SILICA SAND — CANADIAN SOURCES OF INTEREST TO THE DOMESTIC GLASS INDUSTRY

by R. K. COLLINGS*

ABSTRACT

There are few deposits of naturally occurring, high-purity, silica sand in Canada. However, natural sand and sandstone, or friable quartzite deposits, from which sand can be produced, occur at numerous locations. Investigation has shown that material from many of these deposits can be upgraded to silica-sand quality. Glass sand, an extremely pure form of silica sand, produced from two Canadian deposits is being utilized by the Canadian glass industry; however, most of this industry's sand requirements continue to be imported from the United States.

This paper outlines the present trend in the consumption of glass sand in Canada, indicates present sources of silica sand, and describes several Canadian deposits that are of interest as potential sources of silica for the Canadian glass industry.

* Head, Non-Metallic Minerals Section, Mineral Processing Division, Mines Branch, Department of Mines and Technical Surveys, Ottawa, Canada.

INTRODUCTION

For the purpose of this paper, silica sand is considered as any sand, either

Mines Branch Internal Report MP1 63-1

naturally occurring or produced by the reduction of sandstone or friable quartzite, that contains in excess of 98 per cent silicon dioxide, as quartz, with only minor amounts of mineral impurities. Many naturally occurring sands and artificial sands produced by the reduction of quartzose rocks, although not initially of high purity, can be upgraded to silica sand by relatively simple methods. Some of these methods are presented in this paper.

Silica sand, in particular glass-grade sand, is a very useful commodity. Typical applications include its use in the manufacture of glass and glass fiber; silicon carbide; sodium silicate and other chemicals; as well as its uses in the hydraulic fracturing of oil-bearing formations and in foundry moulding.

This paper is concerned primarily with the use of glass sand, an extremely pure form of silica sand, by the Canadian glass industry. This industry requires large quantities of sand annually for the manufacture of glass containers, sheet glass, and glass-fiber products. In 1961, the total consumption of sand by this industry was in the order of 330,000 short tons, valued at over $3 million. Of this amount, 86 per cent was used in the manufacture of glass containers, 10 per cent was used in sheet glass, and 4 per cent was used in glass-fiber products. During the year, seven plants produced glass containers — three in the Montreal area of Quebec, one each at Toronto, Wallaceburg, and Hamilton, Ontario, and one at Redcliff, Alberta. Two plants, one in Toronto, the other in Montreal, produced sheet glass, and three plants, one at Sarnia, Ontario, and two near Edmonton, Alberta, were engaged in glass-fiber manufacture.

The Canadian consumption of glass sand in 1961, by areas, was as follows — Montreal, 41 per cent; southern Ontario, 50 per cent; Alberta, 9 per cent. Quarries at St. Canut and St. Donat, Quebec, supplied over 45 per cent of the requirements of the Montreal-area plants. The balance came from producers in the United States. Plants in southern Ontario and Alberta also were supplied with imported sand. The St. Canut and St. Donat quarries, operated respectively by Canadian Silica Corporation Limited and Dominion Industrial Mineral Corporation, accounted for about 20 per cent of the total consumption of glass sand in Canada in 1961. Thus it can be seen that the major portion of Canada's requirements of glass sand is obtained from the United States. However, increased production as a result of Canadian Silica Corporation's recent expansion at St. Canut, and of the proposed expansion of Dominion Industrial Mineral Corporation for St. Donat, undoubtedly will result in a marked increase in the consumption of Canadian sand by the domestic glass industry during the next few years.

Sources and Methods of Upgrading Sand

In Canada there are relatively few deposits of naturally occurring, high-quality sand. However, there are many deposits of unconsolidated sand, loosely — to firmly — cemented sandstone, and friable quartzite that lend themselves to simple methods of benefication and hence are of interest as potential sources of high-purity sand. Several of these deposits are now being developed; some have been worked intemittently in the past, whereas others have been rejected as being too impure, too far from current markets, or otherwise not suited to economic development.

A brief description of the more important types of silica deposits and methods by which sand from these can be upgraded to meet commercial specifications may be of interest. These deposits are divided into four types:

1. Unconsolidated Sand
2. Loosely-Consolidated Sandstone
3. Firmly-Cemented Sandstone
4. Friable Quartzite

Unconsolidated Sand

Unconsolidated sand deposits occur along the coasts of the Atlantic provinces, Quebec, and British Columbia; along the shores of the Great Lakes and Lake Winnipeg; and at numerous inland locations throughout Canada. Examples are the beach sands near Souris, Prince Edward Island; those at Barrington Bay and Port Mouton on the southeastern coast of Nova Scotia; and those along the shoreline of Vancouver Island, British Columbia.

These, like many unconsolidated sand deposits, are typically impure and contain such minerals as feldspar, mica, hornblende and garnet. Beneficiation generally necessitates several of the following steps:

1. Screening to remove the coarse and fine fractions, which usually contain a large percentage of the total impurity.
2. Magnetic separation to remove iron-bearing minerals.
3. Jigging or tabling to remove heavy minerals.
4. Flotation or electrostatic separation to remove minerals that do not respond to magnetic or gravity methods.
5. Acid leaching to reduce iron and carbonate content.

The high cost of beneficiating most unconsolidated sand deposits, the low recovery, and the fact that many of the known deposits are too far from current markets, tend to discourage their development for silica sand. But such deposits should not be disregarded altogether. The Nova Scotian beach sand deposits, as well as other deposits in the Atlantic provinces, might for example be of interest if a glass container or fiber glass plant were to be erected in this area. Those in British Columbia would be of interest and certainly worthy of considerable investigation if a glass plant were established in Vancouver.

All unconsolidated sand deposits are not, of course, impure. Relatively pure deposits occur along the Mattagami and Missinabi Rivers in northeastern Ontario; in the Pine River district of western Manitoba; and west of Flin Flon, Manitoba. The chief impurity in these is alumina, which occurs in a clay coating on the quartz grains. This clay is readily removed by vigorous attrition scrubbing and washing. The sand deposits along the Mattagami and Missinabi Rivers are too distant from markets to be of present interest although they are potential sources for future development. Those of the Pine River district of Manitoba, if sufficiently large, could be of interest as a potential source of high-purity sand for the Winnipeg area. The deposits west of Flin Flon, like those in northeastern Ontario, are too far from current markets.

Loosely-Consolidated Sandstone

Typical of the loosely-consolidated sandstone deposits of Canada are those in the vicinity of Lake Timiskaming, Quebec; the Sylvania sandstone of the Windsor-Amherstburg area of Ontario; the Black Island deposit, Lake Winnipeg; the Red Deer River and Wapawekka Lake deposits of east-central Saskatchewan; and the Peace River deposits in west-central Alberta.

Such deposits generally are very pure because many of the softer mineral impurities have been removed by weathering, abrasion, and other natural agencies prior to consolidation of the more resistant quartz. Residual impurities are confined to the cementing material and may consist of clay, calcite or dolomite, iron oxide, or other mineral compound. These deposits are usually friable and require little crushing for reduction to grain size. Once free, the quartz grain will generally respond to fairly simple methods of beneficiation which may include:

1. Wet attrition scrubbing and washing to remove clay coating from the quartz.
2. Magnetic separation to remove iron-bearing minerals and introduced mill iron.

3. Acid leaching to reduce iron oxide and carbonate.

Although many of the friable sandstone deposits mentioned can be upgraded by simple methods, other factors have, to date, discouraged their development. For example, the Timiskaming silica deposits, although of good purity, are reported to be of limited extent and hence would be of little interest as a source of sand.

The Sylvania sandstone occurs in several beds at depths that vary from 45 feet at Amherstburg to about 400 feet at Windsor. These beds are porous and frequently are saturated with water. This white sandstone contains little iron and is composed of well-rounded, uniformly-sized quartz grains, loosely cemented by carbonates of calcium and magnesium. These carbonates, which seldom exceed two to three per cent of the total weight of sandstone, can be reduced by vigorous scrubbing followed by acid leaching or by electrostatic separation. However, because of the water and the fact that this sandstone member is extremely weak, underground mining would be difficult and costly. In addition, competition for markets would be exceptionally keen. Sand from the same formation is now produced by open-pit mining at Rockwood, Michigan, less than ten miles from Amherstburg across the Detroit River, and markets for the Rockwood sand are firmly established in southern Ontario.

The silica deposits on Black Island in Lake Winnipeg have been operated from time to time for the production of glass-grade sand. This sandstone is generally white, although some sections of the deposit are iron-stained. The quartz grains are well rounded and loosely bonded with clay. The sandstone breaks readily to grain size and is easily upgraded by water washing. This particular deposit would be an excellent source of sand for a glass container plant in the Winnipeg area. Selkirk Silica Company Limited, Winnipeg, Manitoba, recently resumed operations on Black Island and at its sand-processing plant at Fort Selkirk.

The Red Deer River and Wapawekka Lake silica deposits of east-central Saskatchewan, although of good purity and capable of being upgraded to glass-sand specifications, are too distant from markets. The Peace River deposits, which occur along the Peace River ten miles below Peace River town, are also at some distance from markets. These latter deposits have, however, been under periodic investigation as a possible source of silica for the manufacture of glass fiber in the Edmonton area.

Firmly-Cemented Sandstone

Typical firmly-cemented sandstone deposits are those of the Potsdam formation in the Kingston — Ottawa — Montreal area of eastern Ontario and southern Quebec, and the deposits at Golden and Canal Flats in southeastern British Columbia.

The quartz grains in most firmly-cemented sandstones are bonded with silica, iron oxide, calcite, clay, or other cementing material. These deposits must be drilled and blasted prior to reduction of the sandstone by multi-stage crushing. Following crushing it is necessary to reduce the sandstone to its natural grain size without excessive fracturing of the individual grains of quartz because many consumers, especially foundries, prefer sand that is free of compound and fractured grains. Complete reduction to grain size without some grain fracture, of course, is virtually impossible to achieve and a compromise is the best that can be expected. Following reduction of the sandstone, it generally is necessary to scrub and wash the sand to free and remove impurities which are present in the bonding material or as a coating on the quartz grains. Iron oxide stain usually cannot be eliminated by scrubbing alone but requires acid leaching at elevated temperatures.

The Potsdam sandstone of eastern Ontario and southern Quebec, because of its favorable location with respect to the Toronto and Montreal markets, has, during the last eight to ten years, been intensively investigated as a possible source of silica sand. Results to date have been encouraging. Canadian Silica Corporation's quarry at St. Canut, twenty-five miles northwest of Montreal, is in the Potsdam. This company has shown that sand that is acceptable for use in both coloured and flint-glass manufacture can be produced at St. Canut. The Potsdam formation is being investigated at several other locations in Ontario and Quebec as a source of silica sand.

Iron as pyrite is common in the Potsdam sandstone and several methods of eliminating or at least reducing this impurity have been investigated. Complete removal is difficult because of the manner in which the pyrite occurs Three common forms have been recognized:

1. Moderately large, free grains.
2. Minute, discrete particles that are firmly attached to the quartz.
3. Small particles that are lodged in cracks and crevices in the quartz and that sometime occur within the quartz grains themselves.

Free grains of pyrite can readily be removed by electrostatic separation or by froth flotation. Unfortunately, a large portion of the pyrite present in the Potsdam sandstone occurs as minute grains attached to and included in the quartz. Other methods of removing this impurity must therefore be adopted. Pyrite, which is non-magnetic, may be converted into a magnetic form of iron by roasting at temperatures in the order of 1200°F in a reducing atmosphere. It can then be removed by magnetic separation methods. Complete removal by magnetic means is, however, virtually impossible because many of the attached grains are too small to respond in the magnetic field and are carried along with the quartz. In addition, the included grains of pyrite probably would not be affected by roasting, although fortunately these grains contribute only a small percentage to the total iron.

The pyrite content of sand formed from Potsdam sandstone may also be reduced by heating followed by acid leaching. The sand is first roasted in an oxidizing atmosphere at 1000°F following which it is cooled to about 400°F and treated with sulphuric or hydrochloric acid. Here again the included grains of pyrite will not be affected.

Complete removal of pyrite by these methods is difficult and costly. Further research is required to develop and perfect cheaper and more effective ways of eliminating this impurity, particularly as it occurs in the form of attached and included grains. The iron content of the Potsdam is one of the chief obstacles preventing its wider use as a source of high-purity silica sand.

In British Columbia, the Golden and Canal Flats deposits are being examined as possible sources of silica sand for the Alberta market. These deposits are large and investigation has shown that high-purity sand can be produced from each by procedures that involve reduction to grain size followed by dry or wet attrition scrubbing and sizing.

Friable Quartzite

The fourth type of deposit of interest is friable quartzite. The deposit at St. Donat, Quebec, is a classic example. Part of the Golden, British Columbia, silica deposit might also be considered friable quartzite. The St. Donat deposit contains very little iron but the alumina content is slightly in excess of that desired by the glass industry. This alumina is present as soft, white kaolin which occurs in minute pockets and vugs in the quartzite. The kaolin is largely freed during crushing and subsequently is removed by air separation and screening. This material is processed dry at Lachine and sold for a variety of purposes, including flint-glass manufacture. Wet processing methods are being investigated for a new, enlarged plant that is planned at Ste. Agathe des

Monts, Quebec, which is about twenty miles south of St. Donat. Wet processing undoubtedly will result in a superior, more uniform sand.

Outlook for Canadian Silica Sand

The fact that top-quality, low-cost sand has been readily available from suppliers in the United States has, in the past, tended to discourage large-scale development of available Canadian silica sand sources. The United States deposits from which silica sand is produced are usually very pure and lend themselves to simple and low-cost mining and processing. Also, these are large-scale operations and the producers enjoy low freight rates, enabling them to sell sand in the Montreal area for less than $10.00 per ton. The Quebec producers find themselves in a very different position. The Quebec deposits, because of their nature, require more intensive and therefore higher cost processing compared to the principal glass sand deposits in eastern United States. In addition, transportation costs to markets are at a much higher rate per ton mile than, for example, the current rate from the Illinois deposits to Montreal. However, the two Quebec producers are now effectively competing with United States suppliers in the Montreal area and are supplying an increasing tonnage of premium-grade silica sand. The St. Canut expansion has resulted in a marked increase in the quantity of high-purity domestic said available to consumers. This, with the additional tonnage that will be produced if Dominion Industrial Mineral Corporation proceeds with its proposed expansion, should provide sufficient top-quality sand for the entire Montreal-area market. The increased consumption of domestic sand by consumers in this area is most encouraging and a continuation of this trend will significantly reduce our imports of this commodity.

The Quebec silica producers are presently unable to compete with imported sand in southern Ontario because of added freight cost. It is probable, therefore, that these southern markets will continue to be supplied by United States producers unless a more favourably located deposit is discovered and developed.

The Black Island silica deposits, which are now being developed, although capable of being easily upgraded to glass-sand quality, unfortunately are on an island in Lake Winnipeg, seventy-five miles north of the processing plant at Fort Selkirk. Lake freight to Fort Selkirk and transportation to markets add substantially to the cost of this sand; however, it is hoped that this material can be shipped to Alberta glass plants and sold in competition with imported sand.

The Canal Flats and Golden silica deposits in southeastern British Columbia are of interest as potential sources of silica sand for the Alberta market. This market is rather small and competition from United States suppliers will, of course, be keen but not, we hope, so keen as to discourage the development of yet another domestic source, or sources, of high-purity sand.

Summary

To summarize: the current markets for silica sand for glass manufacture in Canada are located in the Montreal area of Quebec; the Toronto, Hamilton, and Sarnia areas of southern Ontario; and the Redcliff and Edmonton areas of Alberta. Additional markets will become available should glass container plants be erected in Winnipeg and Vancouver. Silica deposits that are of interest as possible sources of glass sand for consumption in these markets include, in addition to the St. Canut and St. Donat deposits, the Potsdam sandstone formations of southern Quebec and eastern Ontario; the Black Island silica deposits in Manitoba; and the Golden and Canal Flats deposits in southeastern British Columbia. These deposits, in particular, should be kept in mind as possible sources of glass sand for new glass, or glass fiber plants, or as supplementary sources of sand for existing plants.

BIBLIOGRAPHY

1. Cole, L. Heber — Silica in Canada, Its Occurrence, Exploitation, and Uses, Dept. of Mines, Mines Branch, Ottawa. Part 1 Eastern Canada No. 555, 1923, 126 pp., Part 2, Western Canada, No. 686, 1928, 59 pp.
2. Dyer W. S. — Sylvania Sandstone Deposit of Amherstburg, Ontario, Ontario Dept. of Mines, Toronto, Vol. XXXVIII, Part 4, 1929, pp. 41-46.
3. Cummings, J. H. — Preliminary Investigation into Possibilities for Producing Silica Sand from British Columbia Sand Deposits, British Columbia Dept. of Mines, Victoria, 1941, 50 pp.
4. Keith, M. L. — Sandstone as a Source of Silica Sands in Southeastern Ontario, Ontario Dept. of Mines, Toronto, Vol. LV, Part 5, 1946, 36 pp.
5. MacPherson, A. R. — Silica In Canada, Dept. of Mines and Resources, Mines Branch, Ottawa, Memorandum Series No. 104, 1949, 21 pp.
6. Crockford, M. B. B. — Geology of the Peace River Glass Sand Deposits, Research Council of Alberta, Edmonton, Mimeographed Circular No. 7, 1949, 20 pp.
7. Hewitt, D. F. — Silica In Ontario, Ontario Dept. of Mines, Toronto, Industrial Mineral Circular No. 2, 1951, 16 pp.
8. Babey W. J. — The Red Deer River Silica Sand Deposits of East Central Saskatchewan, Dept. of Mineral Resources, Province of Saskatchewan, Regina, Report of Investigations No. 7, 1955, 29 pp.
9. Collings, R. K. —The Canadian Silica Industry, Dept. of Mines and Technical Surveys, Mines Branch, Ottawa, Memorandum Series No. 134, 1956, 22 pp.

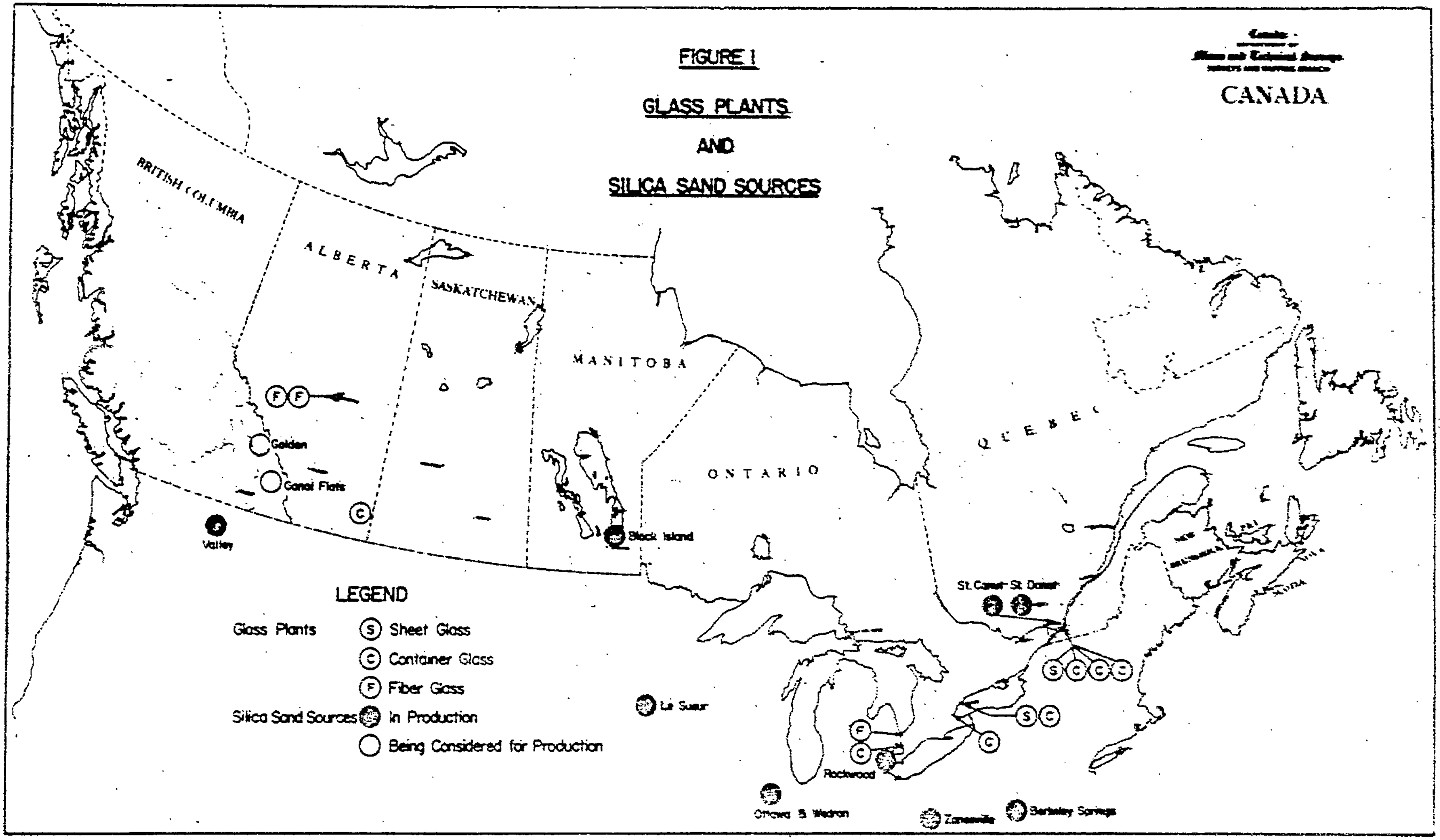

FIGURE I
GLASS PLANTS
AND
SILICA SAND SOURCES
CANADA
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUEBEC
F F
Golden
Canal Flats
C
Valley
Black Island
St. Canut St. Donat
S C C C
S C
C
Le Sueur
F
C
Rockwood
Ottawa & Wedron
Zanesville
Berkeley Springs
LEGEND
Glass Plants
S Sheet Glass
C Container Glass
F Fiber Glass
Silica Sand Sources
In Production
Being Considered for Production

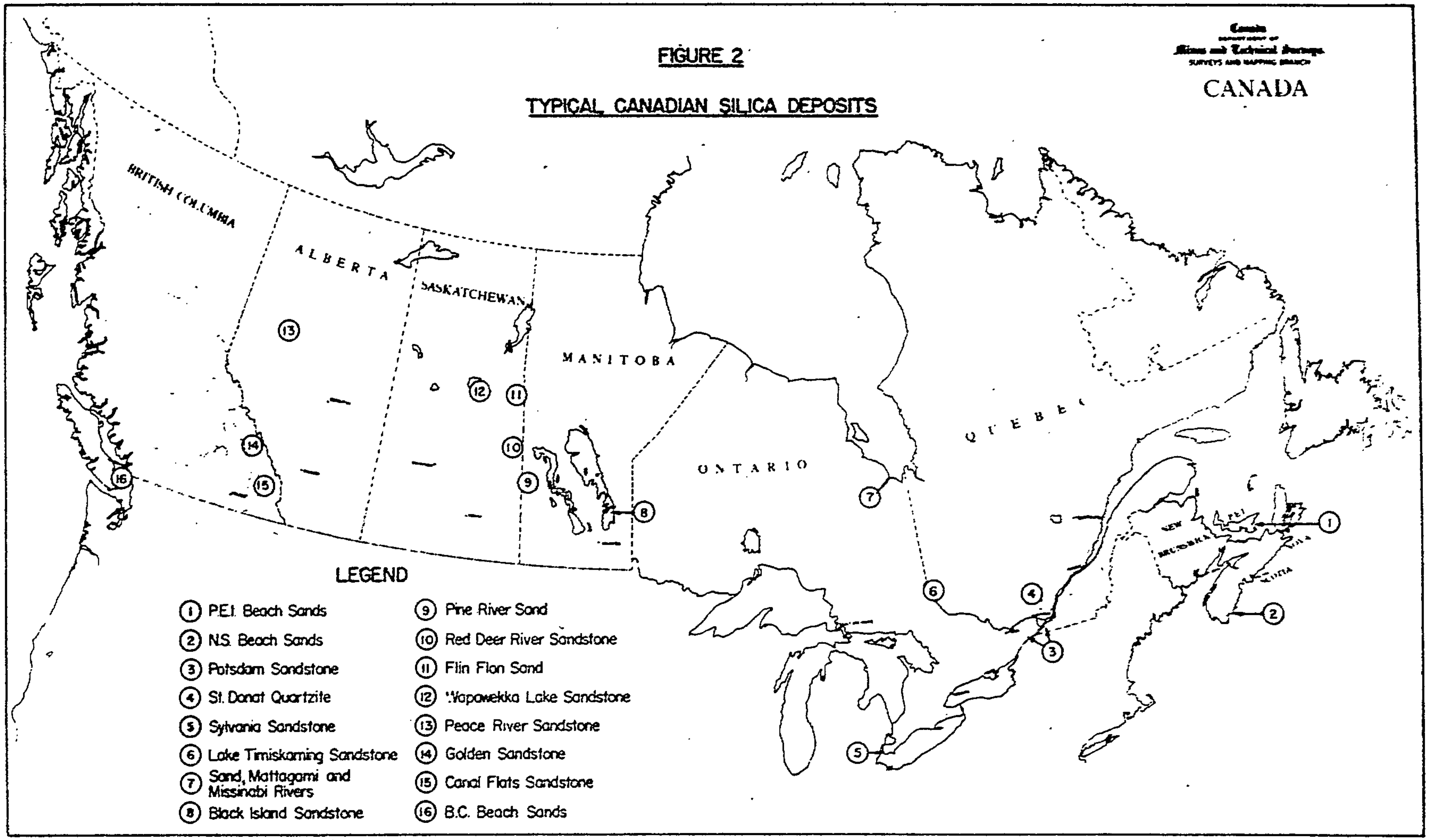
FIGURE 2
TYPICAL CANADIAN SILICA DEPOSITS
CANADA
BRITISH COLUMBIA
ALBERTA
SASKATCHEWAN
MANITOBA
ONTARIO
QUEBEC
NEW BRUNSWICK
P.E.I.
LEGEND
1 P.E.I. Beach Sands
2 N.S. Beach Sands
3 Potsdam Sandstone
4 St. Donat Quartzite
5 Sylvania Sandstone
6 Lake Timiskaming Sandstone
7 Sand, Mattagami and Missinabi Rivers
8 Black Island Sandstone
9 Pine River Sand
10 Red Deer River Sandstone
11 Flin Flon Sand
12 Wapawekka Lake Sandstone
13 Peace River Sandstone
14 Golden Sandstone
15 Canal Flats Sandstone
16 B.C. Beach Sands