May 14, 1963

The attached letter is a copy of intra-company correspondence written by R. D. Johnson, Project Geologist, to Mr. W.F. Atkins, Project Manager. It summarizes existing geological knowledge and presents various exploration considerations based on extensive review of the literature and discussions with knowledgeable persons. It is not a formal report and should not be construed as such. Minor segments on pages 13, 15 and 17 have been deleted for internal reasons, but these do not affect the major aspects of the letter.

R D Johnson

R.D. Johnson, P.Geol.

534 - 8th Avenue S.W.
Calgary, Alberta

January 7, 1963

Mr. W. F. Atkins
Sogepet Limited
88 University Avenue
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Dear Sir:

The purpose of this letter is to present informally the major findings resulting from a partial review of the geological literature, together with some interpretations and speculations. Consideration is given to regional and sectional problems with the whole directed to eventually gleaning the economic significance of the presently scattered observations.

We have discussed most of this material over the past few weeks, and therefore you are well aware that much of the material presented herein is highly speculative and often completely unsubstantiated. This presentation is designed for internal use. I would request and I am sure you agree, that it should under no circumstances be publicly presented or published, either in whole or in part.

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In this letter the term "basin" is used in the sense of a tectonic unit which when moved out of stability acts in a negative fashion. The direction of movement is repetitively negative. The definition of a depositional cycle, as presented by Sloss (1950), is also used. Sloss defines a depositional cycle as having four stages:

1. transgressive overlap with relative homogeneous and stable tectonism
2. increasing definition of tectonic elements and their influence on sedimentation
3. culmination of differentiation of tectonic framework into positive and negative elements
4. general uplift with erosion of positive elements

There is evidence in the Hudson Bay of three depositional cycles. First, the Proterozoic rocks of the Belcher Island Group together with the small windows in the Winisk and Sutton river areas, the possible Proterozoic rocks of the Churchill area, and the Proterozoic rocks in the Rankin Inlet area, together represent evidence that Hudson Bay was a tectonic basin in Proterozoic time. Secondly, and most obvious, are the Paleozoic sediments which may represent one or more depositional cycles. From the evidence at hand, at least one depositional cycle involving the Ordovician-Silurian in Hudson Bay is assured. This cycle may have been preceded by a Cambrian cycle, or there may be Cambrian sediments related to the advance of the Ordovician-Silurian cycle. Again, it is quite possible that Devonian rocks are also involved either as part of the Ordovician-Silurian depositional cycle, or as a following cycle. Thirdly, is the psuedo cycle of glaciation. Glaciation can be considered a depositional cycle in the sense that there was loading, with the area responding in a negative fashion, and a return to isostatic equilibrium with removal of the ice.

Other depositional cycles may have occurred. The existence of Cretaceous rocks in the area south of James Bay suggests the possibility of a Cretaceous seaway extending through Hudson Bay. This suggestion is based on the arguments presented in this letter which indicate more negative conditions in Hudson Bay than James Bay. No published evidence of the possible presence of Cretaceous in Hudson Bay has been seen to date other than the following comment by Low (1903-04, Appendix IV, p.331) regarding the identification of fossil fish from Southampton Island:

> Obscure remains of some species of fish, too imperfectly preserved for identification. This shale appears to resemble the Niobrara-Benton shale of the Manitoban region. (now the Colorado Group of Cretaceous age)

It is not clear whether the shale was found in place or as float.

Major Gravity Features

There are four major gravity features which affect our consideration of the problem. These features are the Patricia "low", the Nelson River "high", the Kapuskasing-Fraserdale "high" and the Chukotat "high".

The Patricia "low" is a series of gravity lows forming a general arcuate northeast trend concave to the north, running from Red Lake in the southeast through Attawapiskat Lake and northeasterly toward Cape Henrietta Maria. Innes (1960) would relate the Proterozoic windows on the Sutton and Winisk rivers to this trend. This may be so or partially so, however, the very existence of Cape Henrietta Maria as a prominent physiographic feature may be of greater significance and fits the trend more accurately. In any case the Patricia Belt is mirrored by the regional distribution of the sedimentary cover as the Ordovician, Silurian and Devonian rocks obey this positive axis. The Patricia Belt is believed by Innes to be "a belt of prominent root structures of Precambrian mountain building" and as such presents a strong argument for considering James Bay separately from Hudson Bay in terms of their post Archean basinal nature.

The second major gravity feature is the Nelson River "high". This feature is a linear group of positive gravity anomalies extending northeastward from Swan Lake to Gillam. The trend, which is fifty to seventy miles wide, is tectonically negative, a fact which is again mirrored in the distribution of the Paleozoic rocks. The Nelson River feature is apparently of major tectonic significance since it "separates two major divisions of the Canadian Shield, of contrasting structural trends, the older Superior province to the south and the younger Churchill province to the north".

The eastward extension of the Nelson River feature is a matter of conjecture. There are reasons for projecting the feature to coincide with the area of basic rocks in the Chukotat River area of northern Labrador, the third gravity feature. There are other arguments for diminishing the trend or turning it southward in the Port Nelson area.

The Chukotat trend, (inferred as a marked gravity low because of the extensive area of basic rocks) as mentioned above may project straight across to the Nelson River trend. However, Dr. Stockwell (in conversation) theorizes that the trend turns southward as it enters Hudson Bay and continues in that direction as a curvilinear feature through the Belcher Islands, then eastward across the mouth of James Bay and on to the area of small Precambrian outliers near Winisk. At present, my own view would not permit the extension of the Chukotat trend from the Belchers to the Winisk area as a positive gravity feature. I would prefer to explain the Precambrian outliers at Winisk as by-products of the negative Patricia gravity belt.

The Kapuskasing-Fraserdale "high", the fourth feature (Innes, 1960), is a series of positive gravity anomalies extending along the Kapuskasing, Abitibi and Moose river systems for at least 400 miles, then merging into a series of broad "positives" under the Paleozoic cover of the James Bay area. Innes (1960) relates this feature to the geology of the sedimentary area as follows:

> In the James Bay lowlands the Paleozoic rocks form a large basin which deepens progressively to the east (Dyer 1931) and which may be structurally related to faulting in the Precambrian basement. The straight and parallel channels of the Mattagami and Moose river systems may be the surface expression of such faulting. In this area the Paleozoic strata are more disturbed than elsewhere in the basin as indicated by several anticlinal arches whose axes strike northeast (Martison 1953). Further evidence that this is a zone of crustal weakness is the presence of post-middle Devonian lamprophyre intrusives in the form of sills, dykes and small laccoliths at Coral Rapids and Sextant Rapids, both locations along the axis of the gravity high.

While the exact pattern is not presently resolved, we do observe several major positive gravity features approaching merger in the Hudson Bay area. Whether the marger is by angular intersection or largely circumferal, the result is the same—a structurally basinal area of the crust.

In discussion, Dr. Brisbin (Univ. of Manitoba) believes the Kapuskasing-Fraserdale feature to be rather sharply defined and of great length. While his work is not complete, he would extend the feature southward and westward through Lake Superior and into the centre of the Williston Basin. Brisbin's southward extension of the Nelson River feature also leads to the centre of the Williston, where the two positive gravity trends cross. Northward and eastward he would bring the Kapuskasing-Fraserdale trend through James Bay and into Hudson Bay. Similarly, he would project both the Nelson River feature and the Chukotat River trend into Hudson Bay, although possibly not on a straight line, to a common intersection in mid-bay with the Kapuskasing-Fraserdale trend. Therefore, considering only gravity data, and by using analogy with the Williston Basin, Brisbin assumes a basinal crustal condition in Hudson Bay.

The Northern Flank

While a northern rim for a Hudson Bay basin is almost a foregone conclusion, presumably because of the northern encircling tendency of the Precambrian areas as presented on the regional geological maps; defining the rim is far less obvious. The regional geology of Southampton Island suggests that the island is a south-tilting block. This is substantiated by Birds' (1953) observation of epeirogenic movements (see section on Southampton Island). The hydrographic maps of Foxe Channel support the suggestion of a northwest structural grain and also suggest that a positive axis might fall through the northern side of Southampton Island and Bell Penninsula. It appears possible that the Boothia Arch, rather than being simply a north projection of the Precambrian area, may in fact be a part of a very long curved feature concave to the north and extending southward and eastward from the Boothia Penninsula through the northern part of Southampton Island to Cape Wolstenholme and Cape Hope's Advance in Ungava.

Glaciation and Related Isostatic Movements

Innes (1960) accepts a thickness of 10,000 feet for the Laurentide ice sheet. Flint (1947) theorizes that, while this mass had several nucleii, as its size diminished two centres became dominant: one in Hudson Bay, the other the highlands of Quebec. Eventually, the Hudson Bay nucleus rotted and disappeared while the Quebec highlands' nucleus lingered. Flint believes that the sea gained entrance to the very much depressed Hudson Bay area through Hudson Strait; the sea waters first mingling with the frontal glacial lake system, Barlow-Ojibway-Agassiz, in the James Bay region.

The Hudson Bay has undoubtedly been a topographically low area since Archean time. Innes (1960) makes the following statement concerning complete readjustment to glacial loading:

> It is of some interest to calculate the remaining uplift in the region of Hudson Bay from the mean negative gravity field. . . . the gravity data suggest the crust has yet to rise about 800 feet before isostatic balance is restored. This result is in close agreement with the remaining crustal uplift (250 metres) estimated by Gutenburg (1941) on rather scanty data. Charts prepared by the Canadian Hydrographic Service show Hudson and James Bays to be shallow depressions with few depths exceeding 120 fathoms. Complete isostatic recovery in this area therefore would practically eliminate both these basins as important physiographic features.

It is argued in this letter that glacial loading caused the crust to react in a manner as if the loading was sedimentary. In a geological sense, glacial unloading may be considered as abrupt. The entire area is now attempting to regain isostatic equilibrium. The various tectonic units should adjust at varying speeds dependent upon their negative or positive gravity character. There has been very little or no chance for erosional or depositional modification of the gross physiographic features. These conditions suggest a most important possibility. In the Hudson Bay area glaciation has a direct relationship to crustal structure and composition. As the area has not as yet reached equilibrium, physiographic features may be interpreted as strongly representative of structural features with their attendant control on stratigraphy. Therefore, physiography should be tentatively regarded as a major aid to primary exploration in the Hudson Bay area.

Glacial Deposits

Literature on the various areas suggests that all present land areas around Hudson Bay were glaciated. Except in the Hudson Bay-James Bay lowlands, the glacial deposits are generally thin and often discontinuous. However, in the "lowlands" the glacial deposits are reportedly very thick, perhaps approaching 300 feet in some areas. Flint (1947) finds evidence in the southern James Bay area to suggest pre-Wisconsin interglacial marine invasion and sedimentation. This evidence suggests the possibility that the abnormally thick glacial deposits of the lowlands resulted from marine and/or fresh water sedimentation during interglacial periods in areas which reacted isostatically slowly to deglaciation.

Another possibility should be checked in the case of these abnormally thick deposits: that is, the possibility that they are not entirely Pleistocene in age. Both the Cretaceous and Devonian are in part represented by "clays" in the James Bay area and some earlier work confused Cretaceous with Pleistocene deposits. Perhaps the lower portion of these deposits are pre-Pleistocene in age. (It is intended to have a paleontological check run on some of the material from Kennco DDH#6) Nevertheless, the first impression is that the material is a till.

Summary of Gross Structural Features

The major feature might be called the Hudson Bay downwarp or basin. It includes the area from the south side of the Foxe Channel to the southern limits of Paleozoic-Cretaceous sediments south of James Bay (from the Boothia-Wolstenholme arch as suggested herein to the Superior gravity low of Innes, 1960,--not discussed herein). It is suggested that if analogy between this basin and others be sought, then comparison is best made with limited basins far back on the craton, such as the Williston, rather than with basins associated with more pronounced synclinal natures or flankward cratonic positions.

The basinal subdivisions are largely controlled by three lesser negative features: the Nelson River gravity high, the Kapuskasing-Fraserdale gravity high, the Chukotat River trend. The area of greatest negative tendency is suggested to coincide generally with the area of deepest water, assuming direct relation between basinal tendency and speed of response to glacial unloading. One major interbasinal positive feature exists: the Patricia gravity low, which is theorized to separate the James Bay area from Hudson Bay.

Additional tectonic features of magnitude, both positive and negative, undoubtedly exist. At present attention might well be focussed on such features as the mid-bay near-shoaling area at 58° 40' latitude, 85° 00' longitude; east and west of a north-south line along 80° 30' from the mouth of James Bay to Mansel Island; Mansel and Coats islands; and the deep straits between the northern islands and the mainlands.

Hudson Bay and James Bay Lowlands

This area has generally been considered as one unit. The Paleozoic geology has suggested an area of onlap on the Precambrian to the west, terminating south of James Bay in an east-west fault. That part of the area south of the Attawapiskat River has received considerable attention in the past, including the drilling of several test holes. The regional geology and stratigraphy is modestly well known and includes Lower Paleozoic and Cretaceous strata. The Paleozoic area north of the Attawapiskat River to the Nelson River has received very little attention in the past with only a few sections measured along an occasional river. The area of the Nelson and Churchill rivers has received considerable attention both historically and in fairly recent time, and the sections along these rivers have been measured in considerable detail. Several holes have been drilled by mining companies to explore the basement in areas where the Paleozoic cover is relatively thin.

Geographical Bulletin No. 15 (Department of Mines and Technical Surveys) presents a map outlining the prospective oil areas in the Hudson Bay region. This map excludes the area south of the Attawapiskat River. Geologically, this is incorrect since the sediments in that area have not been sufficiently explored to exclude them as potentially oil bearing. However, in this report and in future considerations, the area south of the Attawapiskat River will not be considered except as to regional significance. As previously mentioned, James Bay may be tectonically separated from the Hudson Bay; that is, James Bay and Hudson Bay may be parts of a major tectonic unit but most certainly are divisions within that unit. Since past exploration has been limited to the James Bay area, there has been a strong tendency to take this data and by inference use it in Hudson Bay proper. The controls in the two areas may be considerably different and therefore the analogy may have restricted our exploration thinking in the past.

Precambrian of the Lowlands

Our knowledge of the Precambrian underlying the Paleozoics in the Hudson Bay lowlands is very limited and consists of mapping in the area to the west plus observation from three localities in the Paleozoic area: on the Sutton and Winisk rivers, at the Selco Pennycutaway drill hole, and at Port Churchill.

The rocks of the Port Churchill Precambrian ridge are described by Charlewood and Davies (1957):

> Churchill Quartzite
>
> The rock is essentially made up of 70% fairly well-rounded quartz grains and 30% sericite. There are two main sizes of quartz grains, the larger from 0.5 mm to 0.8 mm in diameter and the smaller from 0.07 to 0.1 mm. The sericite is secondary and appears to have an arrangement parallel to the bedding. Well-rounded pebbles of white quartzite, up to 3 inches in diameter are scattered irregularly through the formation.
>
> J. B. Tyrrell thought it might be an altered phase of the Athabasca sandstone.

These authors refer to the Churchill Quartzites as "questionable Proterozoic rocks". A possible source of the white quartzite pebbles might be the Hurwitz Group of early Proterozoic age found in the Rankin Inlet area. This group reportedly contains several thousand feet of white quartzites (exposures on Marble Island, etc.).

The Port Churchill outcrop is unusual in another way. There is considerable data now available to support Nelson's suggestion that the outcrop is very steep-sided. The new data indicates the flanks dip under the Paleozoic at angles in the order of 45 degrees. This fact gives rise to speculation that the east-west coast between the port and Cape Churchill is fault controlled.

In the Selco Pennycutaway drill hole, the base of the Paleozoic sediments was at 588 feet where a forty foot section of diabase was drilled. The diabase was followed by 154 feet of weathered iron rich sericitic schist, then by 682 feet of amphibolitic rocks to a total depth of 1,462 feet. The age of the Precambrian section is unknown, however, since the schist underlying the diabase is strongly weathered and heavily iron stained, it is interesting to speculate that the diabase is Proterozoic, possibly Late Proterozoic in age correlating with the Proterozoic diabase sill of the Winisk-Sutton area as described in the next section.

The Precambrian windows of the Winisk and Sutton rivers are best known through the detailed description by Hawley (1925) of the Sutton Lake exposures. Here the windows form a series of hills capped by a diabase sill 300 feet or more in thickness. The sill is underlain by 10 to 100 feet of iron rich slates, cherts, carbonates and quartzites, followed by a chert breccia and cherty dolomites containing algal structures. The pre-diabase section is cut by dikes. Hawley finds many "striking similarities" between the Sutton Lake exposures and the Precambrian of the Belcher Islands and the east coast of Hudson Bay. He indirectly suggests correlation of these rocks.

Structurally, the Precambrian of the Sutton Lake area dips northward at a greater angle than the Paleozoic rocks. This, Hawley suggests, is evidence of northward tilting coincident with the earliest Paleozoic encroachment. The contact with the surrounding Silurian rocks is obscured.

Paleozoics of the Lowlands

Dr. Sam Nelson's report provides a good summary of the existing knowledge of the Paleozoic sediments. In the nature of new data, the information provided by the seven recent holes drilled in the general Nelson River area is becoming available. The one hole examined to date (Kennco DDH#6) showed no appreciable porosity and no oil staining; however, the amount and nature of the bioclastic material is encouraging. The greatest established Paleozoic thickness to date is the 520 feet encountered in the Kennco DDH#5 (approximately 57° 10', 93° 10').

No new evidence of the development of a basal sand is available. A note of interest however to the possibilities of sand development is the six feet plus of "buff crossbedded sandstone" found at the base of the Silurian section on the Attawapiskat river (Bostock, 1961).

One other note of possible economic interest is the artesian water flow encountered at Kennco DDH#4 in the Weir River area. The flow was encountered at the top of the limestone (170 feet) and gushed to a height of thirteen feet the first day, then subsided and remained constant at three feet. The flow is from below the reported Paleozoic-Pleistocene contact. It is unstated whether the water was fresh or salty.

Pleistocene of the Lowlands

The Pleistocene deposits of the area are presumed to be moderately to very thick with a maximum known thickness in Kennco DDH#5 of 337 feet. Thicknesses in the other Kennco holes along the Weir River all exceeded 150 feet, while at Selco Pennycutaway 144 feet of Pleistocene was drilled. However, to assume a deep overburden everywhere would be a mistake. The deepest overburdens should theoretically be found along the Nelson River gravity high because of the slower time in rebounding to glacial loading.

Other data carrying inferences of regional thickness of overburden include:

1. A hole drilled within a mile or so of the Port Churchill Precambrian ridge encountered 91 feet of overburden followed by 103 feet of limestone (no Precambrian).

2. An outcrop (150' x 150') of limestone at the mouth of the Broad River (57° 10', 93° 10') indicates very thin overburden in that area.

3. Heavy limestone debris on both West and East Penn Islands near the Manitoba-Ontario boundary.

4. Limestone outcrops around the coast of Cape Henrietta Maria. (This would be logical and tie into the theory of the Patricia gravity low.) The only outcrop Manning (1947) saw on his canoe trip between Moose and York Factories was on the east coast of Akimiski Island and at Cape Henrietta Maria.

Structure of the Lowlands

A detailed discussion of this subject is not intended herein, but attention is drawn to several features and speculations:

1. The limestones along the Severn river (and probably generally elsewhere) are not flat-lying but are gently undulating and further warped at Limestone Rapids into "a number of low domes" (A.P. Low, 1886)

2. A major physiographic feature of probable tectonic significance parallels the coast from the "old beach" some sixty-five miles inland from our area, markedly controlling the drainage pattern across the Severn and Winisk areas, crossing Sutton Lakes near the Precambrian window, then apparently swinging northeasterly to Cape Henrietta Maria. This feature plus other factors suggests the dominant structural grain of the area from Cape Tatnam to Cape Henrietta Maria is concentric to the Bay in "hingeline" fashion.

3. The above consideration gives rise to speculation that the "old beach" of the upper Kaskattama River may be more significant than just another strand line.

4. If the rebound to glaciation considerations presented in this letter are adhered to, then the Cape Tatnam area would be theorized as a broad, rather weak, structural nose. The regional geology, however, suggests that the Nelson River trough was the major feature of the area.

<u>Belcher Islands Area</u>

The G.S.C. sea-borne magnetometer work reported on by Dr. Peter Hood indicates considerable thicknesses of sediments underlying the straits between the Belcher Islands and the mainland. The geology of the mainland coast and the islands reveals a sequence of Proterozoic sediments which in the islands (G.D. Jackson, G.S.C. Paper 60-20) is estimated to be 20,000 to 30,000 feet thick. The sequence contains thick series of carbonates, clastics and volcanic flows. Variation in thickness of the section is largely caused by variation in thickness of the volcanic units. The upper 7700 feet of the section is underlain by volcanic rock varying from 960 to 6400 feet thick. All the rocks from this volcanic series down, and partially including the volcanics, have been intruded by diabase sills and dikes.

The overlying unintruded section includes Jackson's unit 15 and 16. Unit 15 may be summarized as about 7000 feet thick, consisting "mainly of dark green to dark grey, laminated to thick-bedded greywacke with interbedded argillite" and "includes minor arkosic sandstones; minor conglomerates, dolomite and tuff". Unit 16 is summarized as "red arkose; minor light grey to light green-grey arkose, undifferentiated quartzite, brown argillite, conglomerate, dolomite, arenaceous dolomite conglomerate".

Hood's work suggests a synclinal area between the Belchers and the mainland opening northward and containing in excess of 7500 feet of sediments. In private discussion, results in this area worried Hood. Theoretically, he would argue that this thickness was depth of sediments to a "basement" rock, presumably a basic dike body. However, in practice he felt that the thickness was probably comprised of Paleozoic rocks, since past experience indicates that an area of Proterozoic rocks as deformed as this area would probably be cut by dikes.

The obvious suggestion would be that Hood's trough probably contains Jackson's Unit 15 and 16 and their lateral equivalents, on the basis of similar thickness. This is not to say that these rocks are Proterozoic. I see no evidence in Jackson's work for including these units in the Proterozoic, or conversely for that matter, suggesting that they may be Paleozoic. The possibility exists that the units are Paleozoic and the description of Unit 16 seems to heighten the suspicion for that unit. Conversely, it is entirely possible that Units 15 and 16 are Proterozoic and that additional Paleozoic or later sediment in the order of 7000 feet thick lay between the Belchers and the mainland. With a possible Paleozoic age in mind for Units 15 and 16, the following description of void filling materials in the Unit 13, the underlying volcanic unit, is interesting: (Unit 14 is confined to the intruded diabase dikes and sills.)

> Quartz and calcite fill most of the voids between the pillows. A black, vitreous, amorphous substance, thought to be anthraxolite, occurs in a few of these fillings and in a few quartz calcite veins associated with the unit.

Since the mineral is not positively identified as anthraxolite, the possibility exists that it is a solid end-product of natural distillation of petroleum.

Other than those mentioned in the above discussion, there are no other rock units of suspected Paleozoic or Cretaceous age present in the Belchers. One single limestone cobble of Upper or Middle Silurian age was found, but it must be assumed that this cobble was probably ice rafted to that location, possibly from great distance.

In terms of prospectiveness for gas and oil, it would be very difficult to recommend any serious investigation much less land acquisition. However, the scant information now available gives rise to further questions so that the developing knowledge of the area should be watched for inferences which might suggest or prove the presence of Paleozoic and/or later sediments shoreward and/or bayward from the Belchers.

Southampton, Coats and Mansel Islands

These islands contain the only exposures of Paleozoic rocks in the entire northern Hudson Bay region. Further, our knowledge of these rocks is extremely limited being based on scattered early geological observations and recent geographical studies. There is a modest amount of material published concerning Southampton Island, but very little concerning Coats or Mansel. For this reason a series of summarizing statements taken from Bird (1953), the major reference for Southampton Island, are herein presented followed by additional notes from Low (1903-04) and Davis (1958):

Summary of Southampton Island from Bird (1953)

The limestone lowlands form a flat monotonous landscape while the crystalline rocks, which form a third of the island, result in uplands of considerable relief. The characteristic crystalline rock is a grey mica gneiss, frequently quartzose. Granitic rocks intrude the gneiss near Coral Harbour and along the east coast. All the Precambrian rocks are cut to varying degrees by pegmatite dikes.

The limestone is thin-bedded, pale yellow, cream or, very rarely, dark grey. The total thickness is unknown, however limestone cliffs 1000 feet high are present at Cape Donovan on the central northeast coast. The age of the limestone is reported as Niagaran (Middle Silurian) at the north end of the island and both Niagaran and Richmond (Upper Ordovician) in the southwest. The limestone appears to rest directly and unconformably on an irregular gneiss floor.

Faulting is common and results in some major scarps in the order of 500 feet high. There is some thought that the northeastern shoreline of the island is fault controlled. Predominant faulting direction is northwesterly and the inferred time of faulting is post Paleozoic.

Bird believes the entire island was covered by limestone and that the limestone cover was at one time at least 350 to 400 and perhaps 1000 feet higher than at present; the difference having been removed by erosion.

The geological history of the island between Late Paleozoic and Tertiary is probably above sea level. Erosion possibly removed considerable thickness of Paleozoic rocks developing a land form of late maturity or old age. "By the Middle Tertiary period Southampton Island was a gently rolling land of limestone with an area of gneiss in what is now the highest part of the main island and possibly also the summits of Bell Hills."

Bird states that Southampton Island together with parts of the Shield were "uplifted by epeirogenic forces towards the close of the Tertiary". He gives evidence that the uplift was unequal, resulting in a tilted surface higher in the north. The uplift was also intermittent. The old erosional surface is presently between 1200 and 1600 feet in the northeast and 1000 to 1200 feet in the centre of the island. The old Tertiary surface is not observed in the southwest part of the island.

Southampton Island was covered by the Wisconsin ice sheet and glaciation is complex. The weight of the ice depressed the land and post glacial marine submergence occurred. All the present limestone areas were submerged and the edges of the Precambrian areas were inundated so that Southampton Island immediately following glaciation was reduced to a main island the shape of the present Precambrian area, though slightly smaller, plus two or three small islands along the north coast of the present Bell Penninsula. Apparently, isostatic correction to ice load is now nearly completed in the central parts of the island, with post-Pleistocene marine features observed at nearly 600 feet. The rate of uplift is decreasing but still continuing; however the rate of uplift was apparently uniform for a long period.

There is evidence suggesting that the 10 to 20 mile wide strip along the northeast central coast "has risen in recent geological time independent of the isostatic changes associated with Pleistocene glaciation" (presumably in the order of 150 feet).

The surface of the southwestern limestone area is flat to very gently undulating. The water off the limestone areas is very shallow. The tide is less than 10 feet and low tide results in coastal flats exceeding two miles in places.

Miscellaneous Notes

Eskimos used flint for fire. The limestones of the island appear barren of chert, however loose nodules are abundant in the Lake Brook area and occur sparsely on some beaches.

Both slate and soapstone are absent on the island.

In general, observations of Southampton reported by Low (1903-04) are more completely covered by Bird (1953). However, the following notes from Low may be useful:

1. At Seahorse Point, the Archean is very quartzose, light grey mica gneiss cut by pink granite gneiss. The granite and gneiss are in contact with Silurian limestone.
2. The western shore of Southampton is low limestone. The water offshore is very shallow and at Cape Kendall dangerous reefs are found at least eight miles off.
3. Limestones on Southampton are light yellow and resemble those of the Winnipeg area.

The only factual report on the geology of Evans Straits, Fisher Straits and Walrus Island, Coats Island and Mansel Island so far examined is by A.P. Low (1903-04):

1. The bottom of Fisher and Evans Straits was found to be even, and covered with fine sand or limestone debris.

2. Walrus Island in Fisher Strait is a single small low-lying island of crystalline rock.

3. Silurian limestone occupies the larger parts of Southampton, Coats and Mansel Island.

4. The highlands traversing Coats Island are caused by crystalline rocks rising from beneath flat lying limestones that cover the rest of the island.

5. Mansfield Island (i.e. Mansel) is all limestone with coasts "somewhat higher than Coats and Southampton, rising inland in low broad terraces to an elevation of upwards of a hundred feet.

The following notes taken from LABRADOR AND HUDSON BAY PILOT, 1954, are added:

Mansel Island, with its northern point lying 255°, about 35 miles from the outer rock to the westward of Digges Islands, is pear-shaped, 50 miles long north and south and 27 miles across at its widest part which is about one-third the length from the north end. It is composed of limestone gravel ridges which are from 10 to 40 feet in height on the west side and about 100 feet high on the east side.

Coats Island, is mostly low and flat, and with the exception of a ridge of high land with an elevation of 500 feet crossing it diagonally at its northeastern end, has no elevation over 100 feet. This ridge is due to a band of crystalline rocks, which rises from beneath the low flat limestones forming the remainder of the island. The ridge terminates to the northward in a prominent headland named Cape Préfontaine, about 400 feet high, which forms the northernmost point of the island. A wide bay on the northwest coast was observed to be partly filled with large low islands. Cape Pembroke, the northeast point of the island, is said also to be a high cliff. At the southern end of the island, Cary's Swan Nest is the eastern extreme and Cape Southampton the western extreme. Shoal water extends for a considerable distance southwestward of the latter cape.

. . . Cape Pembroke is a bold headland with perpendicular cliffs about 500 feet high. . . . The land immediately behind the cliffs is anything from 900 to 1200 feet in height and is an excellent landmark seen many miles out to sea.

Walrus Island, on the western side of the approach to South Bay, lies about 45 miles northeastward of Cape Low, and about 25 miles offshore. It is composed of rock and rises abruptly to a height of 100 feet or more, in conspicuous contrast to the low shores in the approach to South Bay.

One other note which has not as yet been followed up, is the indication on a sketch map presented by Bower (1960) that Coats and Mansel islands have Ordovician to Devonian rocks. The same map shows Southampton strata as Ordovician and Silurian. This is the only reference found to date of the occurrence of Devonian rocks in Hudson Bay.

There is very little geophysical data available in the area of the northern islands. Bower (1960) indicates the thickness of sediments in southwestern Southampton Island to be in the order of 500 feet. However, Hood's (in preparation) more extensive work would indicate thicknesses in excess of 1000 feet over most of the limestone area of Southampton and Coats islands, exceeding 2500 feet in the south ends of both islands and exceeding 5000 feet in the near offshore area off the southern coasts.

Proterozoic Basin in Hudson Bay

Leith (1910) early suggested the existence of a separate basin of Algonkian sedimentation in the Hudson Bay area, separated from the Algonkian areas of southern Ontario and Quebec by the Canadian protaxis. Hawley (1925) substantiates Leith's work:

> The mapping of the Algonkian sediments of Sutton lake aids greatly in answering the question of the existence of a separate Algonkian geosyncline of deposition in Hudson Bay. Examination shows that these rocks of Sutton lake lie practically on the strike of those of the east coast of Hudson bay, the whole forming a sweeping curve paralleling approximately the present shoreline of the bay. The northward dip of the strata at Sutton lake is low, as at Richmond Gulf, and may well be due in part to original deposition. From Sutton lake westward, the strike bends northwestward, suggesting

the previous continuation of the sediments in this direction. The present distribution of Algonkian sediments around Hudson bay strongly suggest the former existence of a broad basin of deposition, the southern border of which is approximately parallel to the present coast lines and a short distance to the south. Such a basin, separate from that of Lake Superior, was first suggested by Dr. Leith, and the new evidence afforded by the Sutton lake area clearly supports this thesis. The close parallelism of the southern shorelines on Hudson bay to the strike of the Algonkian sediments, suggests further that the present outline of the basin has been more or less inherited from this ancient sea or from the same factors which determined the borders of that sea.

The present consideration of Hudson Bay as a repetitive basin is in agreement with these ideas. Interpretation of the regional concept and the local data lead to the following exploration considerations:

1. All of the southern half of the present Hudson Bay is possibly underlain by Proterozoic sediments. This situation is probably true for much of the northern half of the Bay as well.

2. The Proterozoic rocks might well contain thick sections of carbonates, iron-rich rocks, extrusive and intrusives. The total thickness may in the deeper basinal areas be many tens of thousands of feet thick.

3. The Proterozoic section is probably cut by diabase dikes.

4. Since the Upper Proterozoic probably contains tabular bodies and vertical bodies of basic rocks, magnetometer interpretation may be complicated. Nevertheless, there is reason to assume that magnetic basement is the top of the Proterozoic and therefore, assuming Hood's work as carefully done, his thickness consideration should be of post Proterozoic sediments.

Paleozoic Basin in Hudson Bay

To date, Hudson Bay has been viewed by petroleum geologists with only passing interest because of the lack of knowledge concerning the Bay area proper and the on-shore data indication of the presence of only a thin Lower Paleozoic section. The lack of geological information over most of the Hudson Bay-James Bay Lowlands resulted in the general application of the geological data from the area south of the Attawapiskat River to the entire area. As illustrated in this letter, such analogy is probably unwarranted. The James Bay area is viewed herein as more stable than the greater Hudson Bay area.

In summary, there is considerable evidence to theorize the existence of a rather extensive Paleozoic basin in Hudson Bay. The basin is possibly more extensive than presented by Dr. Joubin, broadly mirroring the topography of the present depression. In general, the work done to date would suggest that Dr. Hood's recent work is reasonable and that his depth-to-basement estimates are probably depths to Proterozoic.

Economic Summary

With the current lack of facts to back theory, the present acreage spread seems to represent a solid land position in the Lowland portion of the basin. There are at present no other areas more clearly desirable than the present holdings. By the same token, the entire coastal area from Cape Churchill to Cape Henrietta Maria is generally favorable, depending largely upon establishing the presence of encouraging thicknesses of sediments.

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Again, this letter is an informal presentation of some of the recent findings and thoughts pertinent to the Hudson Bay project. It is both incomplete and sketchily authenticated. However, I trust it will serve to up-date our ideas and prove interesting.

Yours very truly,

R. D. Johnson, P.Geol.

RDJ:sjj