains and northern Richardson Mountains, and again links the Tuktoyaktuk area to the westernmost part of the Northern Interior Plains and adjacent mountain ranges.

RECOMMENDATIONS

Further study is required to unravel the geology of the Permian Wedge, which is underlain by Permian rocks. Their correlation with the formations described by Bamber and Waterhouse (1971) must be tested, and will require extensive paleontological analysis (especially palynological). In addition, more structural information may be derived from newly released COGLA seismic reports and dipmeter logs. This may help to confirm some of the ideas on structure and timing presented above. Study of Mesozoic onlap and facies patterns may help to unravel the tectonic movements of the area through the Mesozoic.

ACKNOWLEDGMENTS

The writer acknowledges gratefully the assistance of the many individuals at the Institute of Sedimentary and Petroleum Geology, Calgary, without which this paper could not have been written. Their help ranges from fast sample and core retrievals to photographic work.

Fossils were identified by W.H. Fritz (who also provided Figure 11), D.C. McGregor, B.S. Norford, A.W. Norris, G.S. Nowlan, J. Utting, and T.T. Uyeno. J.D. Aitken, M.P. Cecile, J. Dixon, D. Morrow, J. Utting, and G.K. Williams stimulated ideas during many discussions. Q. Goodbody introduced me to the geology and stratigraphy of the Arctic Islands. J.S. Bell pointed out the potential of diplogs. J.R. Dietrich and L.S. Lane provided seismic clues to structural problems. The discussions with D.G. Cook provided the nuclei for crystallisation of ideas from the fluid of structural complexities. M.P. Cecile provided many constructive critical suggestions on the first draft of the manuscript. The comments of critical readers G.K. Williams and D.G. Cook substantially improved the quality of this paper. L. Snowdon helped me become familiar with Rock-Eval analysis; the analytical work on the samples was performed by R.G. Fanjoy. Final editing by N.C. Ollerenshaw and L. Reynolds helped the manuscript evolve into its present form.

Financial support for this project was provided by the Department of Energy, Mines and Resources under contracts 23294-6-0867/01-SG, 23294-7-0546/01-SG and 23294-8-0516/01-SG.

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APPENDIX A

WELL DATA

Pertinent general information about a well, such as sample depths and dipmeter values, are presented under the heading "Comments". A lithological description is given separately for cores and cuttings. The depth values are in the original system in which they were measured, thus facilitating correlation with existing wireline and lithologs. Dipmeter values measured above and below the unconformity are presented where available; the sub-unconformity dip at the onset of Cretaceous sedimentation has also been reconstructed with a Wulff nomogram. Unless indicated otherwise, fossil identifications are by the author.

Clastic rocks

The wells penetrating the clastic rocks of the Tuk Horst and Imperial Formation on the Stable Platform to the southwest are described here by group, in alphabetical order. Figure 3 shows schematic lithological columns for each well.

Wells containing Imperial Formation strata

Wells penetrating the Imperial Formation on the Stable Platform are Amaguk H-16, Amarok N-44, Kanguk F-42, Kanguk I-24, Kapik J-39, Kiligvak I-29, Nuvorak O-09, and Russell H-23.

Observations made by workers with experience in the study of clastic formations in the Northern Interior Plains are presented here.

> *G.K. Williams* (*pers. comm., 1987*): "In the plains area there is no easy distinction possible between the Cretaceous and Imperial Formation, except where a Lower Cretaceous sandstone overlies the Devonian formation. Both formations are cherty, contain plant remains, carbonaceous flakes, etc."

> *J. Dixon* (*pers. comm., 1987*): "The Cretaceous Martin Creek and Husky formations sandstone is chemically mature; it is quartz sandstone with very little, but if any, typically white chert. The colour of the sandstone is grey to light grey. Individual grains and porosity are visible. The Cretaceous sandstone is lightly cemented. The Imperial rocks are much more indurated than the Cretaceous. In the Imperial, fractures run through the grains, indicating a fair amount of silicification. The wireline logs of the Cretaceous sequences are correlatable, whereas those of the Imperial Formation are not."

> *H. Wielens* (*work in progress*): "There appear to be two main divisions in the Imperial Formation: 1) a sandy/silty succession underlain by 2) a shaly succession. Quartz veins are common. The Imperial Formation sandstone consists largely of chert: blue is the most common colour with white, grey, milky, some green, and red. These types of chert can be found in every drill cutting sample. Clear quartz is present in two varieties: 1) rounded, frosted grains, and 2) clear, broken, faced crystals, which were originally euhedral. Another variety of siliceous rock is jasper, which is usually present in the form of small pebbles. The Imperial is largely silicified, and has virtually no visible porosity. Plant remains and carbonaceous flakes are common in the shale and siltstone, which are micro-micaceous. The shale, especially in the more shaly successions, usually contains thin siltstone stringers.

> In core samples, distal Bouma DE sequences (Glaister and Hopkins, 1974) are evident in the sandier parts, together with bottom marks, tool marks, soft-sediment deformation by load casting, etc., all on a centimetre scale. This turbiditic character is probably also prevalent in the other, noncored, sandy Imperial intervals."

Amaguk H-16

Comments. The top of the pre-Mesozoic succession is picked at 3136 ft. (956 m), TD is at 4126 ft. (1258 m). The dips are 20°NW for the Cretaceous and 25–30°N for the Paleozoic; both values are quite variable. The reconstructed (at onset of Cretaceous sedimentation) Paleozoic dip is 19–21°NE. A thin coaly seam present near the bottom of the core at 4123 ft. (1257 m) was sampled for Rock-Eval and vitrinite analysis. Another sample was collected at 4113 ft. (1254 m) for Rock-Eval analysis. (All maturity data are given in Tables 9–12.)

Cuttings. The rocks have all the characteristics of the Imperial Formation and contain indurated, cherty, salt and pepper sandstone and siltstone plus interbedded shale. The section is shale dominated, with some coarse sandstone containing plant remains and carbonaceous flakes. The sandstone is rather dark grey; the chert is mainly grey, with a few bluish or green particles.

Core. 4112–4126 ft. (1253–1258 m). The core consists mainly of sandstone with quartz-cemented vertical cracks. The sandstone beds are up to 1 m thick. The grains are up to 3 mm in size, and are suspended in a finer matrix of sand- to silt-size particles. Internally, the sandstone can be divided into coarse and fine intervals. A few shale clasts are suspended within the sandstone.

In the shale, soft-sediment deformation from slumping, as well as a few ripple marks, are the main sedimentary structures; no evidence has been found of bioturbation.

Amarok N-44

Comments. The top of the pre-Mesozoic succession is picked at 3818 ft. (1164 m), TD is at 7652 ft. (2332 m). No dipmeter log was run; the bedding attitude in the core appears to be vertical. Samples for Rock-Eval analysis were taken at 7641 and 7650 ft. (2329 and 2332 m), and from the dark grey shale between depths 7050 and 7200 ft. (2149–2195 m); the interval did not look very promising, because when scratched, the shale produced a white powder. From 7651-7652 ft. (2332–2332.3 m) samples were collected for palynological analysis, yielding a probable late Givetian or early Frasnian age (D.C. McGregor, pers. comm., 1987; Appendix B).

Cuttings. Noteworthy is conglomerate, found at 4900, 6770, and 7050 ft. (1494, 2063, and 2149 m). The pebbles are composed of chert, which is typically white, grey, bluish or green. The conglomerate is very indurated, and, like the sandstone, it fractures through the grains. The salt and pepper sandstone is composed of indurated chert and quartz grains and is similar to that in other wells, although some yellow iron staining is present, as well as jasper. Lower in the well, the iron staining is absent and the sandstone is indistinguishable from that in the other wells. An occasional brown chert pebble can be found. At 4950 ft. (1509 m), the sandstone contains green chert, is whiter, and is somewhat more porous than typical Imperial sandstone. Below 5000 ft. (1524 m), typical Imperial sandstone is again present. The main colour of the chert grains is aquamarine. Some of the sandstone contains chert pebbles and is fairly coarse. Dark grey shale can be found between 7050 and 7200 ft. (2149–2195 m). Pebbles are unusually abundant in this well.

Core. 7634–7652 ft. (2327–2332 m). The core consists of black to dark grey shale with a small amount of pyrite. The main characteristics are generally vertical cleavage and many straight or sinuous slickensides. The shale is hard, and indurated; no evidence of bioturbation has been found. The shale streak is grey, indicating a low source rock potential, and this was confirmed by Rock-Eval analysis. Some silt-size material is present. In a large part of this core, bedding attitudes are vertical, and there is evidence of much soft-sediment deformation on a decimetre scale.

Kanguk F-42

Comments. The top of the pre-Mesozoic succession is picked at 4820 ft. (1469 m) underlying Cretaceous sandstone, TD is at 5070 ft. (1545 m). No dipmeter log was run.

Cuttings. The succession contains the regular Imperial sequence of interbedded sandstone, siltstone, and shale. The sandstone is similar to the salt and pepper Imperial sandstone found in other wells, and has yellow iron stains. It contains mainly clear quartz and a little green or blue chert. The sandstone layers locally are brown from siderite cementation. Milky quartz veins cement fractures.

Kanguk I-24

Comments. The top of the pre-Mesozoic succession is picked at 4565 ft. (1391 m), TD is at 5254 ft. (1601 m). No dipmeter was run. A coaly seam at depth 4607 ft. (1404 m) was sampled for determination of vitrinite reflectance values. Other samples were collected at 4560 ft. (1390 m) for Rock-Eval, and between 4595 and 4599 ft. (1400–1402 m) and 5246 and 5248 ft. (1599–1600 m) for palynological analysis, yielding a probable late Givetian or early Frasnian age (D.C. McGregor, pers. comm., 1987; Appendix B).

Strata in this well resemble typical Imperial Formation strata, with the presence of interbedded grey shale and indurated, cherty, salt and pepper siltstone and sandstone. Minor exceptions are the absence of jasper and a smaller quantity of rounded quartz grains. There is not much green or blue chert present. Euhedral quartz grains can be observed and could have been derived from drusy quartz veins. Some of the chert sandstone is even coarser than that in Nuvorak O-09, described below.

Core. 4561–4607 ft. (1390–1404 m). The Cretaceous–Devonian contact is preserved in the core at 4565 ft. (1391 m). The Cretaceous sandstone is softer and more friable, whereas the Imperial Formation sandstone is very well indurated. The uppermost Imperial sandstone is about 1 m thick and consists of coarse, angular chert grains of up to 3 mm in size, suspended in a matrix of finer sandstone, with grains up to 0.5 mm in size. There are a large number of vertical fractures, cemented by quartz and calcite, with clasts of sandstone wedged inside them. In the sandstone, the grain size varies throughout the beds of medium thickness (10 cm). Fining-upward sequences are visible near the base of the core. There, the fractures are offset up to 5 mm by a younger fracture set. The shale actually contains many healed fractures. Much of the fracturing obviously took place after initial induration, especially in the siltier parts. Neither evidence of bioturbation, nor of fossils, has been found anywhere in the core. Much slumping is evident in the shales, in thin to medium thickness beds; some of it occurred after initial induration. Small faults are common, ripple marks are rare. Of note is a thin bitumen layer, 1 mm thick, at 4607 ft. (1404 m), which was sampled and has a reflectance value equivalent to a vitrinite reflectance of 3.1, indicating that strata at this level are overmature with respect to oil generation. Regarding the present burial depth, a large amount of section must have been eroded to account for these maturity levels.

5239–5254 ft. (1597–1601 m). The bottom part of the core displays flame structures and probable tool marks in the shale, but these features could also be the result of small-scale slumping on a slope. The bedding is thick in sandstone and thin to medium in shale. Otherwise, the sandstone, siltstone, and shale are similar to those in the interval sampled by the upper core in this well.

The absence of fossils, ripples, or bioturbation, and presence of coaly material, probably indicate deposition as flysch, or possibly a brackish depositional environment, close to the sediment source.

Kapik J-39

Comments. The top of the pre-Mesozoic succession is picked at 4045 ft. (1233 m), TD is at 4812 ft. (1467 m). No dipmeter was run, no core is available.

Cuttings. The rocks are similar to those in Russell H-23, with salt and pepper sandstone, composed largely of cherty material (chalcedony), siltstone, shale, and a few pyrite crystals. Glauconite and some pyritized worm tubes are present. The sandstone is poorly sorted and the chert is angular; quartz grains and chert pebbles are the only rounded material. Several beds have a brownish colour.

A typical succession consists of salt and pepper, locally brown, quartzose sandstone, siltstone, and silty shale. Sandstone and siltstone are composed of unsorted clear quartz, chert (white, black, brown, green, blue), and unidentified black minerals, possibly hornblende. The salt and pepper character (usually on the dark side) is caused by the mixing of black and white minerals. The siltstone and shale are micro-micaceous. Carbonaceous flakes and plant remains are typically present. Sandstone and siltstone can form thin stringers or thin beds in the shales. Chert pebbles may be present in the coarser sandstone. Rounded, frosted grains of clear quartz and jasper can be found in many of the samples. The only fossils observed in these rocks are scaphopods. The depositional environment must therefore have been marine, in a location with occasional influxes of coarser clastic sediment, probably transported by turbidity currents.

Kiligvak I-29

Comments. The top of the pre-Mesozoic succession is picked at 650 ft. (198 m), TD is at 6447 ft. (1965 m) in carbonate. No dipmeter was run at the unconformity interval. This well penetrated a generally normal Paleozoic sequence as observed on the Northern Interior Plains. The carbonate underlying the clastic sequence will be described under the "carbonate wells" section in Appendix A.

Cuttings. The conglomerate layers in this well are noteworthy, as well as the large number of pebbles present throughout the succession. These are not found in wells on the Northern Interior Plains, and are exceptional in this well because of its proximity to the mainland and distance from the Tuk Horst. The salt and pepper sandstone can be very coarse; like the siltstone, it is composed of indurated chert and quartz grains, and contains some carbonaceous flakes. The sandstone is similar to that described from the wells above. Also noteworthy is the presence of a few white chert pebbles. Fractures were cemented by milky quartz. In this well, the succession can be divided into an upper sandy and a lower shaly sequence. The succession is shale-dominated from 3600 ft. (1097 m) down into the black, radioactive, siliceous, organic-rich shale of the Canol Formation. Below 3600 ft. (1097 m), the Imperial shale contains a moderate amount of silt, but virtually no sandstone. The shale is grey and micro-micaceous.

Nuvorak O-09

Comments. The top of the pre-Mesozoic succession is picked at 3424 ft. (1044 m), TD is at 3798 ft. (1158 m). Dipmeter data: Cretaceous 3°S, Imperial Formation 15°WNW; by rotating the Cretaceous dip-plane to horizontal, the resulting dip (17°NW) of the pre-Mesozoic plane represents its dip at the onset of Mesozoic sedimentation. Two samples were collected for Rock-Eval analysis, at 3460 ft. (1055 m) and 3482 ft. (1061 m). The latter sample contains plant material, and some of the sample was submitted for vitrinite reflection measurement.

Cuttings. The rocks are similar to those described from Russell H-23 and Kapik J-39, and consist of intercalated, indurated sandstone, siltstone, and shale beds. This well penetrated the sandy sequence only. Part of the salt and pepper, indurated, tight sandstone, which contains largely chert, appears to be coarser than in H-23 or J-39. The siltstone is composed of similar materials. Paleontological samples were described by Chamney *in* Barnes et al. (1974), but are not considered here, due to doubt about the identifications.

Core. 3434–3494 ft. (1047–1065 m). This core is composed of interbedded, grey to dark grey shale and sandstone of the Imperial Formation. Typical bedding thicknesses vary from a few millimetres in shale to 30 cm in sandstone. The sandstone is chert-rich, and contains fining-upward sequences, with grain sizes ranging from 0.1 to 1–2 mm. Plant remains and carbonaceous flakes are visible. In the sandy part of the shale, soft-sediment deformation is evident on a centimetre scale, caused by slumping and loading. Outside the areas of soft-sediment deformation, the rocks display undisturbed lamination. Scouring and tool marks are visible at the bottom of sandstone layers. Also, there are Bouma DE sequences, typical of distal turbidites. Vertical cracks were healed by quartz and a smaller amount of calcite cement. The sand grains are angular or subrounded, white, milky black, blue, or green chert. Some black grains are possibly weathered hornblende. Observed dark brown nodules are composed of siderite. Most of the shale has disintegrated in the core box.

Russell H-23

Comments. The Paleozoic–Mesozoic contact is at 3612 ft. (1101 m), TD is at 6010 ft. (1831 m). No diplog was run. Two samples were collected for Rock-Eval analysis from 5978 and 6008 ft. (1822 and 1831 m).

Cuttings. Below the contact, the rocks are sandy and silty grey, compared to the overlying, black, Cretaceous shale. All of the black shale in the drill cuttings could represent interbedded layers or may be caved. The sandstone is composed of well cemented quartz and chert, and contains pebbles of chert. Brick-red material observed was probably recently oxidized in the sample vial because it still retains a black core (?oxidation by a combination of marcasite and organic material). Pyrite crystals and rounded quartz grains are present in each sample vial, and plant material can be found in a large number of them. The siltstone and shale contain small mica flakes.

The main rock component is sandstone, with minor siltstone and shale. The sandstone is salt and pepper grey, caused by white chert with intermixed black chert and other, softer, black matrix material. Some of the sandstone and siltstone is dark brown. Below 4200 ft. (1280 m), the cuttings are dominantly shale. The sandstone, where present, still contains quartz, chert and jasper. At 4470 ft. (1362 m), bituminous material or coal is present within the sandstone. Glauconite and pyritized worm tubes are common accessories. Below 4750 ft. (1448 m), mainly black shale is present. The source rock potential between 4750 and 5220 ft. (1591–1594 m) should be checked, due to sonic log skipping at this level. The 4930–4940 ft. (1503–1506 m) interval is an intercalated quartz-pebble conglomerate, underlain between 5230 and 5270 ft. (1594–1606 m) by very fine, fissile shale (with iron drill pipe shavings only—the probable result of a drilling problem). The underlying material is black shale. Chert pebbles of all colours, as well as clear quartz, can be found at 5300 and 5820 ft. (1615 and 1774 m).

Core. 5975–6010 ft. (1821–1831 m). The core consists of black, very fissile shale. Soft-sediment deformation on a centimetre scale was caused by slumping. Fractures, with offsets of more than 5 cm vertically, were recemented shortly after that deformation, as indicated by the shale cement, which is similar to the main rock type. Slickensides are ubiquitous and are coated by probable gypsum (soft, black to clear mineral with perfect cleavage). The core is at least 95% shale.

The Russell H-23 Imperial succession can be divided into an upper part with turbidity current deposits and a virtually completely shaly lower part. Few of the other wells contain a similar lower shale succession, regardless of the thickness penetrated.

Wells containing Imperial strata, outside the study area

The wells in this section, Kilannak A-77 and Kugaluk N-02, are of importance for the study area.

Kilannak A-77

Comments. The pick of the Imperial top is uncertain, and may be at 1267 m, TD is at 2996 m. Dipmeter data indicate a questionable dip of 2°W for the Imperial Formation. The value for the Cretaceous is quite variable, around 8°NE. The reconstructed original, pre-Mesozoic dip is 10°SE.

Cuttings. The succession contains interbedded sandstone, siltstone, and shale. The light grey, well indurated sandstone and siltstone are composed of dirty quartz grains, cemented by quartz, but fractured around the grains. The salt and pepper sandstone contains some black grains, but generally the grains are brown to grey or white, dull, rounded to angular chert or quartz. Calcite is present as cement and in fractures. The matrix contains muscovite. Below 1830 m, the dark grey sandstone is quite similar to sandstone found in the Imperial; it is composed of rounded or angular, blue, white, grey, and black chert grains with a few quartz grains, contains muscovite, is cemented by quartz, and has fractures through the grains. Accessories are rounded, clear quartz grains, broken euhedral quartz grains, and jasper. Chert pebbles are present at 2030 m (brown and blue). The shale at this depth has very glossy slickensides, in contrast to the dull shale observed higher in the succession. Carbonaceous flakes are also present at this level.

In general, the sandstone is darker than that in wells farther south. The equivalent of the Canol Formation starts at 2072.5 m and has a sharp contact with the Imperial Formation. The Canol is a very cherty, black shale and scratches brown; in this well it is thinner than normal.

Kugaluk N-02

Comments. The pick of an Imperial top is uncertain. A kick on the sonic wireline log at 170 ft. (52 m) may be the Imperial top; however it could be the base of drift. TD is at 8045 ft. (2452 m). No dipmeter logs are available. Only unwashed drill cuttings were available from 160 to 800 ft. (49–244 m). The remainder of the well was cored continuously. The core was studied in a cursory fashion only, because the main interest was in the composition of the Imperial sandstone.

Cuttings. Both plant remains and large muscovite flakes are present. The sandstone is porous, poorly indurated, contains some chert, and is fractured around the grains. It is similar to Cretaceous sandstone, and differs in induration, composition, and porosity from the Imperial rocks in the wells to the north and also from the sandstone in the Sholokpaqak, Onigat, and Ikhil wells (described below).

Although the age of the unit is uncertain, an Imperial Formation age is assumed here, based on its characteristics and the postulated Imperial age on GSC surface geological maps.

Wells containing non-quartzite clastic strata

The wells in this section are Ikhil (East Reindeer) A-01, Ogeoqeoq J-06, Onigat (East Reindeer) C-38, and Sholokpaqak (East Reindeer) P-60.

Ikhil (East Reindeer) A-01

Comments. The top of the pre-Mesozoic succession is picked on logs at 9260 ft. (2822 m), but cannot be determined from cuttings; TD is at 9693 ft. (2954 m). Dipmeter data are: pre-Mesozoic 42°NW, and about 10°NW for the Cretaceous, with much scatter; the reconstructed pre-Mesozoic dip is 32°NW.

Cuttings. The sandstone is very white, consisting of rounded to subrounded, clear and somewhat milky quartz grains, cemented by milky quartz, and is very well indurated. The rocks fracture through the grain. Some of the sandstone is less indurated, and is porous, but this may represent caved material. The sandstone contains a few black grains. The shale is grey to grey-green, micro-micaceous, and waxy. Pyrite is abundant.

The sandstone in this well differs from that in Sholokpaqak (East Reindeer) P-60 and in the Imperial Formation because of its white colour and high content of clear quartz. It is more closely related to P-60 in its appearance with an abundance of rounded and quartz-cemented, clear quartz grains. The grey shale does not provide much information.

Core. 9532–9543 ft. (2905–2909 m). (The core was described previously in Wielens, 1987.) The core consists of a succession of shale with centimetre-scale interbeds of fine grained sandstone and siltstone. All beds dip about 40 to 45°. Laminae are very fine and wavy or broken and recemented (Fig. 6a). Beds are thinner than 2 cm, and always disturbed. Soft-sediment deformation, on a scale from millimetres to decimetres, is extensive throughout and appears in places to become enterolithic (Fig. 6b). The shale is black, phyllitic, glossy, and slickensided. Vertical fractures were recemented by quartz. The sandstone stringers are indurated to hard quartzite.

Noteworthy is the large amount of weathered biotite at 9540 ft. (2908 m). No evidence of bioturbation was observed. The typical characteristics of the Imperial Formation are absent. The amount of pyrite and extent of soft-sediment deformation, caused by loading and slumping, is much larger here than in the other wells in this area. The lithology is very similar to that observed in Sholokpaqak (East Reindeer) P-60. A tentative Precambrian age is suggested for the clastic rocks in A-01.

Onigat (East Reindeer) C-38

Comments. The top of the pre-Mesozoic succession is picked at the top of a carbonate unit at 4200 ft. (1280 m), TD is at 8512 ft. (2594 m). A dipmeter log is not available. The sample quality is poor, due to extreme caving.

Cuttings. The succession consists of a dolomite unit near the top, underlain by a thick clastic sequence. The dolomite is masked heavily by cavings. The underlying sandstone consists of round, clear quartz grains, well indurated by milky quartz cement. The sandstone fractures through the grains. It is unclear which shale lithotype in the cuttings samples belongs to this succession but it is probably the silty, micro-micaceous, and dark grey shale. The siltstone has a similar colour. It, like the sandstone, is composed of clear quartz and contains no chert. The mica present is muscovite. There are a few quartz veins as fracture filling. The sandstone below 5600 ft. (1705 m) is quartzitic and contains an increased amount of milky quartz, with rare chert grains. Glauconite and biotite are accessories.

A few dolomite beds have been observed within the clastic succession. A large part of the dark grey shale, found deeper in this well, is phyllitic. Distinct micro-micaceous, brick-red shale, and a minor amount of green-grey shale can be found below 6000 ft. (1830 m) depth. Associated siltstone has the same red colour.

Part of the dolomite in this succession is white, cryptocrystalline, and the coarser fragments are black. Both the sandstone and dolomite below 6500 ft. (1980 m) may be red. The greenish shale at this depth may contain rounded, clear quartz grains. It is well cemented and extremely indurated. The sandstone is composed of rounded, clear quartz grains with a greenish matrix. Underlying this coloured sequence is a thick succession of black shale, between 7000 and 7600 ft. (2130–2320 m). The shale does not contain as much mica as that higher in the well. It is silty and contains pyrite.

At about 7000 ft. (2130 m), a few cuttings appear to consist of tuff. They contain phenocrysts and vesicles. Some of the sandstone contains a malachite-green mineral (too dark green for glauconite). Below 7900 ft. (2410 m), the sequence comprises dark grey siltstone and some white, silty dolomite. Underlying this, at 8000 ft. (2440 m), is sandstone with a few chert pebbles (similar to those found near the top of the pre-Mesozoic succession), dark grey, silty shale, and white dolomite.

The presence of interbedded dolomite and clastic rocks, and the coloured shale points to a Cambrian or Precambrian age. Cambrian and Precambrian rocks in both the subsurface of the Northern Interior Plains and outcrops in the Mackenzie Mountains feature reddish shale and carbonate rocks. The extreme induration and large amount of sandstone make the Precambrian age more probable, while the mica content would be anomalous for a Cambrian formation. In addition, this succession resembles the Precambrian clastic sequence in the western part of the Campbell Uplift (M.P. Cecile and L.S. Lane, pers. comm., 1987). The presence of glauconite indicates a marine depositional environment for the clastic sequence.

Core. 4724–4746 ft. (1440–1447 m). This core is characterized by well indurated, dark grey shale with minor, thin siltstone stringers in fining-upward sequences and a fair amount of pyrite. The highly contorted stringers show evidence of small- and large-scale soft-sediment deformation. After induration, extensive fracturing took place. Although some of the cracks were wide enough to be filled with silica cement, others are nearly invisible. There is no evidence of bioturbation.

5805–5828 ft. (1769–1776 m). This core is similar to the one described above. At about 5824 ft. (1775 m) the sediment was broken up after induration (Fig. 7a); part of it was rotated and recemented. Soft-sediment deformation on a centimetre to decimetre scale is common elsewhere in this core.

Both of these cores are lithologically very similar to the Sholokpaqak (East Reindeer) P-60 core, but there is evidence of more deformation. Characteristics of the Imperial Formation are absent.

6342–6365 ft. (1933–1940 m). The upper part of the core consists of a three metre thick, laminated, light grey to buff limestone bed with extensive calcite-filled fractures (Fig. 7b). The fine laminae are the result of variations in argillaceous content; pyrite grain stringers are parallel to the lamination. The limestone is well indurated, and has no burrows, mottling, or fossils. The fine lamination and fine grain size indicate a low energy environment of deposition, within a general environment of turbiditic sedimentation. No conodonts could be recovered from samples collected between 6349 and 6352 ft. (1935–1936 m) (GSC Report 18 TTU-86; Appendix B).

Underlying the limestone is green-grey shale with interbedded conglomerate, sandstone, and siltstone. These units contain fining-upward sequences, with thicknesses ranging from centimetres to decimetres. Some of the sandstone beds have ripple marks. Scouring features are present near the base of the conglomerate beds. Thin-section study shows that in the conglomeratic beds pebbles consist of chert and weathered, vesicular, doleritic rock.

8052–8065 ft. (2454–2458 m). The main part of this core is a debris flow with clasts larger than 5 cm. In thin section, the clasts are rounded chert pebbles and weathered vesicular volcanic rocks, suspended in a coarse, unsorted matrix composed of the same material. Proximity to the same source that provided the volcanic rocks in the adjacent wells is probable.

General comment. The strata in this well were extensively disturbed after induration, in two or more phases. This is indicated by silica-filled cracks which were broken and offset by younger fractures also cemented by silica.

The lithology of the described sequence is similar to that of the sequences in the Ikhil A-01 and Sholokpaqak P-60 wells, which will be described next. The carbonate did not yield any conodonts (T.T. Uyeno, pers. comm., 1986; Appendix B). A Proterozoic age is suggested.

Sholokpaqak (East Reindeer) P-60

Comments. The top of the clastic interval is near 3410 ft. (1039 m), TD is at 6300 ft. (1920 m). The dipmeter log is unavailable.

Cuttings. This well contains a succession of sandstone, siltstone, and shale. Most of the sandstone consists of clear quartz grains, with milky quartz cement. There are some black grains of chert or other minerals. Near the top of the pre-Cretaceous sequence, a large amount of solid hydrocarbon is present. Samples were collected from unwashed cuttings and the bitumen picked for biomarker analysis for comparison with the Cambrian bitumens in the Colville area (Wielens et al., 1990). This bitumen appears to have been in a fluid state during the drilling.

The sandstone is well indurated, and fractures through the grains. Unlike the Imperial sandstone, chert has not been observed as a grain size component in this sandstone unit, although it is present in pebble size. The chert pebbles are milky white, brown, or grey and always have a coarse, frosted surface. They also have a grainy appearance under the microscope. By comparison, typical Imperial Formation chert clasts have semi-glossy surfaces and appear smooth. The coarser sandstone is white in comparison to the Imperial sandstones. Round, frosted quartz grains are present throughout the succession. The siltstone and sandstone are micro-micaceous, grey, and grade into each other. They also have a dull, matte appearance. Parts of the siltstone are brown, as if oil stained. It is unclear whether the siltstone represents cavings from overlying Mesozoic formations. Siltstone beds are common near the top of the pre-Mesozoic succession and the "stain" may be related to the bitumen mentioned above.

The siltstone is grey deeper in the well. Some of the finer grained sandstone there is porous, and breaks along the grains. Locally, the sandstone contains what appears to be red garnet, almandine, or pyrope. Small amounts of glauconite are present, but none of the plant remains mentioned in the Can-Strat lithologs could be found. It is possible that the few scattered biotite flakes were mistaken for plant remains. Many of the siltstone and shale cuttings have a stained appearance. The main shale interval is grey, silty, and micro-micaceous. Much of the deeper sandstone is quartzitic, with some milky white to grey chert pebbles. Some of the shale below 6000 ft. (1828 m) is greenish.

The dolomite interval at the bottom of the well is very similar in colour to the overlying clastic material: it is dark grey, but has a glossy appearance, due to reflection from crystal faces. The dolomite contains white chert.

In general, the sandstone in this well is quite distinct from that typical of the Imperial Formation, and is of possible Precambrian age. No conodonts were recovered from the carbonate (T.T. Uyeno, pers. comm., 1986; Appendix B).

Core. 4560–4593 ft. (1390–1400 m). (The core has been described previously in Wielens, 1987.) The upper 3 m of this core consists of coarse conglomerate. It overlies a 45 m thick succession of green-grey, well indurated shale with interbedded sandstone and siltstone.

The conglomerate contains both angular and rounded clasts of up to 15 cm (Fig. 5a, b). Part of the rock is clast-supported. Some of the angular clasts were still fairly soft during deposition, as shown by their indentation. Thin-section study shows that the clasts are composed of carbonate, rounded chert pebbles, and greenish, weathered, vesicular, ophitic volcanic rocks.

One large, very irregular clast has the appearance of travertine, with encrustation and induration (Fig. 5c).

The matrix is very fine shale, except in the areas protected by the corners of the angular clasts, where it is coarse sandstone. In the fine matrix, soft-sediment deformation by loading is evident, on a centimetre to decimetre scale.

The underlying succession is composed of laminated, very fine clastic sediments, with fining-upward sequences on a centimetre scale, and the occasional sand-pebble layer. Bouma DE sequences indicate a distal source for the fine material. Slumping and load deformation of the soft sediment has left its marks throughout. No evidence was observed of bioturbation.

5183–5201 ft. (1580–1585 m). A debris flow containing angular and rounded clasts of up to 7 cm forms the main part of this core. The clasts are suspended in a matrix of coarse, unsorted sandstone. Thin-section study indicates that both the clasts and matrix are composed of chert, carbonate, and weathered vesicular, ophitic volcanic rock (Fig. 5b).

The para-conglomerate overlies fractured shale with some centimetre-thick interbedded sandstone/siltstone, containing Bouma DE sequences and soft-sediment deformation reflecting loading and slumping. No evidence was found of bioturbation.

Ogeoqeoq J-06

Comments. The top of the pre-Mesozoic clastic succession is at 5865 ft. (1788 m), TD is at 6034 ft. (1839 m). Dipmeter measurements near the unconformity are 20°SW for the Cretaceous, and 15°SW for the pre-Mesozoic. They are very variable on both sides of the unconformity. The calculated original pre-Mesozoic dip is 52°NE.

Cuttings. The top of the sequence consists of a tight sandstone composed of white, rounded, clear quartz, well cemented by milky quartz, and fracturing through the grains. It differs significantly from the overlying, porous, Cretaceous sandstone. The underlying shale has a green or red colour and is silty. Deeper in the well, the sandstone becomes pink; locally it is grey, due to an increase in black mineral content (?biotite).

The rock colours and composition, and their similarity to strata in the Sholokpaqak P-60, Ikhil A-01, and Onigat C-38 wells suggest a Precambrian age.

Tuk Horst

The wells in this section are Akku F-14, Atkinson H-25, Atkinson M-33, Eskimo J-07, Magak A-32, Natagnak H-50, Natagnak K-53, and Natagnak O-59.

Akku F-14

Comments. The top of the pre-Mesozoic succession is picked at 4477 ft. (1365 m), TD is at 4996 ft. (1523 m). No dipmeter logs or core are available.

Cuttings. The main rock type is dolomite, overlying shale-sandstone strata. The dolomite varies in colour from buff to light grey, is fine crystalline, and tight. Some beds have a pinkish or light green colour. No fossils were found (T.T. Uyeno, pers. comm., 1988; Appendix B).

The clastic succession consists of black shale, black siltstone, and coarse to fine sandstone. The siltstone is composed of dark, clear quartz and a few black minerals, and is well cemented and tight. The sandstone, composed of rounded to subangular, clear quartz, cemented tightly by milky quartz, is in fact a quartzite of white to grey colour. Both the siltstone and sandstone are glossy, and contain amphibole or biotite-like minerals. Part of the sandstone is stained red to yellow by iron inclusions in the cement. Interbedded shale is present lower in the sequence; it is brick-red to yellow, occasionally green and black. The black shale may be younger strata, caved into this part of the well. Near the lower end of the sequence, the sandstone is very fine.

The colours of the shale, and to some extent of the dolomite, indicate a Cambrian or even a Precambrian age.

Atkinson H-25

Comments. The top of the pre-Mesozoic section is at 5916 ft. (1803 m), TD is at 5941 ft. (1811 m). Only core is available from this well; there are neither cuttings nor dipmeter logs. All samples collected below the depth of 5760 ft. (1765 m) proved barren of dinoflagellates and spores.

Core. The Cretaceous is represented by conglomerate with a few interbeds of sandstone of up to 1 m in thickness. Both rock types are porous, and have a light brown to grey colour. The pebbles vary in size from 2 mm to 3 cm, are well rounded, and are composed of light to dark grey quartzite. The dip angle is at maximum 10°.

The sub-unconformity quartzite is grey, with extensive horizontal and vertical fractures. These fractures are mainly filled by quartz, leaving some porosity. The vertical fractures appear to have offsets of about 5 mm, but because the core is very broken up, this is uncertain. Lower in the well, the fractures are less well cemented, and there the core disintegrates. The fracture infill has a yellowish white colour. The intact quartzite beds are up to 10 cm thick. The bedding dip angle varies from 10 to 40°. The quartzite is composed of coarse to fine, clear, rounded to subangular quartz, tightly cemented by milky quartz. Pyrite crystals are present as an accessory. The propagating ripples, suspended pebbles, coarser beds, and rapid grain size variation in the quartzite beds all indicate a high-energy depositional environment.

The characteristics of the quartzite suggest a Lower Cambrian age.

Atkinson M-33

Comments. The top of the pre-Mesozoic section is at 6220 ft. (1896 m), TD is at 6327 ft. (1928 m). The dip direction of the Cretaceous conglomerate is 5°SW, and that of the underlying quartzite 25°NW; the restored pre-Mesozoic dip is 25°NW.

Cuttings. The Cretaceous conglomerate is composed of white, rounded, quartzose pebbles. The pre-Mesozoic quartzite is tight, white, and composed of angular to rounded, coarse, clear quartz, cemented by mainly milky quartz. Pyrite crystals and a few dark minerals are all the accessories, concentrated in biotite-like bands. Some of the porous siltstone is also composed of clear, white quartz. Lower in the well, the quartzite contains a dark substance in the matrix that also appears as a coating on the grains; this could be bitumen, coating the clear grains and giving the rock a grey colour. There is some porosity, which could be due to protection of the quartz grains by the coating.

Core. 6274–6285 ft. (1912–1916 m). The green shale and sandstone near the top of the core are laminated on a sub-millimetre scale and contain centimetre thick bands of sandstone. The shale is extremely bioturbated (Fig. 23a). The vertical and horizontal burrows are filled with sandstone composed of clear, rounded quartz grains. There has been deformation after initial induration (Fig. 23b), as indicated by small, recemented fractures. Pyrite is abundant.

Lower in the core, the quartzitic sandstone layers can be up to 3 cm thick, and display crossbedding; the green colour has changed to grey, and the shale is less extensively laminated and bioturbated.

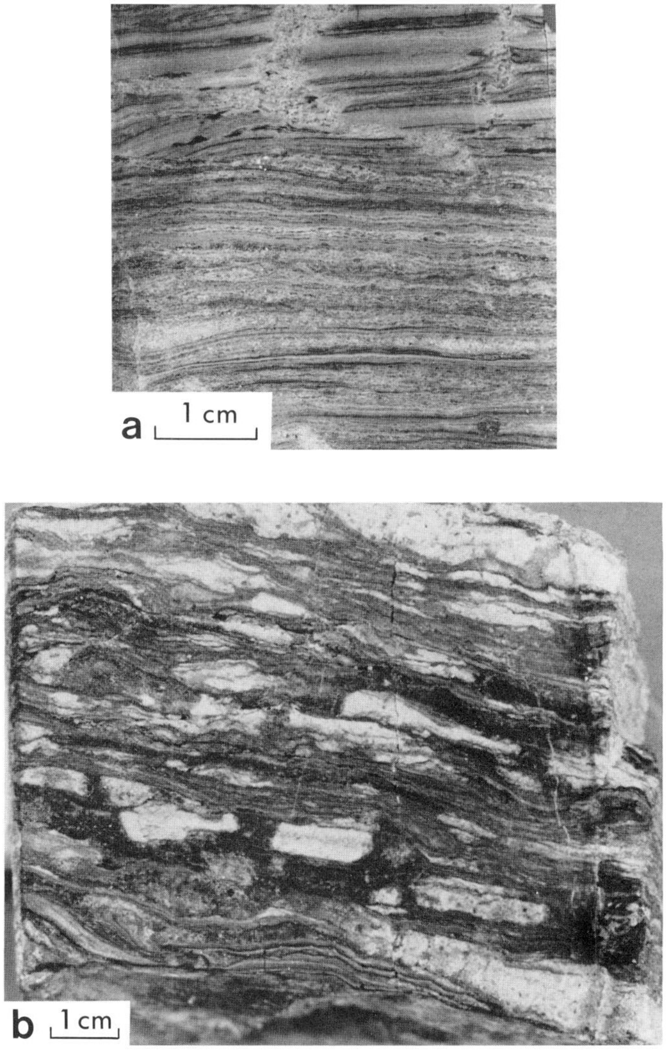

Figure 23. *Core photographs from Atkinson M-33. a) 6275 ft. bioturbation in laminated shale (ISPG photo. 2790-28); b) 6277 ft. shales fractured after initial induration (ISPG photo. 2790-33).*

6313–6327 ft. (1924–1928 m). The quartzite succession in this core is typical of this area, consisting of coarse to fine, rounded to subangular sand grains, with small (up to 5 mm) pebbles, and thin bands of coarser grains containing a small amount of blue chert. Bedding angles varying between 20 and 45° and prograding ripples and high-angle crossbedding appear to indicate a fluvial origin for these strata. The porosity is a result of the many fractures. Pyrite is present in large quantities. No evidence has been found of solid hydrocarbons in this core, which originates from some depth below the unconformity; possible bitumen coating was described above from the cuttings at the same interval.

Eskimo J-07

Comments. The pre-Mesozoic sequence in this well has been cored nearly continuously. It consists of basalt underlain by carbonate rocks, which will be described under the "carbonate wells" section in Appendix A.

The sub-Mesozoic unconformity sequence at 2714 ft. (827 m) is unique, and consists of a 5 m thick, brown sandstone overlying a 70 m thick volcanic succession. The volcanic unit is an amygdaloidal, aphanitic to porphyritic rock, possibly an olivine basalt. Analyses are presented in Table 7. It is dark grey, with local patches of green and red, caused by alteration. Zeolite minerals indicate a later hydrothermal phase. The volcanic rocks overlie 8 m of brecciated, probably metamorphosed, pink to light grey dolomite.

The dolomite contains many stromatolites (Fig. 9), and appears to be a bioherm. A tentative Precambrian age is suggested for this succession.

Magak A-32

Comments. The top of the pre-Mesozoic section is at 4996 ft. (1523 m), TD is at 5160 ft. (1573 m). Dip values are so variable that a mean number is useless. The Cretaceous in this well contains a 60 m thick, coarse, porous sandstone, composed of white quartzite grains. These grains are similar to those in the underlying quartzite.

Cuttings. The pre-Mesozoic consists of a light, olive-green shale, overlying a white, porous, glauconitic sandstone to siltstone. The underlying quartzite is tight and is composed of coarse to fine, clear, rounded to subangular grains cemented tightly by milky quartz. Pyrite crystals are present in both shale and quartzite.

Core. 5004–5024 ft. (1525–1531 m). The top part is bioturbated (Fig. 10a), olive-green, waxy shale with minor, thin, interbedded sandstone. This shale resembles that described in Atkinson M-33, which appeared to be laminated. At 5007 ft. (1526.13 m, GSC locality C-104132a) and 5007.7 ft. (1526.35 m, GSC locality C-104123b), fossil cones have been found in the shale (Figs. 10b, 11), and have been identified by Fritz (pers. comm., 1987; Appendix B) as *Salterella*? sp., a Lower Cambrian index fossil. The sandstone interbeds are similar in appearance to the quartzites; they are white and composed of clear quartz, with milky quartz cement.

The underlying quartzite contains some intercalated, green shale bands similar to the one described from the top of this core. The quartzite itself is composed of coarse to fine, interbedded, clear quartz, with a bed thickness in the order of centimetres. The grains range in size from sub-millimetre to a few millimetres. Bedding dips are very steep and vary from 60 to 80°. There are some fractures. Locally, the coarser grained quartzite is porous, possibly due to leaching. In this well there are hardly any suspended pebbles, but the rocks still resemble a fluvial deposit from a high energy environment, as indicated by prograding ripples, rapid variation of grain size, and high-angle crossbedding. *Salterella*, however, is a marine organism. Some parts of the core have interbeds of green shale of up to a few centimetres in thickness, other parts of the core contain only thin laminae. The green shale appears to be depositionally related to the quartzite.

The presence of Lower Cambrian fossils has a profound bearing on the age of the quartzite. As described above, the shale appears to be closely related to the quartzite, and locally has laminae parallel to the bedding in the quartzite. This would indicate an Early Cambrian age for both the shale and quartzite. This is the first evidence of Cambrian sedimentation in this area, and suggests the existence of a Cambrian depositional basin here, separate from the one to the south in the Northern Interior Plains.

Natagnak H-50

Comments. The top of the pre-Mesozoic section is at 6335 ft. (1931 m), TD is at 6402 ft. (1951 m). Dipmeter values are very variable. Mean dip values for the Cretaceous conglomerate are 18°S, and the underlying quartzite also dips 18°S, indicating a reconstructed horizontal surface as original dip. Samples were collected from the conglomerate between 6119 and 6127 ft. (1865–1868 m) and from the quartzite between 6388 and 6394 ft. (1947–1949 m) for fission-track dating.

Cuttings. The Cretaceous conglomerate is largely composed of material from the underlying pre-Mesozoic quartzite. There is also some sandstone, shale, and green chert. Many of the grains in the Cretaceous sandstone are rounded. The sandstone contains many rounded pebbles.

The pre-Mesozoic, white quartzite is similar in composition to that in the Onigat area wells. It is a coarse quartzite, and contains unsorted, rounded and angular, clear quartz with smaller amounts of milky quartz, cemented by clear and minor milky quartz. The quartzite has no porosity and contains pyrite crystals as an accessory mineral.

Core. 6334–6337 ft. (1931–1932 m). This core straddles the pre-Mesozoic unconformity. The Cretaceous consists of conglomerate interbedded with sandstone. The conglomerate is composed of rounded to subrounded quartzite and chert pebbles, which are white, clear, green, or light grey. The clasts range in size from a few millimetres to a few centimetres, and are cemented by a matrix of sandy and argillaceous material, with different degrees of induration. As a result, the state of the cores grades from disintegration to extreme induration.

Interbedded with the conglomerate are coarse sandstone beds, a few decimetres thick, composed of quartz and chert grains. A large fraction of matrix, sandstone, and pebbles in the conglomerate was derived from the underlying subunconformity quartzite, which is described below.

6364–6402 ft. (1940–1951 m). The quartzite is well indurated, white to light grey, with a few interbedded thin, greenish, argillaceous bands, a few millimetres thick. Pyrite, found mainly in the green argillaceous bands, and other, small, unidentified, pink and black, rounded mineral grains are accessories.

The grains in the quartzite vary in size from submillimetre to commonly a few millimetres, and are composed of clear to somewhat milky quartz. Vertical, recemented fractures, which show evidence of leaching, cut across the bedding. Locally, rounded quartz pebbles, up to 5 mm in size, are suspended in the poorly sorted, coarse matrix. Sedimentary structures include high-angle crossbedding and prograding ripples [depth 6369 ft. (1941 m), angle about 30°]. Bedding size ranges from a centimetre to a decimetre scale, and the grain size grades from fine to coarse inside the beds, changing abruptly only where an argillaceous layer is present. Leaching formed some porosity in a few of the coarser grained beds.

The environment of deposition appears to have been fluvial, as indicated by the crossbedding, prograding ripples, and absence of sorting, indicating a high energy environment.

Natagnak K-53

Comments. The top of the pre-Mesozoic section is at 5550 ft. (1692 m) depth, TD is at 5747 ft. (1752 m). No dipmeter was run. The sequence was assigned an Imperial age by Can-Strat, but has an abnormally high gamma-ray log response for that formation. No evidence has been found of the 1 m thick dolomite bed indicated on the litholog.

Cuttings. The succession consists of siltstone interbedded with subsidiary shale and sandstone. The siltstone is composed of clear quartz grains cemented by quartz, and has a low porosity. The sandstone is well indurated and consists of slightly milky, clear, coarse quartz grains and minor dark grey minerals, tightly cemented by quartz. Some of the quartzite is clear, white-grey, some is dark grey. The grains are rounded to angular. Fractures cross through the grains, and the resulting fracture plane has a glossy appearance. These fractures are dark, due to the presence of black minerals (?hornblende or pyroxene). Similar fractures are present in the siltstone. The shale is green-grey. Except for the shale, these rocks are very dissimilar to typical Imperial strata.

Natagnak O-59

Comments. The top of the pre-Mesozoic section is at 2101.5 m, TD is at 2120 m. The dip direction is 5°E in the Cretaceous conglomerate and 5°N in the pre-Mesozoic quartzite; the restored pre-Mesozoic dip is 7°NW.

Cuttings. The cuttings are identical to those in Natagnak H-50, both above and below the unconformity, except that there are more milky quartz grains and cement.

Core. 2101.3–2101.9 m. The rocks are very similar to the strata in the Natagnak H-50 well. As in Natagnak H-50, the Cretaceous conglomerate is in various states of disintegration. Green or yellow pebbles form the bulk of the rock. Some of the black clasts are shale, others are chert. The pebbles are up to 15 mm in diameter. Glauconite grains and pyrite crystals are accessories in the matrix material.

The sub-unconformity quartzite is composed of well indurated, white to light grey quartz grains, ranging in size from sub-millimetre to generally a few millimetres. The quartzite is similar to the quartzite in Natagnak H-50, but contains slightly more milky quartz. The pyrite crystals are again concentrated in the greenish argillaceous bands, some of which appear stylolitic. Prograding ripples represent the sedimentary structures, as well as some fining-upward sequences, and crossbedding. Abrupt changes in grain size to coarser material can be observed in high-angle crossbedding laminae, which are cut by bands with larger grains. This suggests that the environment of deposition was fluvial.

Carbonate wells

Wells penetrating carbonate strata in the study area are described below. Most of the wells are from the Tuk Flank area, northwest of the Tuk Horst. Some wells are dominated by limestone and others by dolomite. The wells are grouped according to the rock types in each well, and in alphabetical order according to the well name.

Limestone group

The wells in this group are Atkinson A-55, Mayogiak J-17, Mayogiak M-16, Pikiolik E-54, and Tuktu O-19.

Atkinson A-55

Comments. The top of the pre-Mesozoic succession is picked at 6764 ft. (2062 m), TD is at 7325 ft. (2233 m). No dipmeter was run. The core was sampled to obtain conodonts from the interval between 7305 and 7325 ft. (2227–2233 m); unwashed cuttings were sampled between 6770 and 7300 ft. (2063–2225 m). Both intervals proved to be barren.

Cuttings. The succession consists of mainly dolomitic limestone with minor limy dolomite. Near the top of the succession is a pelletal limestone, with dark grey pellets and a light grey matrix. Present over a large interval are rounded, clear quartz grains, embedded in a dolomite matrix; locally they are quite numerous. Rounded, clear quartz is also found separately, as are a few brown and black, rounded chert pebbles. There is one thin layer composed of clear quartzite with glossy fracture, and a sandstone bed with dolomite as the main cementing matrix. Locally, light green, indurated shale can be found.

The dolomite is micritic to fine crystalline and varies in colour from white to black. It also contains a fair amount of rounded quartz grains at several levels. The quartz ranges in size from fine to coarse; free grains are frosted.

The limestone is micritic and dark grey. Very few recognizable fossils are present. (All samples were checked both dry and wet for fossils.) At 7030 ft. (2143 m), the indistinct remains of bivalves, ostracodes, or sponge spicules have been found. The only pyrite observed was a fossilized tube.

The few fossil remains appear to indicate a Paleozoic rather than a Proterozoic age. The sandstone and quartz content is anomalous and is reminiscent of the Sandy Marker as described by Wielens and Williams (1988) for the base of the Mount Kindle or Delorme formations. On the other hand, the sand could be a local phenomenon. The presence of limestone instead of dolomite here could be related to a facies transition if these rocks are of the same age as the Delorme or Mount Kindle formations. The limestone lithology is similar to that found in the Landry–Arnica transition zone.

Core. 7305–7325 ft. (2227–2233 m). The rocks are dark grey to black, mottled, nodular, heavily fractured limestone with locally developed dolomitization. The nodules are grey, the matrix is black, similar in appearance to rocks in Tuktu O-19. Some of the nodules are rounded, others are angular with a brecciated appearance. Dipping surfaces (apparent dip of about 45°) are coated heavily with solid hydrocarbon. It is not obvious if these surfaces represent bedding planes or fractures, but, because calcite spar fills a set of obvious fractures (which were formed in two generations), a bedding plane is the most likely explanation.

Fossil material includes small, calcite-filled imprints of brachiopod shells, and abundant pellets; other fossils are poorly preserved, precluding determination. Usually they have a circular outline, giving the impression of *Amphipora*, *Thamnopora*, crinoid ossicles with one central canal, or scaphopods. Stylolites are present.

Mayogiak J-17

Comments. The top of the pre-Mesozoic is at 9372 ft. (2857 m), TD is at 12 094 ft. (3685 m). No dipmeter log is available. Cretaceous samples were collected at 9371 and 9375 ft. (2856 and 2858 m) for Rock-Eval analysis; pre-Cretaceous samples were collected from 9533 to 9610 ft., and 10 596 to 10 602 ft. (2906–2929 and 3230–3231 m) for conodonts, and from 9638, 9681, 9686, and 9813 ft. (2938, 2951, 2952, 2991 m) for Rock-Eval analysis. The samples indicate fair to good source rock potential. A list of all the cores is presented in Table 4.

The carbonate strata in this well are considered to be Landry Formation, but in some aspects are atypical of the Landry.

Cuttings. The cuttings do not render nearly as much detail as the cores. The only additional information obtained from them is the presence of tentaculitids, especially in the black micritic limestone where no other fossils are present. One tentaculitid, found between 11 270 and 11 280 ft. (3435–3438 m), has been identified as *Nowakia richteri* Boucek and Prantl, of late Emsian age [*serotinus* Zone in conodonts (A.W. Norris, pers. comm., 1987)].

Core. (Comments.) The cores are mainly limestone, but contain some dolomite. The limestone is micritic, black to very dark grey, locally dolomitized. The few fossils present are still recognizable. The depositional environment was low energy and anoxic, in a location where coral rubble, etc., collected. A black, powdery, coaly material is present in several intervals and may be bitumen. Compared with the Landry and Hume formations in the Northern Interior Plains, the rock types in this core resemble those of the Hume rather than the Landry. However, the thickness is far too great for the Hume. The presence of crinoid ossicles with two to five central canals indicates an Emsian age for this succession (Landry Formation). Dips range from 45° near the top to about 15° lower in the core. Mottling in the core is caused by dolomitization, and although this is considered to be a result of bioturbation, very little other evidence has been found of such disturbance.

Fracturing occurred in two distinct phases; the first set of fractures was filled by calcite, and was later offset by the second set of fractures, and/or contorted into an enterolithic shape.

Compared with the adjacent Northern Interior Plains, the presence of dolomite in the Landry near the contact with the Hume Formation is anomalous; however, this phenomenon has been observed in the Mackenzie Mountains.

9366–9383 ft. (2855–2860 m). The uppermost piece of core consists of limy, grey to brown-grey, micritic dolomite. Calcite fills the fractures, of which the steeper ones are offset by a younger, second set, oriented nearly horizontally. Some centimetre-scale banding and fossil ghosts are present in the more limy parts. In the banded succession, the bedding dip is about 45°. The fossil remains have the appearance of, and probably originate from, digitate stromatoporoids. Parts of the dolomite are brecciated.

9490–9520 ft. (2893–2902 m). This limestone core is mottled by dolomitization. Bedding dip is about 45°; brecciation is evident. The limestone is black and micritic, and may be laminated locally; the dolomite is grey and fine crystalline to micritic. Fractures are filled by calcite spar.

Identifiable fossils are *Amphipora*, *Thamnopora*, *Alveolites*, *Stachioides*, and brachiopods. There are only a few stylolites. At 9503 ft. (2897 m), the limestone is brecciated, with the clasts suspended in a carbonate sandy to silty matrix. Laminae in the clasts were partly destroyed by bioturbation. Evidence of a submarine hardground is visible at 9507 ft. (2998 m).

9522–9552 ft. (2902–2911 m). This core consists of limestone with mottling, and the bedding (banding) dip angle is 45°. Parts of the core are brecciated; the fractures were filled by calcite spar and later offset by a second phase of fracturing. Some intervals in the limestone are fossil rich, and have the appearance of bioherms, although the depositional environment was probably too deep for the formation of bioherms. Debris flows from more elevated carbonate banks are considered a more probable origin for the observed accumulation of bioclastic material. Among the fossils in this black limestone are bulbous *Stromatopora*, *Thamnopora*, and small-sized *Amphipora*, which are the most abundant.

9552–9582 ft. (2911–2921 m). This core is composed of black, micritic limestone, with a few brecciated dolomite beds, and a bedding dip of 45°. Calcite filled the vertical fractures, which were offset by a second set of fractures. The same fossils described from the core directly above are present, although less abundant. In addition, crinoid ossicles with double central canals have been observed. Part of the limestone has been altered to a micritic dolomite, which was later brecciated; it contains a few stylolites and laminae.

The top part of this core appears to represent a deeper water depositional environment, as reflected by the presence of crinoid ossicles, and some tabular stromatoporoids. The presence of such crinoid ossicles indicates an Emsian age for this interval.

9582–9632 ft. (2921–2936 m). The core consists of black micritic limestone, with a bedding dip of about 40°, and fractures filled by calcite and/or pyrite; locally the rock is brecciated, and pyrite and sand/silt fill part of the fractures. The pyrite band in this breccia is closely associated with black limestone clasts and appears to have been broken at the same time as them, and later overgrown by a younger generation of pyrite. Part of the matrix in the breccia is laminated. It was deformed by slumping, while still in a plastic stage. The few fossils present, such as gastropods and crinoid ossicles with twin central canals, are suspended in the mud matrix. Slickensides are present and coated with highly reflective material, possibly graphite. Conodonts in the interval from 9533 to 9610 ft. (2906–2929 m) indicate a late Emsian age (T.T. Uyeno, pers. comm., 1988; Appendix B).

9634–9656 ft. (2936–2943 m). The core lithotype is black, fractured, micritic limestone, containing the same type of fossils as those described from the cores above: *Amphipora*, *Thamnopora*, *Alveolites*, *Stachioides*, brachiopods, and crinoid ossicles with twin central canals. Fractures in this otherwise featureless rock are partly filled by bitumen.

9659–9675 ft. (2944–2949 m). This core is similar in general description to the core described above, with gastropods, *Amphipora*, *Thamnopora*, *Alveolites*, *Stachioides*, brachiopods, and crinoid ossicles with twin central canals, suspended in the micritic limestone, and extensive fractures cemented by white calcite.

9675–9705 ft. (2949–2958 m). This core comprises a black, micritic limestone succession as described for the core above, with gastropods, *Amphipora*, *Thamnopora*, brachiopods, and *Stachioides* encrusted by *Alveolites*. Large fossil corals are present. The bedding dip is about 20°.

9787–9817 ft. (2983–2992 m). The core consists of black, micritic limestone, which is similar to that in the core above, with the exception of white, laminated limestone breccia of probably allochthonous origin at one depth interval. The slight, local mottling is caused by alteration to dolomite. Fossils include gastropods, *Amphipora*, *Thamnopora*, *Alveolites*, *Stachioides*, and brachiopods.

10 321–10 347 ft. (3146–3154 m). The core is composed of dark grey, crinoidal, grain-supported lime-sandstone, with nearly horizontal bedding. Apart from crinoid ossicles, a few large corals and large brachiopods are present. Crinoid ossicles usually have two central canals, although some have one. The rock colour is lighter than in the previous cores. Some of the fractures have been filled by calcite spar.

10 596–10 602 ft. (3230–3231 m). The core consists of black, micritic, crinoidal lime mudstone, with a nearly horizontal bedding dip. The rock is fractured, and the resulting space has been filled by calcite spar. Conodont identifications indicate a late Emsian age (T.T. Uyeno, pers. comm., 1988; Appendix B).

10 940–10 947 ft. (3335–3337 m). This interval contains black, micritic limestone with a few brachiopods and crinoid ossicles suspended in mud. The bedding dip is nearly horizontal. The few fractures have been partly filled by calcite spar.

11 238–11 251 ft. (3425–3429 m). The core consists of slightly dolomitic, micritic, black limestone, riddled with vertical fractures, some of which are filled by calcite; others are open; some of the fractures were offset by a younger generation of fractures. The only fossils are a few gastropods.

11 499–11 521 ft. (3505–3512 m). The top of the core is composed of dolomitic, micritic, black limestone, the bottom part of grey dolomite. Stylolites are much more common than in the cores above; there are also vertical fractures, offset by a second set of fractures, all of which were cemented by calcite spar. *Amphipora* is present in the limestone, and remains discernible in the fine crystalline dolomite, where it is less extensively dolomitized than the surrounding matrix. Lower in this core, the fossils have been leached out and replaced by calcite. The bedding dips at about 15°.

12 070–12 093 ft. (3679–3686 m). The rocks consist of light grey dolomite in which *Amphipora* remains are still recognizable. Vertical fractures, cemented by calcite, are present. The bedding dips at 15°. Lower in the core, the dolomite has laminae, cryptalgal structures, and also fenestrae, although not of the bird's-eye type. Vertical cracks visible in the fenestrae are associated only with them; they have been described by Shin (1983) as stromatactis. In one interval of the core, remains of *Amphipora* can be observed. The matrix rock is micritic, mottled dolomite. A submarine hardground is visible at depth 12 086 ft. (3684 m).

Mayogiak M-16

Comments. The top of the pre-Mesozoic is picked at 2866 m, TD is at 3093 m. A dipmeter log was not run. Samples for geochemical analysis were collected from depths of 2850, 2920, and 2990 m; for conodont analysis from between 2866 and 3005 m in the dolomite and between 3005 and 3093 m in the limestone.

Cuttings. The cuttings are from micritic to fine crystalline, locally sandy/silty, dark grey to buff coloured dolomite. There are a few small, rounded grains of clear quartz, some cemented in a pyrite matrix. Rounded, black chert pebbles are very rare. A few shaly beds are intercalated in the dolomites (the shale cannot be caved because the casing shoe was set in the dolomite). They consist of dark brown to black, greasy shale, which may have source rock potential. These rocks are slickensided.

Below 3005 m the dominant rock type is grey, argillaceous, pyritic, and dolomitic limestone. At 3020 m, a tentaculitoid and a possible brachiopod fragment were found. Some crinoid ossicles with a single canal, probable *Amphipora*, and stromatoporoid fragments are also present. A sponge fragment, *Cheatetes* (A.E.H. Pedder, pers. comm., 1987), indicates a Late Ordovician to Permian age range.

The conodonts indicate a probable Middle Devonian age (T.T. Uyeno, pers. comm., 1988; Appendix B).

Core. 2887.3–2894.3 m. The core consists of brecciated, micritic, light grey to buff, limy, and locally laminated dolomite with a bedding dip of about 30°. Many stylolites, both vertical and horizontal, and fractures are present. Ghosts of fossils (crinoid ossicles with a central canal, or *Amphipora*) a brachiopod, and a fenestral texture are visible. Some fracturing occurred immediately following the first stage of induration, resulting in angular, platy fragments suspended in the mud matrix, especially in the laminated, fenestral parts.

Pikiolik E-54

Comments. The top of the pre-Mesozoic is picked at 8985 ft. (2739 m), TD is at 10 230 ft. (3118 m). Dipmeter readings for the Cretaceous are 6–10°NW, for the pre-Mesozoic 14–36°NE. The original pre-Mesozoic dip ranges from 38°NE to 17°E. Dips in core, on the other hand, appear to be horizontal. Samples were collected from the core for conodont dating of the crinoidal interval from 9048 to 9078 ft. (2758–2767 m), and from the corals at 9101, 9102, and 9102.3 ft. (2774.0, 2774.3, 2774.4 m). Brown shale cuttings were sampled for maturity analysis from the Devonian interval between 9280 and 9300 ft. (2829–2835 m), and the Cretaceous between 8970 and 8980 ft. (2734–2737 m) for Rock-Eval analysis, and have fair source rock potential. The shale could be caved material.

Cuttings. Small quantities of chert are present in the dolomite below 9300 ft. (2835 m). The dolomite is light or dark grey, and micritic.

The uppermost carbonate unit is a black, micritic limestone containing crinoid ossicles, tentaculitids and *Amphipora*. The crinoid ossicles have one, two, or four central canals, indicating an Emsian age. Conodonts are less restrictive and indicate a Middle Ordovician to Middle Devonian age (T.T. Uyeno, pers. comm., 1988; Appendix B).

Core. 9048–9108 ft. (2785–2776 m). The core consists of dark grey, micritic limestone, somewhat mottled by dolomitization. The upper part is a crinoidal wackestone, the bottom part contains a large number of corals and stromatoporoids. Part of the fossil-rich limestone is a grainstone, but generally the fossils are suspended in the mud matrix. Fractures have been cemented by calcite spar; the oldest set is offset by a younger generation. The bedding appears to be horizontal. The few slickensides are covered by graphite-like material. In the crinoidal intervals, the crinoid ossicles generally have two to four central canals, which indicates an Emsian age. This age is corroborated by coral fossils lower in the core. Other, less abundant fossils are tentaculitids, brachiopods, and stromatoporoid fragments.

Stylolites are present, at a frequency of about one every 5 cm of depth. Some of the vertical, calcite-spar-filled fractures grade into horsetails. Black bitumen covers part of the fracture surfaces. Locally, sand beds and breccias with rounded to subrounded clasts can be found in the sequence. At 9085 ft. (2769 m), there is an abundance of fossils; this may represent a bioherm, although a debris flow is a more probable explanation for its origin. Some of these fossils are in direct contact, forming a grainstone, but most are suspended in the mud, forming a wackestone. At this level, a breccia composed of dolomitic material contains some cryptalgal lamination and a fenestral texture, although bird's-eye structures are absent. *Amphipora* and *Alveolites* are the major fossils found here, especially in the sandier parts. Some of the stromatoporoids encrust *Alveolites*, while others are large, bulbous forms. Tabulate corals (*Favosites*) and rugose corals (*Spongonaria*) are also present. The latter is approximately time-equivalent to the crinoid ossicles with twin-canal ossicles and indicates an Emsian to early Eifelian age (A. Pedder, pers. comm., 1987).

The crinoidal wackestone in the upper part of the core appears to have been deposited in deeper water than the lower, fossil-rich mudstone; nevertheless, the black micritic muds in the complete interval indicate too deep an environment for in situ deposition of the corals and stromatoporoids.

In overview, the section contains, from top to bottom, a crinoidal limestone, a dolomite, and another crinoidal limestone, with a total penetration of over 300 m. The complete interval has an Emsian age. Pedder (*in* Brideaux et al., 1975) described the corals mentioned above in more detail.

Tuktu O-19

Comments. The top of the pre-Mesozoic is picked at 7215 ft. (2199 m), TD is at 7597 ft. (2316 m). The dip of the Cretaceous surface is 6°NNW, that of the pre-Mesozoic is 18°ESE, and the reconstructed pre-Mesozoic dip is 23°SE. Pedder (in GSC internal report DWM45AEHP) identified a *Spongonaria*, of early Emsian age, in the core from this well. The core has been sampled for conodont dating, between 7352 and 7371 ft. (2241–2247 m).

Cuttings. The cuttings did not yield any information additional to that obtained from the cores.

Core. 7350–7390 ft. (2240–2252 m). The core consists of black micritic limestone with some mottling from dolomitization. Several types of fossils are present:

corals, such as *Favosites*, *Alveolites*, bulbous stromatoporoids encrusted on *Favosites*, *Amphipora*, tentaculitids, crinoid ossicles with one, two or four central canals, and pelletal material. Locally the *Amphipora* is grain supported, but usually the fossils are suspended in the lime-mud matrix. Conodonts in this core indicate a probable Early to early Middle Devonian age (T.T. Uyeno, pers. comm., 1988; Appendix B). There are two generations of fractures; some of them are filled with a limestone breccia in a dolomitized sandy matrix. There are a few limestone bands of lighter colour, indicating a bedding dip of about 15°. These bands may display a vague fenestral texture. The limestone can be rubbly, comprising a black matrix and slightly lighter nodules, which contain fossils. This appearance may be the result of bioturbation. Dissolution generated stylolites and a few vugs, which show evidence of leaching at the top, and, locally, geopetal sediment at the base.

Vertical burrows, less than 1 cm in diameter, are present. All of them are cemented by calcite spar. In the burrows the spar is clear or milky calcite with a pelletal appearance. This core is very similar to that described for Pikiolik E-54, except for the more pelletal character and the burrows, all of which indicate shallower water during deposition.

7582–7597 ft. (2311–2316 m). This core consists of dolomite with a minor amount of limestone; both rock types are very brecciated. Both horizontal and vertical beds are present; the vertical dips may represent bedding in larger, tilted debris blocks. The "vertical" clasts are up to 1 m in size and give the impression of internal, algal laminae. The clasts are angular and composed of grey dolomite, or green, red, brown, or grey limestone. The matrix of the breccia contains a large amount of pyrite and argillaceous material, and is dolomitized. The middle section of the core is less disturbed; it is laminated and has soft-sediment deformation structures, caused by loading.

The algal lamination indicates a shallow marine origin for the dolomite. Part of the calcite spar appears anhydritic, and may indicate a replacement process.

In overview, the penetrated succession consists of a limestone-dolomite-limestone succession, with several indications of a shallow water depositional origin.

Dolomite group

The wells in this group are Akku F-14, Atkinson L-17, Eskimo J-07, Imnak J-29, Kannerk G-42, Kimik D-29, Louth K-45, Mayogiak L-39, Natagnak K-23, Nuna A-10, Pikiolik G-21, Pikiolik M-26, Tuk M-09, and Wagnark C-23.

Akku F-14

Comments. The pre-Mesozoic unconformity is picked at 4477 ft. (1365 m), TD is at 4996 ft. (1523 m). A dipmeter log was not run. Samples for conodonts were collected between 4500 and 4800 ft. (1372–1463 m) in dolomite.

Cuttings. The rock consists of a buff to pink, fine crystalline dolomite with a few laminae, some of which are curved and contain pyrite and fenestrae. Interbedded with the dolomite are greenish, indurated shale with a phyllitic appearance and indurated, brick-red shale, which grades into pink dolomite. Locally, below 4640 ft. (1414 m), the dolomite colour changes to dark grey. Coarse, white dolomite spar is found as fracture filling, and some buff-coloured chert is present, but in substantially smaller quantities than pyrite. At 4750 ft. (1448 m), a quartzitic layer, containing pyrite and biotite, can be observed. Below that level, dolomite is present and appears to grade more and more into quartzite at lower depths. Near the bottom of the dolomite succession, clear quartz grains are suspended in the carbonate, in a transition zone. This dolomite and shale succession is similar to Proterozoic rocks exposed in the Campbell Uplift (M.P. Cecile and L.S. Lane, pers. comm., 1987).

The colours of the red and green shale and pink dolomite are reminiscent of Precambrian rocks; however, the single conodont found precludes ages older than Middle Cambrian (T.T. Uyeno, pers. comm., 1988; Appendix B). The quartzitic clastic rocks would be anomalous for lower Paleozoic formations.

Atkinson L-17

Comments. The top of the pre-Cretaceous unconformity is picked at 2331.5 m, TD is at 2480 m. Dipmeter data indicate a dip of 2°SE for the Cretaceous, and 20°W for the Paleozoic; the reconstructed pre-Mesozoic dip is 22°W. The core was sampled for conodont dating from 2337.0 to 2350.2 m; unwashed cuttings were not available.

Cuttings. The cuttings are mainly caved shale which masks the dolomite. The dark grey dolomite is fine crystalline; the light brown dolomite is micritic. Pyrite is present in thin bands. There are a few clear quartz crystals in addition to rounded, clear, and yellow to red, frosted quartz grains. The dolomite spar occupies most of the total rock, is clear to milky, varies from fine to coarse crystalline, and fills vugs and fractures. One vague imprint of a shell was found. Chert is absent in this well. Dolomite crystals are coarser near the bottom of the penetrated succession.

In general, the sequence consists of dolomite with a few intercalated layers of claystone. There is a small amount of pyrite present, but no chert. Much of the rock is fractured. The depositional environment was generally deep water, with local shallower parts. The ghosts of fossils indicate a Paleozoic age, which is restricted to Middle Ordovician by the conodonts (G.S. Nowlan and T.T. Uyeno, pers. comm., 1988; Appendix B).

Core. 2337-2350.2 m. The rock is mottled, light grey dolomite, which is fractured and locally oil-stained. Ghosts of indistinct fossils can be observed.

At 2338.5 m, recognizable pellets indicate a bedding dip of about 30°. Below 2339.0 m, the dolomite is yellowish grey, micritic mudstone, in which soft-sediment deformation by fracturing occurred immediately following the initial induration. Ten centimetres deeper, spar-filled fossil imprints resembling *Amphipora* are present. Remnants of fenestrae are visible at 2339.25 m, and pellets are present at 2340.0 m. Vugs are small and may be filled by dolomite spar. At 2341.15 m, possible crinoid ossicles can be observed. At 2341.75 m, a breccia/debris flow overlies a layer of dolomite, which contains a possible bulbous stromatoporoid. The matrix consists of dolomite-sandstone, and broken pyrite bands which were later overgrown by pyrite. At 2342 m, *Amphipora*-like fossil remains are present, underlain by laminated dolomite with apparent fenestrae at 2342.25 m. At 2344.4 m, a gastropod was found.

The extensive fracturing throughout the core shows some offsets, indicating a two-stage generation, with recementation by white spar dolomite. There are only a few stylolites.

2411.5-2413.2 m. This core is composed almost entirely of light buff, well indurated claystone, heavily fractured and slickensided, locally brecciated. The bedding appears to dip at about 30°, but is rather indistinct. Parts of the rock are laminated. Intercalated in the shale is a 10 cm thick, dark grey, brecciated dolomite bed containing a crinoid ossicle with a single central canal. Attempted breakdown of the claystone for microfossil separation was unsuccessful.

Eskimo J-07

Comments. The top of the pre-Mesozoic unconformity is picked at 2714 ft. (827 m), TD is at 2971 ft. (906 m). No dipmeter was run. There are core samples only. The bedding dip is about 20°. The rocks were sampled for conodont analysis between 2945 and 2971 ft. (898-906 m), and for geochemical analysis between 2955 and 2968 ft. (901-905 m). The basalt was sampled for X-ray analysis.

Core. 2760-2770 ft., 2849-2892 ft., 2905-2971 ft. (841-844 m, 868-881 m, 885-906 m). A 70 m thick sequence of basaltic rocks, hydrothermally altered in varying degrees, overlies dolomite and has been described in the "clastic rocks" section of Appendix A.

The dolomite is a dense, partly mottled, partly laminated, fine crystalline, grey to orange-pink rock with some solid hydrocarbon (black, soft) in vugs. The rock contains numerous stylolites and brecciated parts, and is recemented in many places. A large fraction of the dolomite is stromatolitic. These fossils were not noted in previous descriptions of this core, although they are visible even on the outside of the core (Fig. 9). Many of the stromatolites appear to be in growth position, and have several pink laminae. Figure 9 shows a passively branching individual; the lack of active branching and walls prevents determination and thus dating. The specimens range in height from 5 to 15 cm. Near their base, laminae with fenestral textures can be observed. Pink and red dolomite spar forms the first coating in the few vugs. White dolomite spar forms the second stage of fill and in some of the vugs is followed by nearly clear quartz crystals. The vugs within stromatolites have an elongate shape; in the matrix their shape is approximately rounded. Spar-filled fractures are offset by a younger, uncemented generation of fractures. The dolomite in the matrix surrounding the stromatolites has a sandy to silty texture. There is also evidence of leaching in spots where the dolomite has a sandy and vuggy appearance. The leached dolomite is cut by the last generation of fractures but not by the first. Brown, clast-like pebbles are present in the sandy parts. It is possible that the leaching was caused by weathering in "organ pipes".

Contact metamorphism on a small scale can be observed near the contact with the overlying volcanic sequence. The dolomite there is generally orange to red, has a marbly, brecciated appearance, and contains large amounts of pyrite. Deeper in the succession, many of the fractures are coated or filled with a graphite-like, black material, which may have been bitumen. Black spots, possibly of the same material, are especially common in the laminated dolomite. Part of the dolomite breccia has rounded, laminated clasts floating in a pinkish, sandy matrix.

The dolomite is largely composed of stromatolites, suggesting a biostrome or bioherm. The spotty orange colour observed in the dolomite varies from a pebbly appearance to an indistinct shape, fading into the surrounding grey dolomite.

Based on the character of the stromatolites (see discussion in the section "The Tuk Horst volcanic rocks and stromatolites" in the text), a Precambrian age for the dolomite is likely. The volcanic rocks were altered too much for a reliable absolute age date to be obtained with the K-Ar method. Not enough minerals were present to apply fission-track dating.

Imnak J-29

Comments. The top of the pre-Mesozoic is picked at 10 840 ft. (3304 m), TD is at 11 170 ft. (3405 m); no dipmeter log was run; no core is available. Samples were collected for conodont analysis between 10 860 and 11 170 ft. (3310–3405 m) in dolomite.

Cuttings. The dominant lithotype is sucrosic, fine crystalline, mottled dolomite, composed of a mixture of white and black dolomite crystals, with a resulting overall dark grey colour. Hints of ghosts of fossils are present. Accessories are pyrite, and rounded, frosted, clear quartz grains, some of which are embedded in dark brown shale, as can be found in post-Paleozoic formations. Broken quartz crystals are also present. Although some of the shale in the samples is fairly indurated, it is unclear whether it represents cavings or actually belongs in the dolomite sequence. The small amount of white to clear dolomite spar is probably fracture filling. Rounded chert pebbles or grains, and grey chert are rare. Below 11 130 ft. (3392 m), the dolomite colour changes gradually to lighter buff, and shows a slight increase in crystallinity.

The complete succession is a dark grey, sucrosic dolomite with possibly a few black shale beds. The succession may be of Paleozoic age. The conodont samples were barren.

Kannerk G-42

Comments. The top of the pre-Mesozoic is picked at 7832 ft. (2387 m), TD is at 8138 ft. (2480 m). No dipmeter log was run. No samples were collected for conodont analysis, due to the abundance of shale.

Cuttings. The rocks consist of a succession of indurated shale and dolomite. Both vary considerably in colour. The dominant colour is light green, but the colour may range from brick-red through pink to white. Locally, dark grey cuttings are present and the shale can be purple.

The dolomite is fine crystalline; the shale has a phyllitic appearance. Locally, rounded, clear quartz grains can be found in the red shale; thin bands and nodules of pink dolomite may be intercalated. At some levels, the dolomite grades into fine grained marls. A few well rounded, black chert pebbles have been observed. Near TD, the amount of well rounded, clear quartz grains increases. Pyrite can be found throughout the section in small quantities.

The fairly intense, wide range of rock colours suggests a Precambrian age, although the sequence may be Cambrian, like the Saline River Formation in the Northern Interior Plains.

Kimik D-29

Comments. The top of the pre-Mesozoic is at 8470 ft. (2582 m), TD is at 8720 ft. (2658 m). Samples were collected for Rock-Eval analysis at 8466 and 8476 ft. (2580–2583 m) and indicate good to excellent source rock potential. The carbonate section of the core was sampled for conodont analysis between 8602 and 8624 ft. (2622–2629 m), and from the unwashed cuttings between 8480 and 8720 ft. (2585–2685 m).

Cuttings. The penetrated succession comprises dolomite with an interval of about 10 m of sand/siltstone and shale beds. Fossil remains are present at 8500 ft. (2591 m) and include scaphopods, an indication of a marine environment. The fine crystalline dolomite is dominantly grey, but ranges in colour from pitch black to light buff. There are some rounded, frosted, clear, and red quartz grains present. Black chert pebbles are well rounded. They are usually associated with caved, brown shale, and therefore were probably derived from Mesozoic formations. Some pyrite is present. Dolomite spar fills vugs and fractures. The sandstone consists of a quartz matrix and some larger, up to 1 mm in size, rounded, frosted quartz grains; the siltstone is also composed of quartz grains.

In general, this largely dolomitic section contains some marine clastic rocks. Ghosts of fossils indicate a Paleozoic age, restricted by conodonts to Middle to Late Ordovician (G.S. Nowlan and T.T. Uyeno, pers. comm., 1988; Appendix B). There are several indications of a shallow water depositional environment. The clastic interval is anomalous, and is not found in the nearby Northern Interior Plains. It may be similar to the Sandy Marker (Wielens and Williams, 1988), and could be of similar age to the quartz sand described in the Atkinson A-55 well.

Core. 8463–8482 ft. (2580–2585 m). On the basis of the wireline logs, this core straddles the pre-Mesozoic unconformity; the lower dolomite interval was not recovered. The core consists of dark brown shale, and chert-pebble conglomerate near the contact. The shale was dated by Brideaux et al. (1975) as Late Jurassic.

8536–8558 ft. (2602–2608 m). The top of this cored interval consists of interbedded, laminated and fractured, light grey, poorly consolidated sandstone, siltstone, and shale. Laminae are in the order of millimetres to centimetres in size, and represent a succession of shale and sandstone layers, all of which are fining-upward but have fairly sharp boundaries at top and bottom. The shale has flame structures. Other deformation is by fractures, which offset the lamination after initial induration. There is no evidence of bioturbation. Below 8545 ft. (2605 m), the sandstone beds increase in thickness to over 10 cm. These beds overlie a brecciated debris flow composed of sandstone and shale clasts.

A one metre thick dolomite bed is present below 8550 ft. (2606 m). It is light grey, mottled, and fine crystalline. Fractures are abundant and cemented by dolomite spar with a small amount of calcite. Underlying the dolomite is another very soft, unconsolidated sand/shale bed.

This sequence of poorly consolidated clastic rocks in the carbonate succession is anomalous, and is not found in the formations of the Northern Interior Plains.

8602–8624 ft. (2622–2629 m). The core consists of fine crystalline, heavily fractured dolomite with a few stylolites. Some of the fractures are offset by a younger generation of fractures. The bedding dip is about 30°. There are indications of fossils, possibly brachiopods and crinoid ossicles with only one canal. Porosity is visible in the form of pinpoint vugs. The dolomite is partly laminated, and grades into featureless, bioturbated carbonate. The rocks give the impression of an original deposit of sandy and muddy limestone. At 8615 ft. (2626 m), both pelletal structures and fenestral pores are present. Below this depth, the dolomite is laminated with local indications of crossbedding, giving again an overall impression of a carbonate sand/mud depositional environment. Some sponge spicules were observed.

Louth K-45

Comments. The top of the pre-Mesozoic is picked at 6947 ft. (2117 m), TD is at 7275 ft. (2217 m). No dipmeter log was run. The rocks were sampled between 6970 and 7270 ft. (2124–2216 m) for conodonts.

Cuttings. The overlying Cretaceous conglomerate contains pebbles derived from the Tuk Horst quartzites. The pre-Mesozoic succession consists of dark grey to buff, fine to medium crystalline dolomite with spar infill in vugs and fractures, and minor pyrite and other sulphides as accessories. A large fraction of the spar is reddish to orange, and coarse crystalline. A few marly, thin, pinkish beds are present. Below 7000 ft. (2135 m), some of the dolomite itself is pinkish along hairline fractures. Brown, well rounded chert pebbles are rare. Below 7100 ft. (2164 m), the pink dolomite increases considerably in quantity, and alternates with yellowish beds, in which the dolomite is more finely crystalline. A few cuttings show evidence of slight leaching. Fossil shading, as mentioned on Can-Strat lithologs, has not been observed.

Although the pink colour of the dolomite is reminiscent of Cambrian or Precambrian rocks, the conodonts have an Ordovician to Triassic age (G.S. Nowlan and T.T. Uyeno, pers. comm., 1988; Appendix B). The absence in this area of formations younger than Devonian restricts the age range from Ordovician to Devonian.

Mayogiak L-39

Comments. The top of the pre-Mesozoic is picked at 14 517 ft. (4425 m), TD is at 14 589 ft. (4447 m). No dipmeter log was run, only the electric wireline log is available for this interval. Can-Strat indicates on the litholog a dolomite bed below 14 516 ft. (4424 m), while D. Myhr mentions, in an internal GSC well history report, "no evidence at all for Paleozoic". Due to the abundance of caved younger shale, this well was not sampled for conodont analysis.

Cuttings. The actual rocks of the pre-Mesozoic interval are masked by extremely heavy caving, but there are a few coarse crystalline, light grey to white dolomite cuttings, some of which appear to be leached or rounded off. They are of questionable value for a rock description, but contradict the statement of Myhr quoted above. Part of the dolomite consists of white and black grains mixed together, giving the rock a grey appearance. No chert has been observed in these samples.

Based on this information, any age estimate other than pre-Mesozoic is impossible.

Natagnak K-23

Comments. The top of the pre-Mesozoic is picked at 4875 ft. (1486 m), TD is at 4977 ft. (1517 m). The dip for the Cretaceous is 6°E, for the Paleozoic 45°(?)NW; the reconstructed pre-Mesozoic dip is 50°NW. Samples for conodont analysis were collected from core between 4954 and 4977 ft. (1510–1517 m), and from cuttings between 4900 and 4970 ft. (1494–1515 m).

Cuttings. The rocks consist of light grey to white, fine crystalline dolomite and coarse crystalline dolomite spar. Pyrite is ubiquitous. Near the top of the pre-Mesozoic section some white marl is present. A few clear, euhedral and also well rounded, frosted quartz grains were observed.

Core. 4954–4977 ft. (1510–1517 m). The rock is micritic, laminated, light grey, fetid, limy dolomite. The laminae in the dolomite are usually white to buff in colour, but may be dark grey, and have an algal appearance. The dark coloured and less disturbed laminae are quite limy. Between the laminae, sandy grains can be observed. Stromatactis, vertical desiccation cracks in the laminae, were cemented by calcite, probably soon after deposition. There are many bird's-eye fenestrae. The bedding is indicated by the lamination, and dips about 40°. At 4965 ft. (1513 m), the laminae are deformed into enterolithic folds. Otherwise, the laminae are very straight, or wavy with radii of 3 to 5 cm. Pellets are present in the mudstone part of the dolomite. The dolomite infill spar may have the appearance of anhydrite pseudomorphs.

At 4961 ft. (1512 m), ghosts of possible brachiopods of very small size are present. A pelletal dolomite is present at 4971 ft. (1515.2 m), and an unidentified fossil at 4972 ft. (1515.5 m). Although part of the dolomite is strictly laminated, part is brecciated, with laminated angular clasts enclosed in spar matrix. These clasts range in size from a few centimetres to blocks of 20 cm across.

The dolomite contains fractures and vugs, some of which are healed by a first generation of dolomite spar and a subsequent generation of very coarse calcite spar. The fracture system shows the usual two generations; the oldest set is vertical, oblique to bedding dip. In some of the horizontal fractures, geopetal cement was deposited prior to the spar infilling.

In overview, a Middle Ordovician age was determined for laminated dolomite (G.S. Nowlan and T.T. Uyeno, pers. comm., 1988; Appendix B). The vertical fractures are again oblique to bedding dip, which may indicate that at least the vertical set was formed after the region was tilted.

Nuna A-10

Comments. The top of the pre-Mesozoic is picked at 3222 m, TD is at 3250.5 m. The dipmeter was run only above the unconformity interval. Cuttings are not available. The core was sampled for conodonts between 3243 and 3250.5 m.

Core. 3243–3250.5 m. The main lithotype is a mottled, light grey-brown, vuggy, fine to medium crystalline dolomite, with a brecciated appearance and a possible bedding dip of about 40°. There are few stylolites and open fractures. Many vugs are completely filled by white, milky dolomite spar, especially at deeper levels. Others have a quartz crystal lining, covering the spar. Part of the dolomite is mudstone; elsewhere it appears to have been brecciated before dolomitization and contains many ghosts of fossils. These fossils range in shape from circular shapes with a central canal, to remnants of digitates, possibly corals or *Amphipora*.

The ghost fossil assemblage gives an impression of bioclastic debris. Some of the clasts in the breccia are angular, others rounded. Soft-sediment deformation by fracturing, with later recementation, occurred in a few of the clasts.

At lower levels in this core, the rocks resemble tabular stromatoporoids and have a fenestral texture. The milky dolomite spar there appears to be a replacement of anhydrite. In addition, there are a few light brown, thin shale beds with small white specks, which may be fossil remains. Near the bottom, the core becomes locally sandy, possibly representing infilling of cavities by sand. A number of fractures were cemented by pyrite.

In general, the core is a light grey-brown, vuggy dolomite, with indications of brecciation and recementation prior to dolomitization. Ghosts of fossils point to a Paleozoic age, and the abundance of possible *Amphipora* may restrict this age to Silurian or Devonian. The intervals sampled for conodonts were barren.

Pikiolik G-21

Comments. The top of the pre-Mesozoic is picked at 1377.5 m, TD is at 1429.6 m. Dipmeter data indicate a dip of 6°N for the Cretaceous and (?)30°NW for the Paleozoic; the reconstructed pre-Mesozoic dip is 26°NW. There is no core. The unwashed cuttings were sampled for conodont analysis between 1380 and 1428 m.

Cuttings. The dolomite near the top of the pre-Mesozoic succession is riddled with pinpoint vugs, and contains large amounts of chert, which ranges in colour from dark brown-grey to light buff. In addition, rounded, frosted, clear, brown, and red quartz grains are abundant. The presence of white sandstone is indicated by rounded, clear quartz grains, cemented together by milky quartz, and grading into a well indurated quartzite. This quartzite is similar to that found on the Tuk Horst. The dolomite ranges in colour from dark to mostly light grey, and is fine crystalline to micritic. There is no evidence of fossil remains. Some pyrite is present.

When compared to the other wells described above, the colour of the dolomite is markedly lighter, and the chert and quartz content is distinctly higher. Some of the quartz is even present in thin quartzitic layers, and one white sandstone/quartzite bed resembles the thick quartzite on the Tuk Horst. No information has been found regarding the age of the rocks, the conodont samples being barren.

Pikiolik M-26

Comments. The top of the pre-Mesozoic is at 5610 ft. (1710 m), TD is at 6510 ft. (1984 m). No dipmeter log was run. The cuttings were sampled between 5620 and 6470 ft. (1713–1972 m) for conodonts. There is an indication of some limestone on the Can-Strat litholog; this well is located just to the east of wells that contain large amounts of limestone.

Cuttings. The cuttings provide some additional information. A small amount of red, brown, black, well rounded chert pebbles is present. One or two clear quartz grains have been found. The dolomite is micritic to fine crystalline, at one depth even sucrosic. The dolomite is brecciated at greater depths. The colour of the dolomite ranges from light grey to buff, but may grade to black in a few thin beds. Limestone is rare.

Core. 5633–5645 ft. (1717–1721 m). The core consists of a limy, light to dark grey, micritic dolomite with a bedding dip of about 45°, and horizontal stylolites, that terminate vertical, calcite-filled fractures. There are a few calcite-spar filled vugs. The rocks display lamination (?algal) and ghosts of pellets or possibly *Amphipora*; locally fenestrae can be discerned in the laminated parts. The sediment was heavily bioturbated in some places, and not at all in others. Most of the core is brecciated. A fair amount of pyrite is present on one vertical fracture plane.

The (?)algal laminae in the core indicate a shallow water environment of deposition, and the ghosts of pellets and fossils indicate a Paleozoic rather than Proterozoic age (the conodont samples were barren). The stylolites postdate the fracturing. The fractures are mainly vertical, as is usual in most other carbonate cores, and independent of the bedding. This may indicate that the vertical fracturing occurred after the rocks were tilted. The few fractures parallel to the bedding may represent an earlier fracturing phase; a two-stage relationship with offset fractures is not obvious in this core.

The succession in this well is different from that in the nearby wells Tuktu O-19 and Pikiolik E-54 in several aspects. The limestone content is minimal. The strata here appear to have been deposited in a shallower environment and contain no identifiable fossils, probably due to the dolomitization. A somewhat older, Ronning-equivalent age is considered more likely than Emsian for these rocks because of the domination of dolomite in the succession.

Tuk M-09

Comments. The top of the pre-Mesozoic is at 2870 m, TD is at 3030 m. Dipmeter logs were not run. Samples were collected for palynology between 3008 and 3009 m (and proved barren), and at 2860, 2865 and 3008.5 m for Rock-Eval analysis and have no source rock potential. The first two samples for Rock-Eval analysis were collected from unwashed cuttings; they were washed and handpicked. Although this well penetrated mainly shale, the presence of dolomite clasts, chert and the absence of sandstone and siltstone point to a facies change from carbonate into shale, rather than an area of clastic deposition. Therefore, this well is described here in the carbonate section.

Cuttings. The Esso well history reports mention the presence of some wood and spores, between 2790 and 2985 m; this would indicate an age not older than Devonian. Beneath these levels there were no fossils.

The cuttings consist of black shale with very little chert and black, glossy shale partings, the gloss being caused by slickensides. In addition, dark grey, locally lighter grey to clear, fine grained quartzite is present. Parts of the milky quartz and white dolomite and calcite spar are probably fracture fillings.

Core. 3008–3009 m. The rock consists of a black debris flow with angular clasts up to a few centimetres in size. The clasts are composed of dolomite, shale, and a smaller amount of chert and pyrite. There are a few ghosts of fossils. On fracture planes, prismatic barite crystals can be found. The bedding appears to dip at 50°. Soft-sediment deformation in the black shale was caused by loading. The rocks are certainly not chert, as indicated on the Can-Strat litholog. They appear to represent a debris flow, such as those commonly found in the area of facies change from carbonate into shale.

Except for the black shale, the Can-Strat litholog does not describe the rocks very well, and although the abundant caved shale masks the actual rock types, there is a clastic succession with shale, breccia and well indurated quartzite underlying the Mesozoic. A Devonian age may be inferred from the report mentioned, but it is very questionable, owing to the large amounts of caved Mesozoic shale.

Wagnark C-23

Comments. The top of the pre-Mesozoic is picked at 13 710 ft. (4179 m), TD is at 13 947 ft. (4251 m). Dip measurements are 10°W for the Cretaceous, and 12°(?)S for the Paleozoic; the reconstructed pre-Mesozoic dip is 16°SE. The well cuttings were sampled for conodonts between 13 720 and 13 947 ft. (4182–4251 m).

Cuttings. Near the top of the succession is black, very glossy, indurated shale with slickensides. White, coarse crystalline dolomite is present in the form of thin chips up to 1 mm thick and 15 mm wide, giving an impression of spar infill from fractures. At deeper levels, the amount of dolomite spar increases, but the cuttings remain thin. Quartz is represented by rounded, frosted, clear to red quartz grains. A minor amount of rounded, orange coloured chert pebbles is present, dissimilar to the chert usually associated with Ronning carbonate. Vugs are rare and small, and are partly filled by dolomite spar. At 13 870 ft. (4228 m), the first thicker dolomite cuttings appear. The coarse crystalline dolomite is white, although it contains a few thin, dark grey bands; otherwise it is featureless. The crystals are up to 1 mm in size. The shale is probably caved and of minor importance; it appears stained with hydrocarbon and contains a small amount of free bitumen. Pyrite was not observed.

In general, the rocks consist of a white, coarse crystalline dolomite with a few thin, darker bands, and is otherwise featureless and devoid of any age indications; the conodont samples were barren.

Well with regular succession

The only well in this section is Kiligvak I-29.

Kiligvak I-29

Comments. The top of the pre-Mesozoic is picked at 650 ft. (198 m) (Imperial Formation), the top of the carbonate (Hume Formation) is at 4355 ft. (1327 m), TD is at 6447 ft. (1965 m). No dipmeter log was run across the unconformity interval. The well is located to the southeast side of the Tuk Horst and contains carbonate and clastic rocks. The regular succession in this well allows the picking of formation tops. The core is too small to sample for conodont analysis. No cuttings are available from the succession below 5920 ft. (1804 m).

Cuttings. The cuttings are generally very small and therefore present a problem for recognizing fossil material. The Hume Formation (top at 4355 ft./1327 m) is black to dark grey limestone with possible crinoid ossicles. The underlying Landry Formation (top at 4532 ft./1381 m) varies in colour. Near the top, it is dark brown to dark grey limestone, changing into grey or even white near the bottom of the formation. It contains crinoid ossicles, brachiopods, ostracodes, and pelletal material. Arnica Formation dolomite beds (top tentatively at 5070 ft./1545 m) are fine to microcrystalline, brown to buff, and underlie the limestone. This is not the massive dolomite in this formation found on the Northern Interior Plains, but typical limy dolomite and mainly dolomitic argillaceous limestone. In general, the carbonate is very fine grained. Accessory minerals are pyrite, and both euhedral and well rounded, clear quartz crystals. A colour change to lighter brown and buff can be observed at about 5600 ft.(1707 m). At 6122 ft. (1866 m), the sonic log shows decreased velocities as a result of an increase in shale content, and the limestone is less dolomitic. The top of the Tatsieta Formation is tentatively picked here.

In the interval for which no cuttings are available, the top of the Mount Kindle Formation is tentatively picked at 6391 ft. (1948 m), taking into account the sonic log response and the presence of chert at this depth in samples from the junkbasket on the drill pipe.

The cuttings contain a minor amount of indurated sandstone; this is probably caved from the Imperial Formation, because it does not contain any carbonate and is composed of bluish chert. Some shaly partings display slickensides similar to those on stylolites, and were probably derived from them.

Core. 5911–5926 ft. (1802–1806 m). The core consists of light grey limestone. Lower in the core, the colour changes from light grey to dark buff. Near the top, some marl and a large (over 7 cm), oscillatory zoned crystal of calcite are present. Locally, the limestone has been brecciated and healed. Vertical fractures were filled by clear calcite. The rock contains many stylolites filled with argillaceous material, and fossils like crinoid ossicles, *Thamnopora*, and ostracodes. Part of the microcrystalline limestone is pelletal and shows some bioturbation; the remainder is featureless mud.

This core was drilled from the lower part of the Arnica Formation, although the presence of limestone indicates it may belong to the upper part of the Tatsieta Formation.

Parsons Lake area

A tight cluster of wells has been drilled in the area near Parsons Lake. The wells contain pre-Mesozoic rock types of closely related ages. Rather than being treated separately throughout Appendix A, and so losing track of the similarities and relationships, they are grouped together here. The wells in this section are Atigi (E Reindeer) G-04, Kamik D-48, Parsons A-44, Parsons D-20, Parsons F-09, Parsons L-37, Parsons L-43, Parsons N-10, Parsons O-27, Parsons P-41, Parsons P-53, Siku A-12, Siku C-11, and Siku E-21.

Atigi (East Reindeer) G-04

Comments. The top of the pre-Mesozoic is picked at 11 785 ft. (3592 m), TD is at 12 250 ft. (3734 m). Dipmeter data indicate a 20°W dip for the Cretaceous, and 40°E for the Paleozoic, with wide scatter in both values; the questionable, reconstructed pre-Mesozoic dip is about 60°E. The cuttings were sampled for conodont analysis between 11 800 and 12 250 ft. (3597–3734 m).

Cuttings. The rocks consist of mottled, light grey to white, but mainly buff, medium crystalline dolomite, containing small amounts of pyrite and clear quartz crystals. Part of the dolomite is fine crystalline and black, with white, fracture-filling spar. The dolomite locally contains brown chert and both rock types may have ghosts of pellets. The more marly beds are limy. The colour and crystal size of this carbonate is quite different from the other dolomite in this area. A small amount of dolomitic, light grey siltstone is present.

Because the samples analyzed for conodonts were barren (T.T. Uyeno, pers. comm., 1988; Appendix B), no estimate can be given of the age of the sequence in this well.

Kamik D-48

Comments. The top of the pre-Mesozoic is picked at 10 540 ft. (3213 m), TD is at 10 614 ft. (3235 m). No dipmeter or logs were run for this interval. No samples were collected for conodont analysis, because the succession is too thin to yield sufficient sample material.

Cuttings. The rocks consist of light grey to grey, fine to medium crystalline, silty dolomite, which is laminated and contains minor amounts of pyrite and brown or white chert. White dolomite spar fills vugs and fractures. There are a few thin laminae of dolomitic, dark grey, salt and pepper siltstone.

The lithological combination of chert and dolomite indicates an age equivalent to the Ronning Group or Road River Formation, based on the lithotypes in surrounding wells.

Parsons A-44

Comments. The top of the pre-Mesozoic is picked at 11 320 ft. (3450 m), TD is at 11 600 ft. (3536 m). Dipmeter data at the contact indicate a dip for the Cretaceous of 4°ESE and for the Paleozoic of 16°ESE; the reconstructed pre-Mesozoic dip is 12°ESE. Samples were taken for conodont analysis from 11 330 to 11 440 ft. (3453–3487 m).

Cuttings. The samples contain abundant caved, black, micaceous shale. Paleozoic shale generally does not contain identifiable mica and is called ''micro-micaceous''. The pre-Mesozoic rocks consist of mainly dark grey limestone, with minor shale and limy dolomite. The carbonate rocks are fine crystalline, and the limestone is finely laminated with black and grey layers. There is a minor amount of grey chert and pyrite. Calcite is fracture filling and has a white colour. With the exception of one possible crinoid ossicle, no fossils were observed in the carbonate section.

The rocks are similar to those of the Landry Formation in Kiligvak I-29; they may be Early Ordovician in age, similar to those in Parsons F-09. The conodont samples were barren.

Parsons D-20

Comments. The top of the pre-Mesozoic is picked at 13 465 ft. (4104 m), TD is at 13 550 ft. (4130 m). Dipmeter data at the contact indicate a dip of 24°NE for the Cretaceous and 18° (?)ESE for the Paleozoic; the reconstructed pre-Mesozoic dip is 24°S. Because of the abundant caved shale and the short interval, this well was not sampled.

Cuttings. The pre-Mesozoic consists of light buff to white, fine crystalline, featureless dolomite. Pyrite and a few euhedral, clear quartz crystals are present. There is no chert. Dolomite spar is derived from vug fillings or fractures.

On the basis of the age of the pre-Mesozoic formations in surrounding wells, a Paleozoic age is suggested.

Parsons F-09

Comments. The top of the pre-Mesozoic is picked at 10 870 ft. (3313 m), TD is at 11 638 ft. (3547 m). The dipmeter log was not run over the unconformity interval. Samples for conodont analysis were collected between 11 000 and 11 240 ft. (3312-3426 m) in dolomite and 11 240 and 11 650 ft. (3426-3551 m) in limestone.

Cuttings. The pre-Mesozoic section comprises, from top to bottom, 45 m of chert, 60 m of cherty dolomite, and 135 m of limestone, including a 15 m thick shale layer. The chert is laminated, white, tan or dark grey, and contains minor amounts of pyrite and euhedral, clear quartz grains, which line fractures and vugs. The dolomite is light to dark grey, fine crystalline, and contains chert and pyrite. Vugs are filled by dolomite spar. The lowermost dolomite has been brecciated and leached, while the spar there is calcitic. The dolomitic limestone intervals are located between 11 230 and 11 430 ft. (3423-3484 m) and 11 480 ft. (3499 m) and TD. It is dark grey, microcrystalline at the top, and fine crystalline near TD. Most of it is featureless except for a possible brachiopod shell imprint (A.W. Norris, pers. comm., 1987) at 11 260 ft. (3432 m), a possible crinoid ossicle, and a small amount of pellets deeper down. The limestone above the shale unit has the appearance of a mudstone. In the underlying limestone unit, calcite fills fractures, and pyrite and ghosts of fossils can be observed. No quartz crystals have been found in the limestone. The shale is dark grey, contains pyrite, and is non-micaceous. It has a greasy appearance.

The complete succession appears somewhat like that in the Kiligvak I-29 well Landry Formation section. The conodonts, however, indicate an Early Ordovician (early to middle Canadian) age (G.S. Nowlan and T.T. Uyeno, pers. comm., 1988; Appendix B).

Parsons L-37

Comments. The unconformity is picked at 12 940 ft. (3944 m), TD is at 13 010 ft. (3965 m). A dipmeter log was not run across the unconformity interval. Sample quality is very poor, owing to the very fine size of the cuttings.

Cuttings. The rocks in the short interval contain brown, bluish, and white chert, interbedded with a minor amount of light brown, fine crystalline dolomite and white calcite spar.

Parsons L-43

Comments. The unconformity is picked at 10 770 ft. (3283 m), TD is at 10 844 ft. (3305 m). Dipmeter data indicate a dip of 4°NE for the Cretaceous and 29°NW for the Paleozoic, indicating a reconstructed pre-Mesozoic dip of 29°NW.

Cuttings. The rocks consist of light brown to bluish chert, with minor light brown, fine crystalline dolomite and grey shale. The samples are heavily contaminated by cavings, and provide little information.

Parsons N-10

Comments. The unconformity is picked at 10 095 ft. (3077 m), TD is at 10 515 ft. (3205 m). Dipmeter data indicate a dip of (?)2°S for the Cretaceous and (?)40°ESE for the Paleozoic; the reconstructed pre-Mesozoic dip is (?)39°ESE. The cuttings were sampled for conodonts from 10 120 to 10 515 ft. (3085-3205 m).

Cuttings. The pre-Mesozoic rocks are composed of equal amounts of chert and dolomite. The chert is brown, tan, bluish, or black, can have a pelletal structure, and can be found in layers or laminae intercalated in the dolomite. The dolomite is dark grey to locally light grey, fine crystalline; coarse, white dolomite spar cement fills fractures and vugs. The dolomite can be laminated and contains small amounts of pyrite. It has a pelletal structure, as indicated by a few white spar pellets; otherwise it is featureless. The rock changes to medium crystalline below 10 200 ft. (3109 m) and is darker in colour, like the chert. Only a few milky quartz grains are present. The few interbeds of siltstone have a grey colour, due to their salt and pepper nature. No fossils and only a few quartz crystals have been found.

This type of dolomite with abundant chert is reminiscent of the Franklin Mountain Formation; another equivalent is the Road River Formation, although black shale is absent in this well. The conodonts indicate an Early Ordovician (early to middle Canadian) age (G.S. Nowlan and T.T. Uyeno, pers. comm., 1988; Appendix B).

Parsons O-27

Comments. The top of the unconformity is picked at 11 705 ft. (3568 m), TD is at 11 714 ft. (3570 m). No dipmeter or logs were run over this interval. Gulf Canada Resources picked the top of the Paleozoic based on "the appearance of grey, grading into white, quartzitic chert".

D. Myhr did not find evidence of Paleozoic rocks, according to his notes in the well history report. No wireline logs were run over this thin interval.

Cuttings. A few grey to brown and white chert cuttings were present in the sample from the lowermost interval (11 710 ft., 3569 m). Based on the presence of thick chert beds in surrounding wells, this lithotype suggests a Road River Formation or Ronning Group equivalent age.

Parsons P-41

Comments. The unconformity is picked at 11 622 ft. (3542 m), TD is at 11 665 ft. (3555 m). Dipmeter data indicate a dip of 27°E for the Cretaceous and (?)29°E for the Paleozoic; the reconstructed pre-Mesozoic dip is a questionable 2°E. The sample quality is poor, owing to the minute size of the cuttings.

Cuttings. Very little evidence was found of the rock types indicated on the Can-Strat lithologs. A few brown chert grains, which may be shattered chert pebbles from a Cretaceous conglomerate, and some limy material in very small grains or as cement were all that could be found. The lithology is therefore very questionable; the well operator describes grey-brown, cryptocrystalline chert and limestone in the well history reports. The wireline logs for the interval are very close to First Reading, and therefore are of no use.

Parsons P-53

Comments. The unconformity is picked at 10 450 ft. (3185 m), TD is at 11 270 ft. (3435 m). Dipmeter data indicate a dip of 8°NE for the Cretaceous and 20°ESE for the Paleozoic; the reconstructed pre-Mesozoic dip is 19°SE. The cuttings were sampled for conodonts from 10 450 to 10 820 ft. (3185–3298 m).

Cuttings. The sequence consists of an upper, 25 m thick dolomite, overlying a thick succession of chert with a few siltstone and shale beds. Some of the dolomite is buff coloured, but most of it is dark grey, and the bulk of the chert is brown to light brown, although locally white.

Chert is the main rock type in this succession. It is present in thin bands or nodules and may display a pelletal character. Below 10 700 ft. (3260 m), the rocks are principally chert.

The dolomite contains some coarse spar cement, although not as much as in other wells. Locally, the dolomite is laminated and silty and may contain pyrite. The rare vugs are coated with clear dolomite crystals. Clear, rounded quartz crystals are accessories. Below 10 800 ft. (3290 m), the colours become darker.

The salt and pepper siltstone is brown or grey and is intercalated in the dolomite as thin layers.

The interbedded dolomite, black shale, and the amount of chert point to an equivalence with the Road River Formation. The sequence contains "probable Middle to Upper Ordovician conodonts" (G.S. Nowlan and T.T. Uyeno, pers. comm., 1988; Appendix B).

Core. 11 260–11 270 ft. (3432–3435 m). The main rock in the core, cut near TD, is grey, laminated, bioturbated, and fractured shale. It locally contains eye-shaped nodules of angular anhydrite and pyrite. The shale is faintly laminated, and displays severe soft-sediment deformation, caused by loading. Lower in the core, laminae up to 2 cm in thickness appear, composed of dolomite or lime mudstone. These laminae are usually broken; a few are rounded at the ends and are folded. Locally, faulting has resulted in boudinage structures, which were recemented before induration of the total rock. The anhydrite was fractured and recemented, and contains geopetal silt and shale in sheltered spots. At one location, an anhydrite nodule is wedged between two of the laminated bands and has indented the limestone. These features indicate that tectonic activity occurred during the formation of the carbonate sediments.

Siku A-12

Comments. The top of the pre-Mesozoic is picked at 10 615 ft. (3235 m), TD is at 10 787 ft. (3288 m). Dipmeter data at the contact indicate a dip of 8°WNW for the Cretaceous and 20°ENE for the Paleozoic; the reconstructed pre-Mesozoic dip is 26°E. Because of the large amount of caved shale, this well was not sampled for conodont analysis.

Cuttings. Cuttings of black shale and orange siltstone are abundant. The large amount of black shale is not reflected on the gamma-ray logs, and is presumably caved, as is the orange siltstone. The pre-Mesozoic rocks are dolomite and chert. The dolomite is light grey to white, fine to microcrystalline; the chert white to bluish. A veinlet of lead-silver-zinc sulphides is present in one interval. The few coarser spar dolomite cuttings are probably from fracture cement. Lithostratigraphic equivalents of such a dolomite with chert are found in the Ronning Group and Road River Formation.

Siku C-11

Comments. The contact is picked at 10 550 ft. (3216 m), TD is at 10 810 ft. (3295 m). Dipmeter data at the pre-Mesozoic unconformity indicate a dip of 10°W for the Cretaceous and 9°NW for the Paleozoic; the reconstructed pre-Mesozoic dip is 8°NNE. No samples were available.

Below 10 350 ft. (3155 m) the lithology is described on the mudlog and Can-Strat litholog as follows. The main rock type is light grey chert, increasing to 100 per cent below 10 700 ft. (3261 m). Above, dark grey to black, bituminous (?Cretaceous) and waxy green shale is present. Dolomite and pyrite are accessories.

Siku E-21

Comments. The top of the pre-Mesozoic is picked at 11 135 ft. (3394 m), TD is at 11 245 ft. (3427 m). Dipmeter data at the contact indicate a dip of 25°WNW for the Cretaceous and 26°WNW for the Paleozoic; the reconstructed pre-Mesozoic dip is 1°WNW. Samples for conodonts were collected from 11 160 to 11 245 ft. (3402–3427 m); the samples were barren (T.T. Uyeno, pers. comm., 1988; Appendix B).

Cuttings. The main rock type is dolomite with minor chert and shale. The dolomite is fine crystalline and dark grey, but may range to light grey or brown-grey in colour. Locally, the dolomite is marly. The chert is brown, the shale black. Pyrite and euhedral, clear quartz crystals are accessories.

The interbedding of black shale, dolomite and chert indicates a Road River Formation age and equivalent depositional environment.

Campbell Uplift area

The well in this section is Inuvik D-54.

Inuvik D-54

Comments. The pre-Mesozoic unconformity is picked at 1050 ft. (320 m), TD is at 5126 ft. (1562 m). No diplog was run over the unconformity interval. Previous attempts to recover conodonts from the core were unsuccessful. Samples collected for acritarch analysis were barren.

Cuttings. In general, the complete succession in this well consists of a descending sequence of clastic, carbonate, and then more clastic rocks. The strata will be treated by interval in some detail because of the position of this well on the edge of the Campbell Uplift.

Upper clastic rocks. 1050–1100 ft. (320–335 m). Pink and apple-green, waxy shale plus some brick red shale are interbedded and contain accessory glauconite, which indicates a marine origin, and pyrite. A few rounded, frosted quartz grains and white and bluish chert pebbles are present. Cone-shaped fossils were found by G.K. Williams in this interval. The fossils are not age-diagnostic, but indicate that the interval is Paleozoic or younger.

1100–1135 ft. (335–346 m). Pink, silt-size quartzite composed of clear quartz grains, cemented by milky pink quartz.

1135–1150 ft. (346–351 m). Red and green shale as above, but the green shale dominates.

1150–1160 ft. (351–354 m). A pink, fine crystalline dolomite layer.

1160–1180 ft. (354–360 m). Siltstone and sandstone, salt and pepper; their clear quartz grains have a black intergranular cement.

1180–1200 ft. (360–366 m). Green shale with only a small quantity of pink and red shale.

1200–1220 ft. (366–372 m). Pink to white sandstone, quartzitic.

1220–1245 ft. (372–379 m). Interbedded quartzite, dolomite, and red and green shale similar to those described above.

1245–1290 ft. (379–393 m). White quartzite containing pinkish chert.

Dolomite. 1290–1500 ft. (393–457 m). Brown-grey, microcrystalline to fine crystalline dolomite with a large amount of white chert is interbedded with white, or salt and pepper grey, quartzitic sandstone, and green-grey shale. The sandstone is composed of rounded or angular, clear quartz grains with black cement. Clear quartz grains are suspended in the dolomite.

1500–1860 ft. (457–567 m). Tan to pinkish dolomite, with local interbeds of sandstone, as in the previous interval, containing large amounts of white to buff chert. The dolomite is microcrystalline to fine crystalline. Suspended quartz crystals and pyrite are accessories. The dolomite and part of the white chert are pelletal.

1860–2300 ft. (567–701 m). Dark grey or brown-grey, fine crystalline dolomite, marly in some beds. The dolomite contains brownish blue chert. The chert content decreases with depth, and the dolomite becomes white to pink in colour. There are some black shale interbeds. The dolomite below 2050 ft. (625 m) is medium crystalline and contains dolomite spar cement in fractures and vugs, as well as a few euhedral quartz crystals. The dolomite appears salt and pepper, due to highly reflecting crystal faces, but is actually very dark grey.

2300–3780 ft. (701–1152 m). The dolomite colour turns to lighter tan or grey with some pink. The crystal faces, as in the overlying interval, are less abundant, i.e., the rock becomes more finely crystalline. Coarse, milky and clear dolomite spar can be found in vugs. Pink to orange veins run through some of the spar. There is very little chert. Part of the dolomite is finely laminated with alternating tan and white bands, which could indicate an algal origin. At 2930 ft. (893 m), the black dolomite is generally fine, although locally medium crystalline. Milky, coarse spar fills fractures. A few thin black shale beds are intercalated at about 3100 ft. (945 m). Between this depth and 3160 ft. (963 m) the dolomite colour is tan; the underlying rock is black until 3470 ft. (1058 m), below which the tan colour dominates again. The amount of spar cement increases with depth. Lower down, the dolomite colour alternates between tan and black. Suspended, euhedral quartz crystals are common. The lowermost dolomite is grey, with a salt and pepper appearance.

Lower clastic rocks. 3780–3800 ft. (1152–1158 m). Below 3750 ft. (1143 m), clastic rocks dominate. White quartzite, similar to that described in the upper clastic succession, is composed of fine, nearly silty, rounded and angular, clear quartz grains. The cement is dolomitic.

3800–3975 ft. (1158–1212 m). Quartzitic sandstone is interbedded with black to dark grey shale, and contains pyrite as an accessory.

3975–4100 ft. (1212–1250 m). Quartzitic, fine, white sandstone, composed of clear quartzose grains; the cement no longer contains dolomite.

4100–4110 ft. (1250–1253 m). Sandstone and volcanic rocks are present. The volcanic rocks, comparable to those in Eskimo J-07, are dark green and maroon and contain pyrite. These volcanic rocks do not appear weathered, and were deposited directly on the sandstone in this interval. Grains of the sand are embedded in the volcanic material. Volcanic material, however, is only a minor constituent in the sandstone.

4110–4500 ft. (1293–1372 m). Indurated, black shale, with a few interbeds of dolomite and sandstone. A few shale beds are olive-green and contain circular concretions of a glassy, crystalline material, and impressions of this same material. Each appears to be one single crystal. On cursory inspection these impressions appear to have the shapes of small ostracodes, as described by C.J. Yorath on the GSC litholog.

4500–4650 ft. (1372–1417 m). Quartzite, white and composed of rounded and angular grains, cemented by dolomite.

4650–4820 ft. (1417–1469 m). Interbedded brick-red and light olive-green, micro-micaceous, waxy shale; the lithotypes grade into each other over intervals of about 1 mm.

4820–5126 ft. (1469–1562 m). White quartzite with milky quartz cement, composed of mainly euhedral (with a few subrounded) crystals of sand size, constitutes the lowermost part of the succession.

Core. 2334–2360 ft. (711–719 m). The core contains strongly mottled, dark grey, brecciated (Fig. 24)

Figure 24. Core photograph from Inuvik D-54. 2337 ft. extensively fractured and recemented dolomite (ISPG photo. 2740-51).

dolomite. The mottling shapes resemble geodes. Locally, the mottling has very sharp boundaries and could be a result of fossil replacement. Leaching created some vugs inside the first set of fractures which were later partly covered by coarse, clear dolomite spar (Fig. 24). Many of the spar-filled vugs have a reddish colour, due to a rust coating over the spar. A later generation of darker, dirty dolomite spar was deposited in vugs lower down in the core. There, the main dolomite is finely laminated, tan to grey mudstone, with intermittent bird's-eye texture.

The red and green colours of the shale indicate a Cambrian or Precambrian age for the sequence. The amount of clastic material above and in the dolomite section is anomalous for the Mount Kindle and Franklin Mountain formations. On the other hand, the possible ghosts of fossils, as described in the core section, point to a Paleozoic age. The ostracodes described by Yorath are unlikely to be anything other than crystalline concretions.

Short description of carbonate rocks in Wolverine H-34

Hume Formation

Dark grey-brown limestone, fossil-rich and microcrystalline.

Landry Formation

Brown, pelletal, fossiliferous limestone, microcrystalline, and fairly light coloured.

Arnica Formation

Brown, very fine crystalline, vuggy, sucrosic dolomite; tan to light brown in the sample vial.

Tatsieta Formation

Tan, microcrystalline, pelletal limestone with marly interbeds, of smooth appearance, and with clear calcite crystals.

Peel Formation

Brown-grey, fine crystalline, limy dolomite, more grey than the formations above. Contains green shale partings and appears fine sucrosic.

Mount Kindle Formation

Medium crystalline, brown to light brown, mottled dolomite, containing white chert in small quantities. There is also coarse crystalline, lighter tan dolomite.

Franklin Mountain Formation

The rocks vary from fine to medium crystalline deeper in the succession, to mainly coarse crystalline, light tan to nearly white dolomite containing large amounts of white chert. The top was picked by Williams at the Sandy Marker, which may be represented by only a few quartz grains. This pick corresponds well with the author's pick, based on gamma-sonic wireline log characteristics (transition from quiet to noisy). Pugh (1983) used a different pick, based on the colour change and coarseness observed below the Mt. Kindle Formation in this well.

APPENDIX B

PALEONTOLOGICAL ANALYSIS

The paleontological results in this appendix have been extracted from the following Geological Survey of Canada internal reports: Report C-3-WHF-1987; Report F1-6-1987-DCM; Report F1-3-1988-DCM; Report 003-GSN-1988; Report 1-TTU-74; Report 18-TTU-86; Report 18-TTU-88; Report 3-JU-87; and Report 3-JU-88.

FROM REPORT C-3-WHF-1987, BY W.H. FRITZ, JUNE 12, 1987

Depth (GSC loc.)	Fossil identification	Age	Comments
IOE Magak A-32 well, 69°39'09" N, 132°07'52" W, NTS 107 C. Fossils collected by H. Wielens.			
5007-5007.3 ft. (C-104132a)	*Salterella*? sp.	L. Cambrian	Five thin sections and various cut surfaces exhibit small cones. Internal features not visible because of alteration. Core.
5004-5007 ft. (C-104132b)	*Salterella*? sp.	L. Cambrian	Small cones, four of which exhibit central tubes. Picked residues.
5008-5011 ft. (C-104132c)	*Salterella*? sp.	L. Cambrian	One small cone. Picked residues.
5020-5022 ft. (C-104132d)	*Salterella*? sp.	L. Cambrian	Nineteen small cones, two of which exhibit pseudo-cone-in-cone structure. Picked residues.

Remarks. Although poorly preserved, the above samples strongly suggest the presence of *Salterella*. The projected maximum size of the largest fragment is estimated at 5 mm, well within the maximum size of 10 mm for the genus. The angle of expansion and lack of curvature are consistent with the genus. The central tubes visible among the specimens in C-104132b, and the inclined laminae in the outer wall visible on specimens in C-104132d are the two most important features used in making the identification. The fact that the above material was collected from different horizons, that it is poorly preserved, and that no inner laminar cone structure is visible in cross section (due to diagenesis?) requires that the identification be questioned.

Correlation. *Salterella* is considered a good index fossil for the medial part of the Lower Cambrian *Bonnia-Olenellus* Zone. In the N.W.T. and eastern Yukon, *Salterella* has been found near the base of the Illtyd Formation and in the upper one-third of the Sekwi Formation. *Salterella* has not been recorded from formations assigned, or questionably assigned, to the Lower Cambrian on the Mackenzie Platform, such as the Mount Clark, Mount Cap, and Old Fort Island Formations. However, the identification of *Wanneria* cf. *W. walcotti* (Wanner) and *Olenellus paraoculus* Fritz (Report C-2-WHF-1986) in Petro-Canada well PCI Canterra Bele O-35 indicates the medial part of the *Bonnia-Olenellus* Zone within the Lower Cambrian clastics covering the Mackenzie Platform. Elsewhere in North America, *Salterella* is known to occur in inner detrital belt and middle carbonate belt strata, and only in the Taconic Allochthon of New York has it been reported in outer detrital belt strata (Fritz and Yochelson, 1988).

FROM REPORT F1-6-1987-DCM, BY D.C. MCGREGOR, NOVEMBER 17, 1987

Depth (GSC loc.)	Fossil identification	Age	Comments
IOE Kanguk I-24 well, 69°53'40" N, 131°05'12" W, NTS 107 D/13. Samples submitted by H. Wielens.			
4595-4599 ft. (C-30209)	*Aneurospora goensis* Streel *A. greggsii* (McGregor) Streel ?*Archaeoperisaccus* sp. ?*Densosporites* sp. *Hystricosporites* sp.	Possibly late Givetian or early Frasnian	Spores are abundant in this sample, but they have been so strongly altered diagenetically that most of them are unidentifiable. The Thermal Alteration Index is about 4-, (dark brown to black). Fine details necessary for identification of most species have been obliterated.

Depth (GSC loc.)	Fossil identification	Age	Comments
5246-5248 ft. (C-30209)	?*Ancyrospora* sp. *Archaeoperisaccus timanicus*? Pashkevich *Chelinospora concinna*? Allen ?*Cymbosporites magnificus* (McGregor) McGregor & Camfield	Possibly late Givetian or early Frasnian	Same as for previous sample.
Imp CIGOL Amarok N-44 well, 69°53'59" N, 130°56'16" W, NTS 107 D/14			
7651-7652 ft. (C-38410)	?*Archaeoperisaccus* sp. ?*Chelinospora concinna* Allen *Cymbosporites magnificus*? (McGregor) McGregor & Camfield *Hystricosporites* sp.	Possbly late Givetian or early Frasnian	Same as for first sample.

FROM REPORT F1-3-1988-DCM, BY D.C. MCGREGOR, APRIL 22, 1988

Palynology of core samples from the Imperial Formation in four wells (NTS 107 D/13, D/14 and E/3), submitted by H. Wielens. Thermal maturity and organic matter type of residues obtained from these samples were presented by J. Utting (1988).

Depth (GSC loc.)	Fossil identification	Age	Comments
Nuvorak O-09 well, 69°58'55" N, 130°30'56" W			
3437-3460 ft. (C-025246)			Rare spores of post-Silurian age were recovered. They are so poorly preserved that no more precise age determination is possible. No other kinds of palynomorphs were found.
3481-3494 ft. (C-025246)			The sample contains small organic fragments, most of which are smaller than 40 µm. No identifiable palynomorphs were found, and no age determination or other stratigraphic conclusions can be made.
IOE Kanguk I-24 well, 69°53'40" N, 131°05'12" W			
4569 ft. (C-030209)	Possible inner body of *Archaeoperisaccus*	Possibly latest Givetian or Frasnian	A few corroded and carbonized spores were recovered. Most of the intact spores are small (less than 40 µm in diameter), but there are indications that the assemblage contained larger specimens that have been fragmented.
Russell H-23 well, 70°02'18" N, 130°06'28" W			
5975-6010 ft. (C-038995)		Probably younger than Silurian	Spores are rare, and are the only palynomorphs found. No zonally significant taxa were identified.
Imp CIGOL Amarok N-44 well, 69°53'59" N, 130°56'16" W			
7634-7644 ft. (C-038410)			No palynomorphs.

FROM REPORT 003-GSN-1988, BY G.S. NOWLAN, FEBRUARY 29, 1988 (REVIEWED: MARCH 19, 1990)

Report on eleven cuttings samples in seven wells, submitted for microfossil analysis by H. Wielens; NTS 107 B/15, C/09, C/16, D/12, D/13.

Depth (GSC loc.)	Fossil identification	Age	Comments
Parsons F-09 well, 68°58'28" N, 133°31'45" W, NTS 107 B/15			
11 000-11 240 ft. (C-033937)	aff. *Paltodus bassleri* Furnish s.f. (7) *Rossodus manitouensis* Repetski & Ethington (2)	Early Ordovician (early to mid-Canadian)	Weight dissolved: 523 g (72% breakdown); 9 conodont elements (CAI 4).
Kimik D-29 well, 69°38'05" N, 132°22'10" W, NTS 107 C/09			
8602-8613 ft. (C-039362)	*Panderodus gibber* Nowlan & Barnes (1) *Panderodus* sp. (1) Oistodontiform element indet. (1) Denticulate fragments (2)		Weight dissolved: 556g (86% breakdown); 5 conodont elements (CAI 4.5).
8613-8624 ft. (C-039632)	Dichognathiform element indet. (1) Denticulate fragment (3)	Probably Middle to Late Ordovician	Weight dissolved: 672 g (93% breakdown); 4 fragmentary elements (CAI approx. 4.5). The fragmentary elements present are most similar to elements of the genus *Plectodina*. The age cannot be precisely identified.
Parsons N-10 well, 68°59'49" N, 133°31'50" W, NTS 107 B/15			
10 120-10 575 ft. (C-048834)	*Acontiodus staufferi* Furnish s.f. (1) aff. *Paltodus bassleri* Furnish s.f. (4) ?*Protopanderodus* sp. (3) *Utahconus* sp. (1) Drepanodontiform element indet. (2) Coniform element indet. (2)	Early Ordovician (probably early to mid-Canadian)	Weight dissolved: 1317 g (73% breakdown); 13 conodont elements (CAI 4).
Louth K-45 well, 69°59'32" N, 131°26'47" W, NTS 107 D/13			
6970-7270 ft. (C-051228)	Coniform element indet. (2)	Ordovician to Triassic	Weight dissolved: 580 g (78% breakdown); 2 conodont elements (CAI 4).
Natagnak K-23 well, 69°42'31" N, 131°36'44" W, NTS 107 D/12			
4954-4965 ft. (C-055446)	Coniform element indet. (4)		Weight dissolved: 265 g (50% breakdown); 4 conodont elements (CAI 4).
4965-4977 ft. (C-055446)	*Multioistodus compressus* Harris & Harris (1) *M. auritus* (Harris & Harris) (2) Drepanodontiform element indet. (1)	Early Middle Ordovician (Whiterockian)	Weight dissolved: 238 g (51% breakdown); 4 moderately well preserved conodont elements (CAI 4).

Depth (GSC loc.)	Fossil identification	Age	Comments
Parsons P-53 well, 68°52'49" N, 133°42'57" W, NTS 107 B/15			
10 450-10 820 ft. (C-126049)	Drepanodontiform element indet. (2) Scandodontiform element indet. (1) Coniform element indet. (2)	Possibly Middle to Late Ordovician	Weight dissolved: 835 g (43% breakdown); 5 conodont elements (CAI 4).
Atkinson L-17 well, 69°46'34" N, 132°04'32" W, NTS 107 C/16			
2337-2340.6 m (C-161100)	*Multioistodus subdentatus* Cullison (2) Coniform element indet. (2)	Undoubted early Middle Ordovician (Whiterockian)	Weight dissolved: 363 g (49% breakdown); 4 conodont elements (CAI 5?).
2340.6-2344.4 m (C-161100)	*Multioistodus* sp. (1)	Early Middle Ordovician (Whiterockian)	Weight dissolved: 305 g (47% breakdown); 1 conodont element (CAI indeterminate).
2344.4-2350.2 m (C-161100)	*Multioistodus* sp. (1) Acodontiform element indet. (1) Oistodontiform element indet. (1)	Early Middle Ordovician (Whiterockian)	Weight dissolved: 318 g (50% breakdown); 3 conodont elements (CAI 5?).

FROM REPORT 1-TTU-74, BY T.T. UYENO, MARCH 11, 1974

Depth (GSC loc.)	Fossil identification	Age	Comments
Orksut I-44 well, Banks Island			
9010-9110 ft. (C-29857)	*Pandorinellina exigua exigua* (Philip) transitional to *P. expansa* Uyeno & Mason	Late Early Devonian (Emsian) to early Middle Devonian (early Eifelian); *dehiscens* to *costatus* zones	

FROM REPORT 18-TTU-86, BY T.T. UYENO, JULY 21, 1986

Depth (GSC loc.)	Fossil identification	Age	Comments
Gulf Sholokpaqak (E. Reindeer) P-60 well, 66°39'N, 133°49' W, NTS 106 K			
4579.5-4580 ft. (C-105240)	No conodonts recovered		Weights: initial = 904 g; final = 904 g (no breakdown)

Depth (GSC loc.)	Fossil identification	Age	Comments
Gulf Onigat (E. Reindeer) C-38 well, 68°47' N, 133°38' W, NTS 107 B			
6349-6352 ft. (C-105241)	No conodonts recovered		Weights: initial = 790 g; final = 128 g.

FROM REPORT 18-TTU-88, BY T.T. UYENO, FEBRUARY 10, 1988

50 conodont samples from 24 wells, submitted by H. Wielens.

Depth (GSC loc.)	Fossil identification	Age	Comments
Akku F-14 well, F-14-69-30-132-15, 69°23'15" N, 132°19'08" W, NTS 107 C			
4500-4600 ft. (C-67698)	Indet. smooth cone (fragmented)	Indeterminate	Weights: initial = 641 g; final = 153 g; core.
4600-4700 ft. (C-67698)	None recovered	Indeterminate	Weights: initial = 537 g; final = 123 g; core.
4700-4800 ft. (C-67698)	None recovered	Indeterminate	Weights: initial = 613 g; final = 200 g; core.
Atigi (East Reindeer) G-04 well, G-04-69-00-133-45, 68°53'16" N, 133°46'03" W, NTS 107 B			
11 800-12 100 ft. (C-30223)	None recovered	Indeterminate	Weights: initial = 505 g; final = 62 g; cuttings.
12 100-12 250 ft. (C-30223)	None recovered	Indeterminate	Weights: initial = 394 g; final = 50 g; cuttings.
Atkinson A-55 well, A-55-69-50-131-45, 69°44'09" N, 131°57'54" W, NTS 107 D			
7305-7325 ft. (C-130846)	None recovered	Indeterminate	Weights: initial = 647 g; final = 111 g; core. Tiny fragmented brachiopod shells recovered; a possible early Paleozoic, pre-Devonian age tentatively suggested by Dr. A.W. Norris.
6770-6990 ft. (C-130846)	None recovered	Indeterminate	Weights: initial = 537 g; final = 123 g; unwashed cuttings.
6990-7300 ft. (C-130846)	None recovered	Indeterminate	Weights: initial = 690 g; final = 129 g; unwashed cuttings.
Atkinson L-17 well, L-17-69-50-132-00, 69°46'34" N, 132°04'32" W, NTS 107 C			
2337.0-2340.6 m (C-161100)	See 003-GSN-1988 (above)	Probably Middle Ordovician, Chazyan	Weights: initial = 739 g; final = 376 g; core.

Depth (GSC loc.)	Fossil identification	Age	Comments
2340.6-2344.4 m (C-161100)	See 003-GSN-1988	Probably Middle Ordovician, Chazyan	Weights: initial = 645 g; final = 340 g; core.
2344.4-2350.2 m (C-161100)	See 003-GSN-1988	Probably Middle Ordovician, Chazyan	Weights: initial = 639 g; final = 321 g; core.

Remarks. Similar conodonts have been reported from the Sunblood Formation in southern Mackenzie Mountains (Tipnis et al., 1978).

Eskimo J-07 well, J-07-69-20-132-30, 69°16'43" N, 132°30'59" W, NTS 107 C

2945-2954 ft. (C-30203)	None recovered	Indeterminate	Weights: initial = 572 g; final = 156 g; core.
2954-2963 ft. (C-30203)	None recovered	Indeterminate	Weights: initial = 631 g; final = 114 g; core.
2963-2971 ft. (C-30203)	None recovered	Indeterminate	Weights: initial = 752 g; final = 135 g; core.

Imnak J-29 well, J-29-69-10-133-00, 69°08'41" N, 133°06'05" W, NTS 107 C

10 860-11 170 ft. (C-53290)	None recovered	Indeterminate	Weights: initial = 1012 g; final = 195 g; cuttings.

Inuvik D-54 well, D-54-68-30-133-30, 68°23'13" N, 133°44' 25" W, NTS 107 B

1900-2150 ft. (C-34513)	None recovered	Indeterminate	Weights: initial = 796 g; final = 147 g; cuttings.
3100-3350 ft. (C-34513)	None recovered	Indeterminate	Weights: initial = 734 g; final = 56 g; cuttings.

Kilannak A-77 well, A-77-70-50-129-00, 70°46'15" N, 129°21'29" NTS 107 E

2100.0-2160.0 m (C-80092)	A single indet. fragment	Indeterminate	Weights: initial = 534 g; final = 2 g; cuttings.
2160.0-2230.0 m (C-80092)	*Panderodus* sp. Pb element, possibly of *Pandorinellina exigua* (Philip) or *P. expansa* Uyeno & Mason	Mid-Ordovician to Mid-Devonian; if Pb assignment correct, then Early to early Middle Devonian	Weights: initial = 533 g; final = 2 g; cuttings.
2235.0-2305.0 m (C-80092)	*Panderodus* sp. *Polygnathus inversus* Klapper & Johnson transitional to *P. serotinus* Telford	Late Emsian, *inversus* to *serotinus* zones	Weights: initial = 562 g; final = 1 g; cuttings.
2310.0-2360.0 m (C-80092)	*Belodella* sp. *Panderodus* sp.	Late Silurian to Middle Devonian	Weights: initial = 383 g; final = 2 g; cuttings.
2365.0-2460.0 m (C-80092)	*Belodella* sp. *Panderodus* sp.	Late Silurian to Middle Devonian	Weights: initial = 656 g; final = 2 g; cuttings.
2750.0-2850.0 m (C-80092)	None recovered	Indeterminate	Weights: initial = 638 g; final = 53 g; cuttings.

Depth (GSC loc.)	Fossil identification	Age	Comments
Kimik D-29 well, D-29-69-40-132-15, 69°38'05" N, 132°22'10" W, NTS 107 C			
8480-8720 ft. (C-39362)	None recovered	Indeterminate	Weights: initial = 690 g; final = 230 g; unwashed cuttings.
8602-8613 ft. (C-39362)	See 003-GSN-1988	Probably Middle Ordovician, Whiterockian(?)	Weights: initial = 645 g; final = 89 g; core.
8613-8624 ft. (C-39362)	See 003-GSN-1988	Probably Middle Ordovician	Weights: initial = 724 g; final = 52 g; core.
Louth K-45 well, K-45-70-00-131-15, 69°59'32" N, 131°26'47" W, NTS 107 D			
6970-7270 ft. (C-51228)	See 003-GSN-1988	Probably Middle Ordovician	Weights: initial = 746 g; final = 166 g; cuttings.
Mayogiak J-17 well, J-17-69-30-132-45, 69°20'43" N, 132°48'12" W, NTS 107 C			
9553-9610 ft. (C-25726)	*Panderodus* sp. *Polygnathus inversus* Klapper & Johnson Indet. simple cone	Late Emsian, *inversus* to *serotinus* zones	Weights: initial = 670 g; final = 31 g; core.
10 596-10 602 ft. (C-25726)	*Belodella* sp. *Panderodus* sp. *Polygnathus inversus* Klapper & Johnson *Steptotaxis* sp. [Coronellan (S_{2c}) element]	Late Emsian, *inversus* to *serotinus* zones	Weights: initial = 485 g; final = 87 g; core.
Mayogiak M-16 well, M-16-69-30-132-45, 69°25'55" N, 132°49'30" W, NTS 107 C			
2866-3005 ft. (C-126447)	None recovered	Indeterminate	Weights: initial = 590 g; final = 97 g; core.
3005-3093 ft. (C-126447)	*Polygnathus* cf. *P. parawebbi* Chatterton (a single fragmentary Pa element)	Probably Middle Devonian	Weights: initial = 494 g; final = 40 g; core.
Natagnak K-23 well, K-23-69-50-131-30, 69°42'31" N, 131°36'44" W, NTS 107 D			
4954-4965 ft. (C-55446)	See 003-GSN-1988	Probably Ordovician	Weights: initial = 534 g; final = 269 g; core.
4965-4977 ft. (C-55446)	See 003-GSN-1988	Probably Middle Ordovician, Whiterockian(?)	Weights: initial = 467 g; final = 229 g; core.
4900-4970 ft. (C-55446)	None recovered	Indeterminate	Weights: initial = 603 g; final = 191 g; unwashed cuttings.
Nuna A-10 well, A-10-69-10-133-15, 69°09'00" N, 133°15'04" W, NTS 107 C			
3243.0-3245.0 m (C-126448)	None recovered	Indeterminate	Weights: initial = 506 g; final = 39 g; core.

Depth (GSC loc.)	Fossil identification	Age	Comments
3245.0-3248.0 m (C-126448)	None recovered	Indeterminate	Weights: initial = 488 g; final = 33 g; core.
3248.0-3250.5 m (C-126448)	None recovered	Indeterminate	Weights: initial = 577 g; final = 130 g; core.
Parsons A-44 well, A-44-69-00-133-30, 68°53'05" N, 133°40'36" W, NTS 107 B			
11 330-11 440 ft. (C-140788)	None recovered	Indeterminate	Weights: initial = 548 g; final = 186 g; cuttings; see also Report 4-DHM-1986.
Parsons F-09-well, F-09-69-00-133-30, 68°58'28" N, 133°31'45" W, NTS 107 B			
11 000-11 240 ft. (C-33937)	See 003-GSN-1988	Early to Middle Ordovician	Weights: initial = 726 g; final = 203 g; cuttings.
11 240-11 450 ft. (C-33937)	None recovered	Indeterminate	Weights: initial = 555 g; final = 155 g; cuttings.
11 450-11 650 ft. (C-33937)	None recovered	Indeterminate	Weights: initial = 744 g; final = 320 g; cuttings; a single foraminiferal specimen, obviously a contaminant, Jurassic age suggested by Dr. J.H. Wall.
Parsons N-10 well, N-10-69-00-133-30, 68°59'49" N, 133°31'50" W, NTS 107 B			
10 120-10 575 ft. (C-48834)	See 003-GSN-1988	Early to Middle Ordovician	Weights: initial = 1796 g; final = 479 g; cuttings.
Parsons P-53 well, P-53-69-00-133-30, 68°52'49" N, 133°42'57" W, NTS 107 B			
10 450-10 820 ft. (C-126049)	See 003-GSN-1988	Probably Early to Middle Ordovician	Weights: initial = 1960 g; final = 1125 g; cuttings.
Pikiolik E-54 well, E-54-69-30-132-30, 69°23'15" N, 132°44'35" W, NTS 107 C			
9048-9078 ft. (C-30359)	*Panderodus* sp. indet. fragments of hindeodelliform(?) elements Indet. simple cone	Mid-Ordovician to Mid-Devonian	Weights: initial = 773 g; final = 44 g; core.
Pikiolik G-21 well, G-21-69-30-132-30, 69°20'23" N, 132°35'44" W, NTS 107 C			
1380.0-1428.0 m (C-126449)	None recovered	Indeterminate	Weights: initial = 552 g; final = 87 g; cuttings.
Pikiolik M-26 well, M-26-69-30-132-30, 69°25'55" N, 132°37'26" W, NTS 107 C			
5610-5920 ft. (C-23460)	None recovered	Indeterminate	Weights: initial = 791 g; final = 77 g; core; a single foraminiferal specimen, obviously a contaminant, Jurassic to Early Cretaceous age suggested by Dr. J.H. Wall.
5930-6470 ft. (C-23460)	None recovered	Indeterminate	Weights: initial = 1235 g; final = 107 g; core.

Depth (GSC loc.)	Fossil identification	Age	Comments
Siku E-21 well, E-21-69-10-133-30, 69°00'30" N, 133°36'54" W, NTS 107 C			
11 160-11 245 ft. (C-86836)	None recovered	Indeterminate	Weights: initial = 256 g; final = 0 g; cuttings.
Tuktu O-19 well, O-19-69-20-132-45, 69°18'55" N, 132°48'17" W, NTS 107 C			
7352-7371 ft. (C-30230)	Ozarkodiniform (Pb) element, possibly of *Pandorinellina exigua* (Philip) or *P. expansa* Uyeno & Mason Indet. simple cone	Probably Early to early Middle Devonian	Weights: initial = 671 g; final = 16 g; core.
Wagnark C-23 well, C-23-69-20-135-15, 69°12'01" N, 133°21'45" W, NTS 107 C			
13 720-13 950 ft. (C-126050)	None recovered	Indeterminate	Weights: initial = 936 g; final = 122 g; cuttings.

FROM REPORT 3-JU-87, BY J. UTTING, FEBRUARY 4, 1987

Palynological examination of three core samples (GSC loc. C-25315), submitted by H. Wielens

Depth (GSC loc.)	Fossil identification	Age	Comments
Gulf Sholokpaqak (E. Reindeer) P-60 well, NTS 107 B			
4566-4577 ft. (C-25315)	None recovered	Indeterminate	No definite organic matter was recovered. A few black fragments (up to 170 microns) were recovered after heavy liquid treatment. In order to determine if these were coal, additional large (100g) samples were processed; the fragments thus obtained showed no reaction to oxidizing agents, indicating that they are not coal and are probably inorganic.
4578-4593 ft. (C-25315)	None recovered	Indeterminate	
5197-5201 ft. (C-25315)	None recovered	Indeterminate	

FROM REPORT 3-JU-88, BY J. UTTING, MARCH 8, 1988

Thermal maturity and organic matter of core samples from the Imperial Formation, Tuktoyaktuk Peninsula (NTS 107), requested by H. Wielens. The thermal alteration index (TAI) was assessed according to the five point scale of Hunt (1979) and Utting (1987). In addition, approximate proportions of the organic matter constituents were assessed. See also Report F1-3-1988-DCM.

Depth (GSC loc.)	Organic matter	Spore colour/TAI
Imp CIGOL Amarok N-44 well, 69°53'59" N, 130°56'16" W		
7634-7644 m (C-38410)	Rare amorphous, coaly, woody and exinous fragments	No palynomorphs, but exinous fragments dark brown to black suggesting high TAI.

Depth (GSC loc.)	Organic matter	Spore colour/TAI
IOE Kanguk I-24 well, 69°54'40" N, 131°05'12" W		
4569 m (C-30209)	Dominated (approx. 75%) by coaly and woody medium sized (up to 75 μm) fragments, remainder are exinous fragments	Dark brown to brownish black, and black. TAI 3+ to 4-.
4594-4607 m (C-30209)	Dominated (approx. 75%) by medium to large (up to 100 μm) coaly and woody fragments, remainder are exinous fragments	Dark brown to brownish black, and black. TAI 3+ to 4-.
Nuvorak O-09 well, 69°58'55" N, 130°30'56" W		
3437-3460 m (C-25246)	Approx. 25% small to medium (up to 60 μm) coaly and 25% woody fragments, remainder consists of exinous fragments	Light brown. TAI 2+.
3481-3494 m (C-25246)	Approx. 25% small to medium (up to 60 μm) coaly and 25% woody fragments, remainder consists of exinous fragments	Light brown. TAI 2+.
Russell H-23 well, 70°02'18" N, 130°06'28" W		
5975-6010 m (C-38995)	Medium sized (up to 60 μm) coaly fragments (approx. 30%), woody fragments (approx. 30%), exinous fragments (approx. 40%)	Light brown. TAI 2+.