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DEPARTMENT OF ENERGY,
MINES AND RESOURCES

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PALEOZOIC GEOLOGY OF WOLFE ISLAND, BATH, SYDENHAM AND GANANOQUE MAP-AREAS, ONTARIO

B. A. Liberty

1971

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B. A. Liberty

DEPARTMENT OF ENERGY, MINES AND RESOURCES

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ABSTRACT

The lower Paleozoic stratigraphy of an area in southeastern Ontario is described using the lithological nomenclature proposed previously by the author.

PALEOZOIC GEOLOGY OF WOLFE ISLAND, BATH, SYDENHAM AND GANANOQUE MAP-AREAS

INTRODUCTION

The lithological nomenclature previously proposed and adopted by Liberty (1955, 1963a, 1964, 1967a, 1968, 1969a) for southern Ontario is used here for the stratigraphic succession in the Kingston area. This succession has been mapped from northern Michigan, eastward into northern New York State.

GEOLOGICAL SETTING

The Cambrian and Middle Ordovician rocks of the Kingston area progressively onlap the Precambrian rocks of the Canadian Shield and are overlain by the surficial deposits of Pleistocene age.

The Precambrian rocks, mapped in detail by Wynne-Edwards (1962, 1967) and Hewitt (1963), include: crystalline limestone, interlayered quartzite and marble, quartzite, several types of gneiss, pyroxene granulite, migmatite, gabbro, pegmatite, red granite, monzonite, and diabase and andesite dykes. Most of the Precambrian inliers are monadnocks of granite gneiss. They vary in length from less than 100 feet to more than half a mile and may rise as much as 100 feet above the general ground surface and 350 feet above the buried Precambrian surface (Liberty, 1961).

A veneer of glacial drift covers most of the area. Glacial striae are best preserved in strata of the Verulam Formation. Most striae trend about 220 degrees, but a second set has been found to trend about 270 degrees in the eastern half of the Lake Ontario area and corroborates previous work in the Belleville area (Liberty, 1961). Drumlins and eskers occur in the area.

PALEOZOIC STRATIGRAPHY

Paleozoic strata comprise rocks of Cambrian and Ordovician ages. No known Cambrian fossils have been found in the oldest Potsdam Formation in the Kingston area, but a Cambrian age has been generally accepted from investigations in New York State. The overlying Shadow Lake Formation, though poorly fossiliferous, is considered to be of Middle Ordovician age; it is conformable with the overlying well-dated Middle Ordovician Gull River Formation.

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Potsdam Formation

The Potsdam Formation is well exposed at the Park of Pillars, 10 miles northeast of Kingston. It comprises very evenly textured quartz sandstone and siltstone, varying in colour from red and pink to white, grey, and yellow. Crossbeds and small to large (0.1 to 0.5 feet) concretions are common. Vertical cylindrical structures (Hawley, 1934) are considered to be sandstone pipes; these vary in diameter from 1/4 inch to 25 feet and are composed of internal concentric rings and conically shaped sheaths (pointing upwards); they are unique to the formation and the Kingston area. A minor disconformity separates the Potsdam and the overlying Shadow Lake Formation (Middle Ordovician age). Definite evidence of a Cambrian age for the Potsdam Formation in Ontario is lacking; Lingula acuminata and Ophileta compacta, previously reported by Logan (1863), have been found (Liberty, 1969b); an Ordovician age for at least the upper part of the Potsdam is suspected (Wilson, 1946; Liberty, 1969b). At least 70 feet of the formation occur in outcrop in the area and a boring at Knowlton Lake indicates a total thickness there of 149 feet. An additional 81 feet of dark grey Paleozoic shale was logged, by the writer, at the base of the formation in the first Dominion Observatory boring at Knowlton Lake. This unit is separated as a lower member at this one location only.

Shadow Lake Formation

The Shadow Lake Formation (Okulitch, 1939) was redefined by (Liberty, 1955, 1969a) to embrace red and green shale and arkose in the Lake Simcoe area; it conforms with Johnston's (1912) 'basal series'.

In the Kingston district the formation comprises deeply weathered red, black, and green shales, sandstones, and arkoses (Liberty, 1967a). Thin 0.5- to 1.5-foot-thick beds of black shale, 15- to 20-foot thicknesses of grey sandstone, and arkose beds up to 40 feet thick occur. The formation is usually absent over and on the flanks of Precambrian 'highs'. It can be seen at the base of the Inverary South road-cut (1/2 mile south-southeast of Inverary) and at Rush Bay on the south shore of Howe Island (2 miles west of the east end). The contact with the underlying Potsdam is defined as between the shale-arkose section and the underlying Potsdam sandstone. The formation is considered as correlative with the Pamelia (partly on the basis of Ctenobolbina clavigera (Jones), see Copeland, 1958) of the Ottawa Valley and New York State and of the Glenwood Formation of Michigan.

SIMCOE GROUP

The Simcoe Group (Liberty, 1955, 1963a, 1969a) comprises the carbonate rock sequence lying above the Shadow Lake Formation and below the Whitby Formation (Liberty, 1963a, 1968). It is divisible into four formations: Gull River, Bobcaygeon, Verulam, and Lindsay, in ascending order, that in turn are divisible into ten members. The uppermost Lindsay Formation is not present. In the Kingston area the Simcoe Group thickens markedly, and some of the members may be subdivided into mappable submembers. These are of considerable value in the recognition of faults and in compiling composite sections.

The Simcoe Group is of Blackriveran, Trentonian, and Edenian ages. The Blackriveran-Trentonian time boundary is within the Bobcaygeon Formation. The Wilderness-Barneveld time boundary, as defined at the base of the Sherman Fall biostratigraphic unit, is located about 40 feet above the base of the Verulam Formation within the map-area. The group is about 900 feet thick in the Prince Edward County-Kingston area. The uppermost Lindsay Formation is not exposed east of Prince Edward County and thus is not included in the following descriptions. In the Ottawa Valley the group includes, by definition, the St. Martin, Ottawa, and Eastview Formations.

Gull River Formation

The Gull River Formation (Okulitch, 1939) was redefined (Liberty, 1955, 1963a, 1969a) to conform to Johnston's (1911) Lowville and to include Okulitch's Moore Hill Formation as its uppermost strata. The formation is divisible into four members, the uppermost of which is restricted to the Kingston district.

The lower member A is composed of three submembers. The lower submember (2-5 feet thick) consists of brown, fine-crystalline limestone and grey, lithographic limestone. The middle submember is brown to dark brown lithographic and sublithographic limestone. Much of this lithology has a mottled, digitate appearance (fingers of yellow, fine-crystalline dolomite). Certain parts, however, do not have this mottled appearance. Beds average 0.5 to 1.5 feet; thickness of the middle submember is about 70 to 75 feet; it can be seen at Inverary South road-cut (1/2 mile south-southeast of Inverary). The upper submember comprises an alternation of grey and brown-weathering carbonates. Generally these are grey, sublithographic and lithographic, in part pelletoid, limestones and brown to yellowish brown, resistant to nonresistant, fine-grained to very fine crystalline dolomitic limestone and dolomite. Calcite vugs are common in the dolomite; mineral molds, conglomerates, and calcarenites are common throughout the unit; bedding is even and varies from 0.5 to 1.5 feet in thickness. This upper submember is very distinctive, about 90 to 100 feet thick, and is divisible into three units. The submember can be seen north of Kingston at the Highway 401-Montreal Street road-cut (strata below the north access road) and farther east at Highways 401 and 15 intersection road-cut (all strata there except the Precambrian inlier). At this latter locality and at the 'Rideau type section' at Kingston Mills on the Cataraqui River north of Kingston, the Rideau beds of Baker (1961; not of Ami, 1902) occur within this upper submember, some 70 to 100 feet above the top of the Potsdam Formation. Heretofore, the Rideau beds have been considered to be the stratigraphically lowest Middle Ordovician unit. In actuality they represent a conglomeratic facies within the upper submember; it is composed of Precambrian material derived from the Precambrian surface. The original lithology of the upper submember is easily seen, and it permits ready identification.

Member B consists of two units. The lower submember, about 20 feet thick, is composed of thin and medium beds of grey- to white-weathering, light grey lithographic limestone. These strata can weather more thinly and show a laminated character in certain sections; shale developments occur locally, as in the lower road-cut, at the Highway 401-Newburgh road intersection. This submember is locally fossiliferous. It can be seen at the base

of the Highway 401-Collins Creek intersection road-cut and at the level of the north access road at the Highway 401-Montreal Street intersection road-cut. The upper submember, about 18 feet thick, is composed of medium beds of grey and dark grey, fine, semicrystalline, bioclastic, lithographic, and argillaceous limestone. Also included are several layers of oolitic limestone and black shale partings. The unit can be seen near the base of the Highway 401 and Collins Creek intersection road-cut (south side of road).

Member C is divisible into several units, which are actually an alternation of two types of rock. One is thin bedded, and in the Kingston area may vary from the 0.1-foot-thick beds of lithographic dark grey limestone (Highway 2 road-cut east of Napanee) to a 'shale' in the road-cut a mile east of Sydenham. Interbedded with this are 2 1/2-3-foot-thick massive beds of grey-weathered, grey, semicrystalline and lithographic limestone. These units are locally fossiliferous, with the corals Tetradium cellulosum and Tetradium fibratum. Thicknesses of these individual units at this location are: 7, 7 1/2, 10, 11 1/2, 5 and 2 1/2 feet respectively, for thin and thick bedded units. Three stromatolite zones are associated with the thin-bedded units; the largest specimens are in the stratigraphically highest zone and are well exposed west of Millhaven on Highway 33 and on the northwest shore of Wolfe Island. The whole sequence can be seen to best advantage in the Highway 2 road-cut east of Napanee, and the Highway 401 and Collins Creek intersection road-cut, and varies from 25 to 50 feet in thickness.

The uppermost member D of the Gull River Formation is a unit that occurs in New York State and the Kingston area only; it is the Chaumont limestone of New York State. It is composed of brown, lithographic, sublithographic, admixed fine-crystalline and sublithographic and admixed fine-granular and sublithographic limestones. This unit generally weathers to massive grey beds (2 to 5 feet thick). Thinner beds (0.1 to 0.2 feet thick) can also be developed between the more massive beds; 1- to 2-foot-thick beds of shale also occur. The uppermost strata comprise 2 to 9 feet of white-weathered, grey lithographic limestone and admixed fine-crystalline and lithographic limestone. The member had formerly been reported as 20 feet thick; it is now known to be in the order of 50 to 55 feet thick; in the road-cut east of Camden, it is 45 feet thick. This member is fossiliferous and includes: Columnaria halli, Tetradium cellulosum, Tetradium fibratum, Fletcheria sinclairi, Streptelasma corniculum, Stromatocerium sp., Rhynchotrema minnesotensis, Zygospira recurvirostris, Cyrtodonta huronensis, Hormotoma gracilis, Trochonema sp., Bathyurus sp., Ceraurus pleurexanthemus, Isotelus sp., and Leperditia sp.

The contact between the Gull River Formation and the underlying Shadow Lake Formation is defined as between the dominantly lithographic, sublithographic limestone and underlying shale-arkose section of the Shadow Lake.

Within the Kingston area, member A can be traced readily, although the digitately mottled beds thin drastically to 1 1/2 feet in a westerly direction. Member B also changes westward, its lower submember being less massive and more laminated with shale, and becoming thin-bedded and laminated lithographic limestone in the base of the Marmora road-cut, 40 miles northwest of the present area. Its upper submember also becomes more thickly bedded and slightly more lithographic. The thin-bedded units of member C disappear west of Napanee and the remaining more massive units coalesce to form the 'Moore Hill beds' (Liberty, 1963a), the uppermost 12 feet in the Marmora

road-cut. Member D is not traceable west of Napanee. Westward the youngest unit of the Gull River Formation is member C, the 'Moore Hill beds', which contains the Chaumont fauna. The absence of member D west of the Kingston area confirms the presence of a disconformity between the Gull River and the overlying Bobcaygeon Formation.

On the basis of the writer's investigations, the following correlations are pertinent. The upper submember of member A of the Gull River Formation is correlated with type Pamelia of New York State. The lower and middle submembers are not recognized in New York State (Liberty, 1965, p. 107; Young, 1942). The lower submember of member B is correlated with the New York State type Lowville and member D traces into the Chaumont of New York State. Thus the intervening strata are correlated a priori with the Lowville. The complete Gull River Formation correlates with the Pamelia-Lowville-Leray (Chaumont) beds of the Ottawa Valley (Wilson, 1946; Cooper, 1956). There, it is the lithological equivalent of Pamelia-Lowville beds. The Gull River Formation can be traced westward to Manitoulin and to St. Joseph Island (Liberty, 1967b, pp. 154-155). In the northern peninsula of Michigan, the Gull River Formation of St. Joseph Island has been recognized as far west as Munising (Liberty, 1969b) as 'lower' Bony Falls Formation (semiquotes are those of the writer).

Bobcaygeon Formation

The Bobcaygeon Formation (Liberty, 1963a, 1964, 1969a) is a lithogenetic unit lying between the lithographic limestone of the Gull River Formation and the equally distinctive interbedded limestone and shale of the Verulam Formation. The formation includes the strata previously referred to as Rockland and Hull by Caley and Liberty (1950) and Liberty (1952).

The formation varies from 20 to 30 feet in thickness. For the most part, it is typified by medium- to thin-bedded, grey, calcarenitic and sublithographic limestone. The formation can be seen 2 miles southeast of the village of Wolfe Island, in Bath Creek north of Highway 33, and on the south shore of Simcoe Island.

The lower member is usually the more resistant and is about 15 to 18 feet thick. It comprises an alternation of fine calcarenitic limestone and sublithographic limestone in 0.2-0.3-foot-thick beds. The unit is predominantly brownish grey to grey and weathers bluish grey. Strata are fossiliferous; thin dark shale partings are present in the lowest few feet; microcross-bedding is evident in the calcarenites. The upper member is less resistant and thinner, 5 to 10 feet only. Bedding is thicker to massive, but weathers platy. It consists of mostly bluish grey weathered, grey, sublithographic claystone and limestone of which some is digitately mottled (slightly yellowish), and weathers to an irregular pitted surface. The last lithology is similar to high Bobcaygeon lithology west of the map-area. At anomalous localities the whole formation comprises an alternation of calcarenites and sublithographic limestone; at others, calcarenite may be developed in either the lower or upper part of the formation. On the adjacent Belleville sheet on the west side of Salmon River where it crosses Highway 401, the lower member can be seen to underlie the upper member. An example of the alternation of lithologies can be seen in the formation at the west end of the Highway 401 road-cut at Napanee (Selby and Napanee beds).

The contact between the Bobcaygeon and the underlying Gull River Formation is defined as between general calcarenites and argillaceous limestone and the underlying lithographic limestone.

The fauna is reasonably abundant and varied. It includes: Receptaculites occidentalis, Tetradium cellulosum, Columnaria halli, Calapoecia canadensis, Solenopora compacta, Triplecia cuspidata, 'Dalmanella' rogata, Doleroides ottawanus, Maclurites logani, Phragmolites compressus, and Gonioceras sp.

The Bobcaygeon Formation is correlated with the Chaumont-Rockland-Leray-Hull (Kirkfield) strata, as faunal elements of all these are enclosed. The lowest few feet enclose no Rockland elements but retain a Chaumont fauna. Lithologically the formation is traceable westward into the lower, middle, and upper members of the Bobcaygeon in the Lake Simcoe area (Coboconk-Kirkfield units), the Cloche Island beds on Manitoulin Island, and the uppermost Bony Falls Formation in northern Michigan (Liberty, 1968). Eastward it is correlated with the Leray (Chaumont of Cooper, 1956) - Rockland beds of the Ottawa Formation in the Ottawa Valley.

The base of the Bobcaygeon Formation conforms to the base of Kay's Rocklandian (Kay, 1937, 1960). The top of the formation lies at the top of Kirkfieldian in the type and reference area, but Kay has found Kirkfieldian faunas in the base of the overlying (Verulam) formation in the Kingston area (Kay, 1942).

Verulam Formation

The Verulam Formation (pronounced Fur-oo-lam) (Liberty, 1955, 1963a, 1969a) is the most distinctive lithologic unit of the Simcoe Group. The formation includes those strata previously referred to as Sherman Fall by Caley and Liberty (1950) and Liberty (1952, et seq.). The formation outcrops in the Bath, Amherst Island, and Wolfe Island areas, is the youngest bedrock formation in the Kingston area, and is equivalent to the lower member of the Verulam Formation of adjacent map-sheets.

The formation is typified by the alternation of limestone 'hardbands' and 'shale' on the weathered section. The 'hardbands' vary between 0.3 and 0.9 feet in thickness, and are very evenly textured, fine- and medium-crystalline, fossiliferous limestone. The alternating 'shale' is usually weathered calcareous claystone, but thin friable dark shale partings are present also. In the middle of the formation, bluish weathering, dark grey and blue, sublithographic limestone can become the dominant lithology; soft, argillaceous, brown limestone is also present.

The lowest unit comprises 20 to 30 feet of soft, irregularly bedded, argillaceous limestone; this unit contains a profusion of the hat-shaped 'Prasoporid' bryozoans. As this unit is absent at two localities, a disconformity is now suspected between the Verulam and the underlying Bobcaygeon Formation at these localities. The middle strata comprise: greyish blue, fine calcarenites; thin beds of brown and dark grey, soft, sublithographic limestone; thin beds of bioclastic limestone containing silicified fossils: black chert nodules; and a profusion of Prasoporid bryozoans. The uppermost strata (10-15 feet) consist of ribbon limestone (0.05-0.1 foot thick), blue, very fine crystalline limestone with equally thin beds of shale and calcareous

claystone. Thickness of the formation is about 350 feet. The subdivision can be seen to advantage in the quarries 1 mile west of Bath and 4 miles north of Millhaven.

The contact between the Verulam and Bobcaygeon Formations is defined as between the dominant blue, thin bedded limestones and shales of the Verulam and the more massive grey, fine-grained and calcarenitic Bobcaygeon.

The abundant and varied fauna includes: Receptaculites occidentalis, Pasceolus globosus, Solenopora compacta, Columnaria halli, Trematis ottawaensis, Rafinesquina deltoidea, Encrinurus cybeleformis, Hemiarges paulianus, Cryptolithus tesselatus, Fusispira subfusiformis, and Hormotoma trentonensis. Cryptolithus has now been found at three localities in this area of Ontario.

Several 'zones' with profuse 'Dalmanella', 'Prasopora' and echinoderms are known within the formation, and with care can be used stratigraphically. Semiquotes are those of the writer and denote only lack of generic determination (internal preservation, thin sections, etc.).

The Verulam Formation is correlated with the Sherman Fall and lowermost Cobourg of New York State and the Ottawa Valley. The lowest few feet are correlated with Kay's 1943, Kirkfield. Lithologically the formation is traceable westward across Ontario into the 'unnamed beds' on Manitoulin Island (Liberty, 1954, 1957, 1968) and the Chandler Falls Formation in northern Michigan. In the Ottawa Valley, in the Canada Cement Company quarry at Hull, Quebec, the Hull 'upper beds' (Raymond, 1914) is the lithic equivalent of the upper member of the Verulam in the Lake Simcoe area; the Hull 'lower beds' is Verulam also. The semiquotes are those of the writer - to denote the mentioned but unlabelled stratigraphy of Raymond.

The base of the Cobourg 'Formation' (biostratigraphic) as defined by Kay (1937) lies in a middle portion of the Verulam Formation. Kay's Sherman Fall beds consistently lie above the base of the Verulam Formation. Within the Kingston area, Kay's Kirkfield beds lie in lowest Verulam strata, as is the case in the Belleville area (Liberty, 1961). As Kay's Kirkfield lies below the Verulam in the reference section (Kirkfield quarry, northwest of Lindsay - Liberty, 1953), it is suggested that the lower contact of the Verulam Formation is time transgressive, becoming older in an eastward direction (Liberty, 1963a, 1963b, 1964) away from the Ontario Dome of the Muskoka-Haliburton region (Grabau, 1920).

STRUCTURAL GEOLOGY

Regional dip of the Paleozoic strata in the area is from 10 to 15 feet per mile. Higher angle initial dips on the Precambrian surface may be seen at several localities and vary from 8 to 15 degrees. The stratigraphic units strike from east to southeast. The influence of the underlying Precambrian surface topography is of major importance in strata below the Verulam Formation (i.e. 350 feet of relief). Drape of the Ordovician and Cambrian formations over this surface is responsible for the areal configuration of the formations in the Millhaven-Ernestown-Asselstine area for example.

Also responsible for the areal configuration, but to a minor degree, is faulting. Most faults exhibit small throws of 2 to 10 feet; a 100-foot

displacement, down faulted to the west, is recorded at Napanee on the east side of the Napanee River (Liberty, 1963a). Whereas most faulting is considered to be due to post-ice adjustment to load, other mechanisms must be considered for the larger fault cited above and others (Kay, 1942; Hobson and Holzl, 1966). The existence of Kay's monoclines (1942) has been corroborated. As these monoclines produce a pronounced pattern when viewed on a small scale map, the writer considers the pattern to be controlled by tectonics of the underlying Precambrian basement.

Mention should also be made of the Kingston Precambrian-basement 'high'. This is most easily documented in the area of the Cataraqui River and with reference to the road-cuts at the intersections of Highway 401 (Macdonald-Cartier Freeway) with Highway 15 and Montreal Street (Kingston). In this area the lowest part of the section is absent: Potsdam, Shadow Lake and lower and middle submembers of member A, of the Gull River Formation, all comprising a minimum of 100 feet thickness. It is the author's interpretation that such relations are present throughout the City of Kingston, between the Little Cataraqui Creek and Cataraqui River, thus explaining several anomalous aspects in the drilling data of this area.

The presence of the Gull River Formation member D in the Kingston area, and its absence to the west, lends considerable weight to evidence for a disconformity between the Gull River and Bobcaygeon Formations west of this map-area (Liberty, 1963a, p. 12). At one or two localities a minor disconformity is evidenced in member B strata of the Gull River road-cut, 3 miles northwest of Cataraqui on Highway 38. Mention must also be made of the suspected disconformity at the base of the Verulam Formation.

ECONOMIC GEOLOGY

Within the map-area, there are many quarries mostly in the Gull River Formation. There are two quarries in the Potsdam Formation: Kingston Quarries Limited in lots 8 and 9, concession V, Pittsburgh Township (Frontenac County) and in lot 11, concession VI, Storrington Township (Frontenac County) producing building stone. The main use of limestone in the Kingston area is concrete aggregate. Few quarries are being worked actively at present. A list of these include:

1. Frontenac Quarries Ltd. (east side Division Street, 1/2 mile south of Highway 401)	Gull River Formation member A, upper submember
2. McInnes and O'Connor Ltd. (west side of Highway 15, 2 miles southwest of intersection with Highway 401)	Gull River Formation member A, upper submember
3. Municipal Sand and Gravel (1 mile east of Collins Bay, on south side of Highway 33)	Gull River Formation member A, upper submember

4. Griffen Bros. Construction (lot 18, concession V, Pittsburgh Township, 1/2 mile southwest of Joyceville) — Gull River Formation member A, middle submember

A complete list of quarries would be very long. The other major quarry rock formations are the Gull River Formation, member D, and the Verulam Formation. Examples of quarries within these units are:

Gull River Formation, member D

1. 1,000 feet east of the intersection Highway 401-Collins Creek, southeast side of intersection.
2. 1,000 feet north of drive-in theatre (2.7 miles northeast of Cataraqui) in Kingston.
3. Quarry - 1 1/2 miles east-southeast of Elginburg (Sydenham Road). This is Kay's Glenburnie quarry.

Verulam Formation

1. 4 miles north-northwest of Millhaven.
2. 1 mile southwest of Bath.
3. 1 mile northeast of Millhaven.

There are several sand and gravel pits within the map-area, but few are active. Road-metal appears to be the main product for which many quarries are operated but considerable amounts of sand are used for asphalt, sand and fill, brick sand, and cement sand. A list of the pits that have been worked in recent years or are presently being worked include:

	Product	Deposit
R.H. Richardson Sand Supply (lot 1, concession V, Loughborough Township)	sand and fine gravel	kame
Kingston Sand and Gravel Ltd. (lot 32, concession V, Kingston Township)	sand and pebbles	beach
Lot 1, concession V, Loughborough Township)	gravel	beach
J.W. McKendry (lot 32, concession VI, Kingston Township)	sand	beach
J.W. McKendry (lot 20, concession VII, Storrington Township)	sand and gravel	kame
Johnson Pit (lot 19, concession VII, Storrington Township)	sand and gravel	kame
Marker Block and Tile Ltd. (lot 25, concession VI, Pittsburgh Township)	sand and gravel	kame

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