GEOLOGICAL STUDIES IN SOMERSET ISLAND, UNIVERSITY OF OTTAWA EXPEDITION, 1965

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ABSTRACT. Geological studies around Aston Bay and Limestone Island, Stanwell-Fletcher Lake, and Creswell Bay in Somerset Island include the structure of the Pre-Cambrian metamorphic basement, the stratigraphy, sedimentology, and palaeontology of the Aston and Hunting formations, the Palaeozoic rocks, and the younger strata north of Stanwell-Fletcher Lake. The Recent sedimentology of the lake and local Quaternary features are investigated.

RÉSUMÉ. *Études géologiques à l'île Somerset, expédition de l'université d'Ottawa, 1965.* Les études géologiques effectuées autour de la baie Aston et de l'île Limestone, du lac Stanwell-Fletcher et de la baie Creswell, à l'île Somerset, ont porté sur la structure du soubassement précambrien, la stratigraphie, la sédimentologie et la paléontologie des formations d'Aston et de Hunting, les roches paléozoïques et les strates plus récentes au nord du lac Stanwell-Fletcher. On a étudié aussi la sédimentologie récente du lac et les traits du Quaternaire local.

АБСТРАКТ. ГЕОЛОГИЧЕСКИЕ ИССЛЕДОВАНИЯ НА ОСТРОВЕ СОМЕРСЕТ, Экспедиция Оттавского университета, 1965. Геологические исследования вокруг залива Астон и острова Лаймстон, озера Стануэлл-Флетчер и залива Крессуэлл на острове Сомерсет включают структуру до-кембрийского метаморфического фундамента, стратиграфию, седиментацию и палеонтологию формаций Астон и Хантинг, палеозойские породы и более позднюю толщу к северу от озера Стануэлл-Флетчер. Неогенная седиментация озера, как и местные четвертичные особенности также подвергаются изучению.

EACH OF THE topics pursued during the 1965 expedition had been initiated, or indicated as a promising field, during the previous season's work (Dineley 1965) as a contribution to the study of the Boothia Arch or Uplift (Kerr and Christie 1965). Laboratory studies during the intervening winter months have made satisfactory progress, and the area of the operation was not expanded greatly from that of 1964. The 1965 field program involved the study of all geological formations and geomorphology of certain areas between Cape Anne, Pressure Point, the southern margin of Stanwell-Fletcher Lake, and the south shore of Creswell Bay.

Members of the expedition arrived in Somerset Island in mid-May; others followed later, and the field season closed early in August. Apart from the geological and geophysical work, observations were also made of the weather, wild life, ancient eskimo sites, etc., and these have been conveyed to the appropriate authorities in Ottawa. A collection of insects made for Dr. D. R. Oliver, Department of Agriculture, is believed to be the first from the island.

Geology of the Pre-Cambrian Formations

Dr. R. L. Brown (University of New Brunswick) and Dr. I. W. D. Dalziel (University of Wisconsin), who are working with the Ottawa group, began a

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study of the structural history of the Boothia Arch, and spent the season on the Pre-Cambrian metamorphic rocks north of Stanwell-Fletcher Lake. These rocks were involved in at least three fold episodes prior to the deposition of the Aston and Hunting formations. A number of major folds occurs; all of these belong to the second generation. They are tight, asymmetric structures with nearly horizontal axes and well developed axial plane cleavage. The minor first folds consist of relic isoclines, and the third structures are open (conjugate) warps in the regional foliation trend. While final conclusions must await microscopic studies, mesoscopic examination indicates that the main metamorphism preceded the second folding. A structural traverse was completed across about two-thirds of the arch. The sense of movement of the second folds indicates that lower structural levels are exposed towards the centre of the arch rather than at the eastern margin. It is hoped to complete this traverse with a study of the western part of the arch on Prince of Wales Island in 1966.

The structural setting of Stanwell-Fletcher Lake and the detailed geology of the crystalline rocks between the lake and Creswell Bay were investigated by J. Giguere. His studies show that the lake itself occupies what appears to be a basin, down-faulted on the western side and with a hinge area on its eastern. A marked scarp is traceable for some 30 miles to north and south on the western side of the lake and is locally offset by small faults. The rocks involved consist of gneisses of the almandine amphibolite facies, probably of sedimentary origin. They are quartz almandine rock, quartz feldspar hornblende gneiss, and quartz biotite feldspar hornblende gneiss. Intrusive into the country rocks are irregular

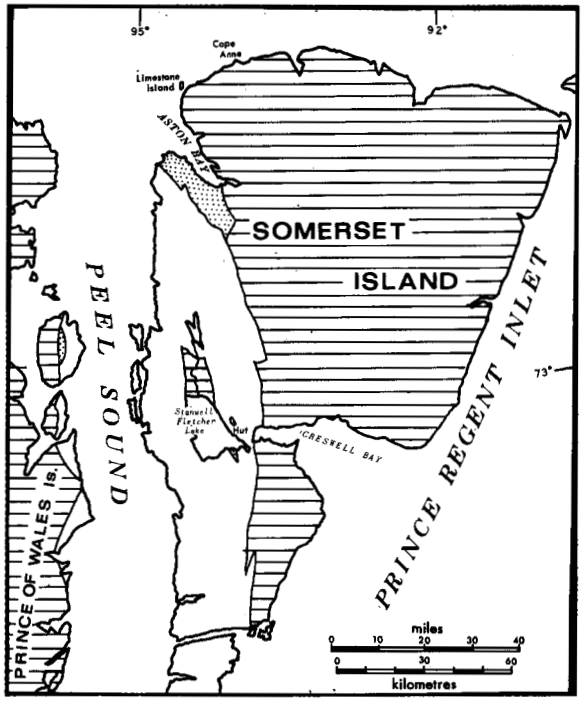

Fig. 1. Sketch map of geology of Somerset Island, District of Franklin, N.W.T. The Pre-Cambrian metamorphic and igneous basement is shown unshaded; the Aston and Hunting formations are dotted; the Palaeozoic and younger outcrops are shown with horizontal lines. The University of Ottawa group was based at a hut on the southeastern side of Stanwell-Fletcher Lake.

bodies of granite and gabbroic material. The granites show a gneissic structure but the gabbroic dikes are post-metamorphism in age. A study of minor fold structures indicates at least two effective phases of folding.

Work begun on the Proterozoic (?) Aston and Hunting formations by G. E. Benson in 1964 was this year completed by M. F. Tuke and the detailed results from both seasons will constitute the first of the larger papers accruing from the expeditions. Attention was principally given to questions of the formation boundaries, age, and depositional environments. At the single observed contact of the Aston with the basement, a basal breccia lies unconformably upon the lower rocks. The arenaceous Aston grades upwards into the Hunting which is subdivided into:

4. Shale and dolostone
3. Dolostone with 'convolute bedding'
2. Grey massive dolostone with chert
1. Sandstone, shale, and dolostone.

The contact of the Hunting with the Palaeozoic also appears to be gradational, the boundary being placed at the base of a conspicuous band of worm-bored dolostone. No fossils other than stromatolites were found in the Aston and Hunting formations, and the only trace fossils are worm burrows. The Aston formation, mainly immature pebbly micaceous sandstone, shows much current bedding, generally indicating a southwestern source. Sedimentary features, lithologies and bed geometry suggest a fluvial origin. The Hunting formation is thought to have been deposited in a lagoonal environment. Lithologies are for the most part fine dolostones with many oolitic beds, ripple marks, desiccation cracks, and other structures. Essentially shallow water with periodic subaerial exposure permitted much stromatolitic (algal) growth locally. The wide variety of stromatolitic bodies present has received further attention.

The similarity of the Hunting to the Cornwallis formation is noted, and the absence of any break in the Hunting-Palaeozoic succession suggests that the Hunting may be Palaeozoic in age.

Dikes and sills are common in the Aston but only a few thin sills are present in the Hunting. No intrusives were found in the local Palaeozoic beds. The intrusives clearly die out rapidly within the upper parts of the Hunting but their absence from the Palaeozoic is no certain indication that they are of Pre-Palaeozoic date.

Geology and Palaeontology of the Palaeozoic Formations

Immediately east of Aston Bay the Palaeozoic strata underlying the Read Bay (Silurian) formation were examined in some detail by Dineley. The Read Bay crops out further east than shown on the previous map (Blackader and Christie 1963) and the area of beds correlated with the Allen Bay formation below it (Thorsteinsson 1958) is correspondingly larger. A significant proportion of the beds is highly quartzose fine sandstone, devoid of fossils. Limestones are usually also barren; a few are fossiliferous and several are packed with trace fossils. One or two beds may be sufficiently widespread to suggest a direct correlation with other islands in the Arctic. The rocks are thrown into wide

homoclines dipping gently east for the most part but there are narrow north-south striking bands of high dip with normal and reverse faulting. The thickness of strata is not great, possibly between 2,000 and 3,000 feet, but more probably nearer 2,000. The structures observed north and east of Aston Bay and the structure of the country north of the inner part of Creswell Bay (within the basement) suggest that the influence of the basement is direct and strong.

The Read Bay succession at Pressure Point, eastern Aston Bay and north of Creswell Bay shows several facies or member changes. The successions recorded there will be compared with those of the northeast and east. The fauna is prolific and much of the limestone is highly bioclastic (biostromal). No reef structures were seen but indications are that they may exist within the region. The upper part of the formation shows a progressive facies change to the usually unfossiliferous limestones and siltstones of the Peel Sound basal beds on the eastern side of the Boothia Arch. It is thus comparable to member D of the Read Bay formation in Cornwallis Island. Ostracoderms are locally common and are clearly part of a continuing Siluro-Devonian fauna. Samples were taken from selected horizons for the digestion of conodont faunas.

The Devonian Peel Sound Formation outcrops on Somerset Island in the northwest corner and in the south central part around Creswell Bay. During 1965 preliminary sedimentological investigation was made in part of the northern area by B. R. Rust, and around Creswell Bay by M. F. Tuke.

In northern Somerset Island the Peel Sound Formation lies conformably on the marine Read Bay Formation in a shallow syncline. Dip measurements on the western limb of the syncline indicate the presence of approximately 3,500 feet of Peel Sound beds, made up of 4 members:

4. Polymict conglomerate	300
3. Sandstone	850
2. Oligomict conglomerate	1850
1. Standstone, siltstone, limestone and dolostone	500
	3500 ft.

The lowest beds are grey-green or light red calcilutite or dolostone, calcareous shale and calcareous siltstone, with ripple marks, desiccation cracks and planar- and cross-lamination. There is complete lithological and faunal transition from the underlying Read Bay Formation, and the boundary is drawn arbitrarily, following Fortier *et al.* (1963, p. 122). Higher in the sequence of the lowest member the rocks are coarser and more consistently red in colour, with calcareous sandstone and calcarenite predominant.

The oligomict conglomerate largely consists of rounded calcilutite clasts in a calcarenite matrix, with minor chert and quartzite pebbles. The proportion of quartzite clasts increases higher in the succession, and rare granophyric clasts have been found. Clast diameter varies up to a maximum of 9 inches. Planar cross-bedding in thin impersistent calcarenite bodies is the only directional structure observed.

The sandstone member is principally made up of red quartzose sandstone, locally feldspathic and/or lithic, with many thin pebble horizons. The pebbles are rounded, and are mostly quartzite, with minor calcilutite and granitic clasts.

Planar cross-bedding is common, although not well exposed, and pebble-filled scours, some of which are strongly directional, occur at one horizon.

The polymict conglomerate member has a high clast:matrix ratio, with well-rounded clasts set in immature sandstone. The maximum clast diameter is 1 foot, with an average diameter of about 3 inches. At least 10 distinct clastic types are present, the commonest being quartzite, calcilutite and gneiss.

The succession described above is almost twice as thick as that of the eastern limb of the syncline (Fortier *et al.* 1963, pp. 122-23). The thick oligomict conglomerate is notably absent from the eastern limb, and it is clear that there is a minor facies change from west to east. Palaeocurrent directions measured from cross-beds throughout the sequence lie between west and south-southeast, with a modal source direction in the south-southwest. The succession indicates environmental change from shallow marine conditions at the end of Read Bay deposition, through a transitional (probably lagoonal) stage to continental (fluviatile) conditions for the upper 3 members of the Peel Sound Formation. The sequence of clast lithologies in the Peel Sound rocks indicates the uplift and successive erosion of Palaeozoic (chiefly calcilutite), Proterozoic (mostly quartzite) and Archean rocks. This, together with the SSW source, supports the hypothesis of Devonian uplift along the Boothia Arch, which lies to the south and west of the present area (Kerr and Christie 1965).

The Peel Sound Formation in the Creswell Bay area outcrops on both limbs of a shallow syncline which is faulted on the western side. The beds in the centre of the syncline are covered by alluvium. On the east limb of the syncline about 700 feet of limestone and sandy limestone of the Peel Sound Formation lie conformably on the Read Bay Formation. Desiccation cracks and ripple marks are abundant, and salt casts and evaporite deposits occur at several horizons. It is concluded that the limestones were deposited in shallow water that occasionally evaporated. On the west limb of the syncline the Peel Sound Formation consists of 200 feet of calcilutite overlain by 200 feet of red siltstone. Ripple marks and desiccation cracks are present in the calcilutite but neither salt casts nor evaporites were observed. Rare cross-bedding in the siltstone suggests a northwestern source of palaeocurrents. The exposures in these two areas provide further evidence of facies change in the Peel Sound Formation within comparatively small areas.

On the southwest shore of Creswell Bay the Peel Sound formation consists of sandstone and grit overlain by conglomerate. At some localities the conglomerate clasts were dominantly limestone but elsewhere they are mostly acid igneous or chiefly basaltic. The clasts are all well rounded and are closely packed in a matrix of friable sandstone. This conglomerate may be equivalent to the polymict conglomerate found in the northern part of Somerset Island.

The fauna of the Peel Sound formation is being studied by D. L. Dineley, who obtained very large collections of ostracoderm and placoderm remains from the localities discovered near Pressure Point and east of Cape Anne in 1964. A number of new localities near Pressure Point also proved highly productive. Fossiliferous horizons both north and south of Creswell Bay also yielded large numbers of ostracoderms. The faunas all lie within the basal 300 feet or so of the Peel Sound formation, higher horizons produced only rare scraps of material and most are apparently barren. In addition to the vertebrates, plant remains,

ostracods, eurypterids, and gastropods occur locally in large numbers. A preliminary report on the location of the fishes will be published by the Geological Survey of Canada. The heterostraci include Cyathaspididae akin to *Anglaspis*, *Lystraspis*, and *Pionaspis* and possibly new forms of *Cyathaspis*, together with other large members of the group, Traquairaspididae and at least two problematic types. Among the osteostraci are two almost complete specimens close to *Hemicyclaspis* and fragments of other cephalaspids. The fauna is cosmopolitan, showing affinities to British, western Canadian and, probably, Russian assemblages.

The Cretaceous/Tertiary Rocks

Cretaceous/Tertiary rocks were found north of Stanwell-Fletcher Lake in 1964, and have since been located west and south of the lake. They are probably present under much of the lake, and it is likely that they cover at least 200 square miles of this part of Somerset Island. The dip of the beds north of the lake is a few degrees southwest, and the thickness is of the order of 500 to 1000 feet.

Rust and U. Mayr's study of these rocks reveals two major subdivisions: a lower unit of green clay and siltstone, and a thicker upper unit of soft, light-coloured sandstone with abundant cross-bedding. Plant remains and trace fossils are locally common, and inarticulate brachiopods and arthropods have been found. Vertebrate remains have been collected, including teeth and bones of large reptiles.

The sandstones are well sorted and of medium grain size (except for thin, impersistent beds) and show no lithological evidence that the present boundaries correspond to those of the original basin of deposition. The sediments were laid directly on the Pre-Cambrian basement, perhaps in a delta or estuary, across which palaeocurrents travelled from north to south. The western margin is a fault along which displacement of the Cretaceous/Tertiary rocks indicates a dip-separation of several hundred feet.

Sedimentary features of the sandstones and siltstones are being studied by Rust, and Mayr is working on the fauna and flora. The vertebrates are being examined in liaison with Dr. D. Russell of the National Museum, while Dr. R. Cox of the Geological Survey is assisting with the study of the microflora. It is hoped that a microflora will also indicate the age of unconsolidated sand and clay lying above the Cretaceous/Tertiary beds, but of uncertain relationship to them.

Sediment and Related Studies in Stanwell-Fletcher Lake

Ice thickness, water depth, temperature, and salinity were measured on a one-mile by two-mile grid on Stanwell-Fletcher Lake by Rust and J. P. Coakley. Water samples and cores were taken at each station. Results so far show that the main topographic feature is a NW-SE trough with a maximum depth of more than 325 feet. The lake water is essentially isothermal and fresh, although Recent raised marine beaches occur above the present lake shore. The bottom sediments are chiefly mud containing plant material and a few ice-rafted pebbles, but fine to medium-grained sands predominate in the northeast corner of the lake, where rivers draining Cretaceous/Tertiary sandstones have built extensive deltas.

Laboratory studies are being made of trace elements in the water, and the texture, composition, and sedimentary structures of the bottom sediments. A heat budget will be prepared from the temperature observations.

Unconsolidated sands and varved silts and clays were discovered south of Stanwell-Fletcher Lake about 100 feet above lake level. They are older than the most recent glacial deposits of the area, and are thought to be raised Pleistocene lacustrine and fluvio-lacustrine sediments. They will be further investigated in 1966.

Pleistocene Geology

Observations on the present and raised shoreline features near Pressure Point and in the Stanwell-Fletcher Lake-Creswell Bay area were made by I. D. Mercer. The succession of beaches in these parts was accurately levelled to about 100 feet above present sea level; from here up the succession is less distinct and frequent cliff features begin. Marine fossils from many horizons were collected; of these faunas several have been examined by Dr. F. Wagner of the Geological Survey of Canada. Observations on the preservation and possible ecology of some of these faunas were made. Silts from several localities have been sampled for microfauna and the study of these is proceeding.

The survey of terrace features, etc. in the Hunting Valley was continued and observations were made on processes distributing larger debris across the valley floor. Seismic examination of the valley fill was conducted.

Geophysical Work

G. F. West and J. W. Hall (University of Toronto) set up an eight-channel seismic refraction apparatus for work in the Hunting Valley area at Aston Bay and at Stanwell-Fletcher Lake. Using a surface shooting procedure, a velocity of over 17,000 feet per second was established for the Hunting formation and the depth and shape of the Hunting Valley was found. The valley proves to be excavated to, and filled from, a depth of about 300 feet below present sea level and has a pronounced U-shape. Bad weather and problems of terrain and logistics cut short the work on the Aston formation and the operation was moved to the low ground north of Stanwell-Fletcher Lake. Here two crossed profiles were shot to the northeast and northwest of the lake. These established that the Cretaceous/Tertiary rocks reach locally a depth of about 1000 feet in the west and about 700 to 800 feet in the east, assuming that the permafrost continues down to the Pre-Cambrian basement. The surface of the Pre-Cambrian below the Cretaceous/Tertiary is not smooth and is more irregular under the eastern profile than under the west. There is a trace of a slightly higher velocity in the lower half of the section, and this is sharper in the east than in the west. A dip of between 5 and 10 degrees to the west is calculated.

S. Dodson continued the magnetometer exploration work begun in Aston Bay in 1965, using the Sharpe A3 magnetometer, and also maintained the continuous recording magnetometer set up at base camp in Aston Bay by Mr. L. Law, Dominion Observatory.

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