The Peel Sound Formation (Devonian) of Prince of Wales and Adjacent Islands: *A Preliminary Report*

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ABSTRACT. Stratigraphic and sedimentological work on the Peel Sound Formation reveals discrete passage phases between three laterally equivalent facies: rudaceous, arenaceous, and carbonate. The role of fluvial, transitional, and marine environments is assessed for this redbed-to-marine sequence and its vertebrate faunas, all of which appear to be comparable to Old Red Sandstone rocks elsewhere. The Boothia Arch was of prime importance in the development of the facies and possibly also in the local control of contemporary vertebrate distribution. Clasts within the Peel Sound Formation include lithologies readily identifiable with older Palaeozoic or Precambrian rocks exposed in Prince of Wales and Somerset islands. The vertebrate faunas, mainly in large but isolated faunules, appear to be equivalent to those of the Downtonian and Dittonian stages. In addition to numerous cyathaspidids and pteraspidids, there are several new forms: most are heterostraci, but osteostraci, arthrodires and a few osteichthyes also occur.

RÉSUMÉ. *Rapport préliminaire sur la formation de Peel Sound (Dévonien) dans l'île du Prince-de-Galles et les îles adjacentes.* L'étude stratigraphique et sédimentologique de la formation de Peel Sound révèle des phases de passage discontinu entre trois faciès latéralement équivalents : graviers, arènes, et carbonates. On évalue le rôle des trois milieux, fluvial, de transition et marin, pour cette séquence, qui va des sédiments clastiques rouges *(redbeds)* aux sédiments marins, et pour ses faunes de vertébrés qui semblent toutes comparables à celles des roches *Old Red Sandstone* trouvées ailleurs. L'arc de Boothia a eu une importance primordiale dans le développement de ces faciès et peut-être aussi dans la distribution locale des vertébrés de même âge. Les sédiments clastiques de la formation de Peel Sound comprennent des lithologies facilement identifiables à l'aide des roches du Paléozoïque ancien et du Précambrien qui affleurent dans les îles Somerset et du Prince-de-Galles. Les faunes de vertébrés — surtout sous forme de larges faunules isolées — semblent équivalentes à celle des étages Downtonien et Dittonien. En plus de nombreux cyathaspididés et ptéraspididés, on trouve plusieurs formes nouvelles : il s'agit surtout d'hétérostraces, mais on découvre aussi des ostéostraces, des arthrodires, et quelques ostéichthyes.

РЕЗЮМЕ. *Предварительные данные о формации Пилского Пролива (Девон) на острове Принца Уэльского и соседних островах.* Стратиграфические исследования и изучение осадочных пород формации Пилского Пролива выявили присутствие раздельных переходных фаз между тремя эквивалентными в горизонтальном направлении фациями: грубообломочными, песчанистыми и карбонатными. Определено влияние речной, промежуточной и морской среды на образование данной толщи континентальных и морских отложений и ее позвоночной фауны. Все факторы указывают на сходство с толщами Древнего Красного Песчаника. Арка Буфия оказала главное влияние на образование фаций и, возможно, также на распределение позвоночных. Образцы осадочных пород из формации

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Пилского Пролива по литологическому составу весьма близки к более древним палеозойским и докембрийским породам, выходы которых встречаются на островах Принца Уэльского и Сомерсет. Фауна позвоночных, встречающаяся главным образом на больших, но изолированных, участках, по-видимому эквивалентна фауне даунтонского и диттонского ярусов. Кроме многочисленных циатаспидидов и птераспидидов, было обнаружено несколько новых форм.

INTRODUCTION

During the past few years members of the Department of Geology, University of Ottawa, together with other workers, have been investigating the region of the Boothia Arch or Uplift (Dineley 1965, 1966*a*). This feature in the geology of the central Arctic Islands of Canada has been made generally known by the work of the Geological Survey of Canada (Fortier *et al.* 1963; Blackadar and Christie 1963; Kerr and Christie 1965), and a number of interesting problems relating to the evolution of the Arch are currently under study at the University of Ottawa. The present paper is intended as an extended progress report on one of the topics which have been most actively studied by our group, rather than as a final treatment of our data.

The larger part of Prince of Wales Island is made up of a flat-lying variegated

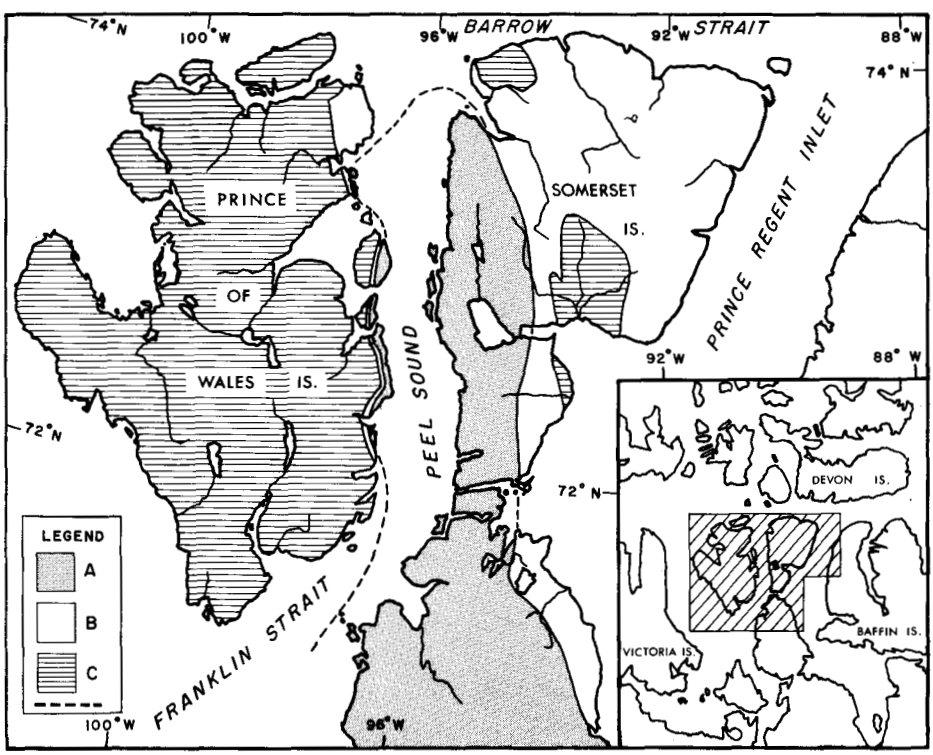

FIG. 1. Location and general geological map of the Boothia Arch, N.W.T. (A) Crystalline Precambrian rocks of Boothia Arch; (B) Proterozoic and Palaeozoic rocks older than Peel Sound Formation; (C) Peel Sound Formation. Dashed line indicates probable outcrop boundary of crystalline Precambrian rocks of the Boothia Arch.

set of terrigenous clastic and carbonate sediments known as the Peel Sound Formation. Reconnaissance work by the Geological Survey of Canada (Blackadar and Christie 1963) indicated a Devonian age for these beds, and facies variations within the formation were tentatively mapped. The western margin of the Boothia Arch occupies a narrow strip of the east coast of Prince of Wales and adjacent islands (Fig. 1). Here the Palaeozoic rocks are steeply inclined to the west, but decline rapidly within a kilometre.

Field work was carried out on the island by the University of Ottawa Group during the summers of 1966 and 1967; the work was directed by the senior author (D. L. Dineley). A study of the sedimentology of the formation was carried out by A. D. Miall, who also amassed such stratigraphic detail as was available and made collections of the sparse invertebrate fauna. At the same time, D. S. Broad searched for fossil vertebrates which, in places, are extremely abundant. Several large and spectacular collections of these remains were made and are now being studied in detail.

SEDIMENTOLOGY AND STRATIGRAPHY

The Geological Survey of Canada map of 1963 (No. 37-1963) subdivides the Peel Sound Formation into three parts, occupying areas on Prince of Wales Island: they are a conglomerate, a sandstone, and a carbonate outcrop. The clastic successions were tentatively mapped as lateral facies variations of the same formation, but the status of the carbonate beds was regarded as uncertain, particularly because they perhaps could be correlated with a major group of Silurian limestones (the Read Bay Formation) immediately underlying the Peel Sound Formation in eastern Prince of Wales Island. One of the aims of the present study is to examine the Peel Sound Formation subdivisions in greater detail, and to determine their exact relations to each other.

The conglomerate belt varies from 1 to 11 miles (14 km.) in width (Fig. 2). Within this belt, lithologies other than pebble and boulder conglomerate generally comprise less than 5 per cent of the succession. Clasts of up to 4 feet (1.25 m.) in diameter are not uncommon. Pebble types include several lithologies, all of which can be readily identified with one or other of the older Palaeozoic and Precambrian rocks now exposed on Somerset Island and easternmost Prince of Wales Island.

Conglomerates appear rather suddenly at the base of the Peel Sound Formation, just above the contact with the Read Bay limestones. The reason for this is thought to be that the Boothia Arch was activated in the early Devonian, destroying the tranquil marine environment of Read Bay times and creating a major land mass over the present site of Peel Sound and the Boothia Peninsula. Erosion under sub-aerial, semi-arid conditions, with occasional torrential floods, could then have been responsible for developing the thick clastic wedges banked up against the east and west flanks of the arch. (The rocks of the eastern flank, in Somerset Island, were studied by members of previous field parties from Ottawa.) There is ample evidence in the form of paleocurrent directions, as derived from sedimentary structures, that the Prince of Wales rocks have an easterly source.

There is also much to suggest that the uplift of the Boothia Arch was not a single episode but an intermittently continued process; for example, coarse intraclasts of Peel Sound Formation are present at various levels within the conglomerate succession.

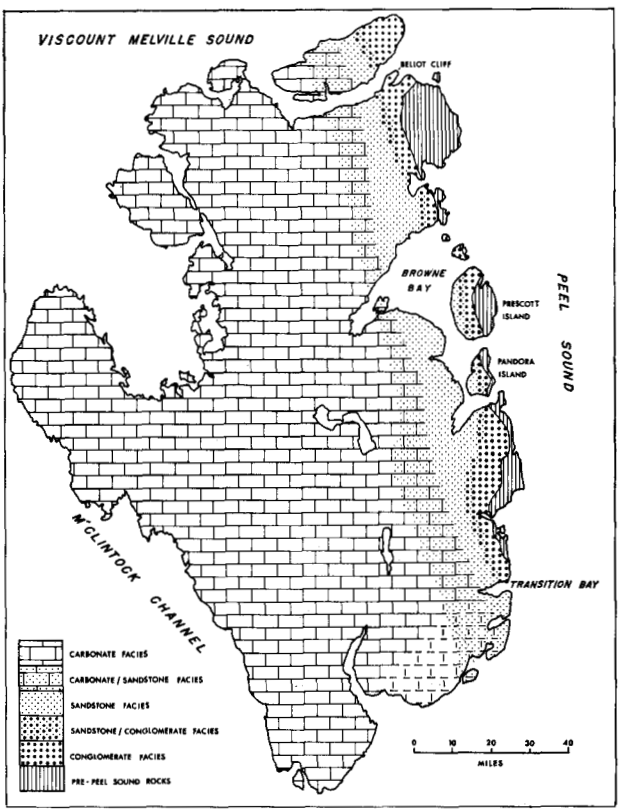

FIG. 2. Sketch map of facies distribution in the Peel Sound Formation of Prince of Wales Island.

Running parallel to the conglomerate belt and adjacent to its western edge is a zone of monotonous redbed sandstone showing rare washout channels, and rare smaller-scale current features such as trough cross-beds and planar cross-sets. It has been possible to show that the conglomerates wedge out westward and interfinger with these sands in a transition zone less than 2 miles wide (2.6 km.). The sandstone belt itself varies in width from 6 to 12 miles (19 km.) (Fig. 2).

More than half the area of the Island is made up of beds belonging to the carbonate subdivision of the Peel Sound Formation. The predominant rock type is a massive or laminated calcilutite, often partially or wholly dolomitised, and emitting a strong petroliferous odour from fresh fractures. The fauna is marine, including corals, brachiopods, trilobites, and gastropods, and it is hoped that some of the assemblages collected will assist the correlation of these beds. Because the strata are horizontal, or nearly so, over almost the whole of the island (except near the basal contact with the Read Bay Formation along the eastern edge of Prince of Wales Island) and because the 3 facies types all occur within similar

heights above sea level, it seems probable that all 3 are equivalent in time. As mentioned above, the intertonguing between the sandstone and conglomerate facies actually can be mapped.

There is a transition zone between the sandstone and carbonate facies which may be traced, as may the other lithologic belts, from north to south across the island. Within this zone, which is approximately 8 miles (12.75 km.) wide, are seen sections showing interbedded redbed clastics, grey sandstones and shales, calcareous siltites, and pure limestones. The fauna varies in character from marine (limestones and shales with colonial corals) through brackish (*Lingula* sp. in grey sandstones and siltstones) to freshwater (?) (red and grey sandstones and siltstones containing vertebrate remains).

A tentative palaeogeographic interpretation is being constructed for the area; its dominating feature must have been the ridge of high land to the east of the Island which underwent rapid but probably intermittent erosion. Banked against its western margins was a long but narrow zone of overlapping coarse alluvial fans, and these merged into a broader coastal plain region, now occupied by the sandstone facies belt, in which fluvial deposition was predominant. At the western edge of this zone lay an area of fluctuating conditions. At times red or grey clastics extended far to the west under a fluvial and lacustrine regime. This seems to have been the environment most favourable for vertebrate habitation and preservation.

Between these phases of fluvial or lacustrine conditions the marine influence predominated, and grey shales or argillaceous limestones containing marine fossils are now found up to 10 miles (16 km.) east of the westernmost redbed clastics. A very characteristic lithology in this transition zone is a small-scale limestone-shale alternation. The repeated units of a few inches to a foot (30 cm.) may form sediment columns up to 20 feet thick (6 m.). Here ostracods tend to be very abundant. A lagoonal environment is suggested, the rhythmic alternations being perhaps seasonal in origin. Elsewhere, scattered occurrences of salt casts in shales suggest the spasmodic development of evaporitic conditions in the lagoon. Clearly, the history of this transition zone is a complex one.

Meanwhile in the western half of the island lay the sea, in which the clastic influence was probably small. Here the fine carbonates with their invertebrate faunas were accumulated.

Material gathered during the last two field seasons is now being studied, and it is hoped that much of what has been reported above will be enlarged and elaborated in the near future. A certain amount of statistical work on the conglomerates has now been done. Measurements of sorting in random samples, counts of pebble lithology, sphericity and roundness measurements on key lithologic types, may lead to interesting conclusions concerning local conglomerate variations and large-scale dispersal patterns around the flanks of the Arch.

The carbonate beds also await further study. Although rather monotonous calcilutites and calcisiltites predominate, a number of minor variations are evident, for example, bored or contorted strata, the origins of which need to be elucidated. Geochemical analysis of these rocks should also enable an estimate to be made of the influence of the land-derived clastic materials on the marine sediments at these points most distant from the source area.

VERTEBRATE PALAEONTOLOGY

In its lithologies and structural setting, the similarity of the Peel Sound Formation to Devonian continental rocks elsewhere is striking, and the presence of vertebrate faunas akin to those of the Old Red Sandstone was suspected. Fossil vertebrates of Siluro-Devonian age were reported from Somerset Island by Thorsteinsson in 1963. Large collections of vertebrates made by Dineley in 1964 (1966*a*) and 1965 (1966*b*) confirmed the presence of numerous vertebrate faunules in the Read Bay and Peel Sound formations of Somerset Island. The probability of similar faunas occurring in the Peel Sound Formation on Prince of Wales Island 40 miles (64 km.) to the west initiated the extensive search and collection programs in 1966 and 1967. Most of the accessible localities on Prince of Wales and adjacent islands were visited, and the resultant collection of about 3,000 pounds of material far exceeded expectations in quality, quantity, and variety. Several new forms are present but most of the material awaits detailed examination. Some preliminary conclusions can, however, be drawn.

Collections of vertebrates have been made from nearly all stratigraphic horizons and from all 3 facies of the Peel Sound Formation. The fossils are locally abundant in the transition zone between the red clastic and the carbonate facies, and in the basal Peel Sound sandstones, but are less common in the conglomerate facies.

Along the north coast of Prince of Wales Island, the facies transition westward from conglomerate through red sandstone to carbonate is reflected to a certain extent by the relative abundance of vertebrate fossils. Although scattered fish remains occur in the most westerly redbeds, the most abundant vertebrate faunas are found where red clastics are intercalated with calcarenites and calcisiltites of the carbonate facies. For example, on Baring Channel (18 miles southwest of Bellot Cliff), two lenses of calcisiltite and calcarenite yielded enormous quantities of well-preserved material, including some complete specimens of a large *Ctenaspis*. One lens was characterised by large numbers of well-preserved cephalaspids with associated specimens of *Ctenaspis* and a few pteraspids. The other contained abundant large pteraspids, *Ctenaspis,* Arthrodira (probably Arctolepida), acanthodian spines, possibly Antiarchs and Eurypterida, in addition to ostracods and plant material. Further west, in the marine carbonate facies, "bone beds" consisting of finely comminuted material occur, but their detailed composition and mode of origin is at the moment uncertain. Much of the material obtained from the "bone beds" is of large, thick, lozenge-shaped scales and large dermal bones of an osteichthyan character.

Excellent exposures through the Read Bay Formation, and basal Peel Sound sandstones occur in vertical strata 6 miles (9.5 km.) north of Transition Bay on the east coast of Prince of Wales Island. At this locality, the presence of no less than 15 separate fish-bearing horizons within the basal 580 feet (180 m.) of the Peel Sound Formation permitted stratigraphic collection. The faunas here consist of possibly as many as 11 genera, mostly Cyathaspida, and include several new forms. Some are enormous, attaining a length in some cases of 15 cm., and may compare with those reported from Somerset Island (Dineley 1965). It is

interesting, nevertheless, to note that this fauna differs appreciably, in the absence of Osteostraci, from that collected by Dineley (1966*b*) from a comparable stratigraphic horizon on Somerset Island. From higher horizons all the Prince of Wales Osteostraci have remarkably long cornua. One possible explanation for these differences is that the Boothia Arch barrier in early Peel Sound times may have exerted an influence upon the migration and distribution of the local vertebrates.

The mode of preservation of the fossils suggests in almost every instance a thanatocoenose assemblage which has been transported some distance. A single pteraspid with squamation has been found, although ctenaspids, cyathaspids and cephalaspids with part or (rarely) complete squamation also occur. Most of the fossils are robust types, as are those on Somerset Island, and appear to have been adapted to environments similar to those in which ostracoderms flourished elsewhere. Their over-all stratigraphic value is likely to be considerable, but in particular it is fortunate that at least 1 large and 1 small form of pteraspid has been found. The pteraspids are of known stratigraphic value in Europe, and Denison's (1964) studies of the cyathaspids form an important foundation for their use in the stratigraphy of the Silurian and Lower Devonian.

The relative abundance of the better preserved ostracoderm material in the sandy facies, and of much-broken or merely scattered plates in the carbonate rocks examined so far, adds weight to the idea that these agnatha were more common in fresh waters than in the sea — at least as mature animals. No fossil agnatha larvae are known, but the sea may have been their habitat; adult animals undoubtedly occupied the rivers and their remains are rare in the carbonate rocks. This apparently uneven distribution of mature animals is worth noting here because few other regions are known where there is such a continuous sequence of Lower Devonian coastal plain to carbonate environments. Such a distribution has long been suspected, of course.

It is expected that detailed studies of the succession of faunas north of Transition Bay will suggest a more precise palaeontological definition of the boundary between the Read Bay and Peel Sound formations, and lead to a reappraisal of the Siluro-Devonian boundary in this part of the Arctic.

Extensive preparation of the collected material remains to be done but, when completed, the results should have significant bearing on palaeontological and palaeogeographic problems.

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