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Limestone (Crystalline Marble) in the Parry Sound - Huntsville Area

by

C. Marmont

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V.G. Milne

V.G. Milne, Director
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Foreword

The economic importance and value of industrial minerals is continually increasing and a resurgence of interest in industrial mineral commodities is taking place. This resurgence has underlined the need to increase efforts to compile and publish information on the industrial mineral deposits of Ontario.

Industrial mineral and building stone production in the Huntsville - Parry Sound area is currently limited to aggregate and flagstone, but in the past, small amounts of silica, feldspar, mica and limestone have been produced. Considerable interest is currently being shown in a number of graphite deposits. The geology of the area is complex and the greater part has not been mapped geologically. Consequently, the mineral potential of the area has not been fully assessed.

The study area has good infrastructure and is favourably located to supply raw materials to the industries of the Great Lakes Basin.

This report presents some of the results of the second year's work of a three-year programme designed to evaluate the industrial mineral, rare element and building stone potential of the Parry Sound - Huntsville area. It should be of interest to the minerals industry, and to local municipalities and developers.

V.G. Milne
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Thanks are due to Mr. Hans Meyn, Dr. Janet Springer, Mr. D.J. Villard, and Mr. P.M. Zuberec whose critical reviews helped improve the manuscript.

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Abstract

This report presents the results of investigations conducted on limestones in the Parry Sound area during 1987. This was the second year of a three-year programme to evaluate the industrial minerals and building stone potential of parts of the Muskoka, Parry Sound and Nipissing districts. Limestones in this area have been metamorphosed to crystalline marbles of upper amphibolite and granulite facies, and all are tectonic breccias containing lithic inclusions and disseminated silicate minerals. Most are calcitic, a few dolomitic. Several occurrences are probably capable of sustaining operations to produce agricultural limestone and other products whose economic return depends on sale of large tonnages. It may be possible to beneficiate the marbles to produce filler grade calcite of higher sale value, but it will be difficult to compete with established producers operating with rather purer limestones.

The area has good infrastructure and is well located to service the industrial complexes of the Great Lakes Basin.

SUMMARY

This report describes the results of work performed on limestone during 1987. It represents a part of the second year's work of a three-year programme to evaluate the industrial minerals potential of the District of Parry Sound and parts of the districts of Muskoka and Nipissing. Separate reports cover work performed on feldspar and building stone.

Most of the "limestones" in the study area are located within the "Parry Sound Domain" which is the centre of three major thrust units identified in the Ontario segment of the Central Gneiss Belt of the Grenville Structural Province. The limestones have been metamorphosed to crystalline marbles of upper amphibolite and granulite grade, and all are tectonic breccias containing a variety of lithic inclusions and disseminated non-carbonate minerals.

During 1987 many of the known marble occurrences were visited and sampled, and one occurrence was mapped in detail. The regional survey indicated that dolomite and magnesian calcites are restricted to the southern part of the Parry Sound Domain; the rest are calcitic. Strontium values range up to 3750 ppm and are commonly in excess of 1500 ppm. Heavy metal values are low.

Most occurrences are too small or too impure to support economic development. However several larger prospects and occurrences exist which contain relatively small amounts of inclusions and disseminated non-carbonate minerals. These could be developed for local use as aggregate, agricultural limestone, for lake liming or for tailings ponds neutralization. It would be difficult for these limestones to compete with existing producers of high quality filler grade material.

CONCLUSIONS

During the 1987 field season, many of the known limestone (marble) occurrences in the Parry Sound Domain were visited and sampled; and one occurrence was mapped in detail. The results of field examination, analytical and petrographic studies, and review of assessment file data indicate that all the occurrences visited to date are marble tectonic breccias. Thus all are contaminated to some degree with various disseminated silicate minerals, graphite, spinels and brucite; as well as rock fragments of diverse composition ranging in size from a few millimetres to several tens (or even hundreds) of metres.

Most are calcitic, but dolomite and magnesian calcites occur in the southern part of the Parry Sound Domain. Strontium values

range up to 3750 ppm. The acid insoluble content of marbles free of lithic inclusions is apparently random and ranges from over 40% to less than 5%. Analytical values of heavy metals are low.

There is no geological or technological reason why these carbonates could not be processed to produce a filler grade material. The most serious problem is probably the presence of graphite whose smearing upon crushing would discolour the fine product (Holz, 1983). However, whether such beneficiation could be done economically, involving as it does the processing of a large amount of waste material at the quarry and the mill, is another matter. Some of the marble occurrences could be used as sources of aggregate; as agricultural limestone; or for neutralizing lakes or tailings ponds; as poultry grit; and asphalt filler (Scott and Dunham, 1984). In these applications little or no processing need be undertaken and discolouration would not be important, but transportation costs would limit their use to local markets.

Of the occurrences known to the author, the following appear to be of reasonable size and contain a lower proportion of disseminated non-carbonate minerals and lithic inclusions:

Ferguson Township, Con. 8, lot 12;

McKellar Township, Con. 9, lot 7 west end of Oliver Lake;

Ryerson Township, Con. 5, lots 28-30;
Spence Township, Con. 5, lot 33;
Hagerman Township, Con. B, lot 32.

The Ferguson and Hagerman deposits are partially stripped, and amenable to bulk sampling as a first test. The other deposits require stripping and/or pitting and/or drilling to be properly evaluated.

Other smaller occurrences which appear to be relatively clean, and which form topographic highs readily amenable to exploration and possible later quarrying are:

Croft Township, Con. 10, lot 32 (sample 0375, Map 1).
Hagerman Township, Con. 8, lot 35 (sample 0379, Map 1).
Croft Township, Con. 5, lots 20-21 (sample 0373, Map 1).

Satterly (1943) mentions that an occurrence in Ferrie Township, Con. 3, lot 1 is of a reasonable size and fairly clean. This has not yet been visited.

Insufficient work has been performed to date to fully assess the potential of the dolomitic marble band in Christie Township, Con. 11, lot 10; and a small number of occurrences have yet to be visited in Ferrie, McKellar, Lount, Monteith and Pringle townships.

RECOMMENDATIONS

An ideal marble deposit contains a minimal amount of non-carbonate impurities; has either a high calcium or high magnesium composition; is readily accessible and not far removed from markets; and is reasonably large, with positive relief suitable for open pit mining methods. If a deposit is capable of producing products of high value, any lower grade material present may still be recoverable as lower value products such as agricultural limestone. However, if the deposit contains only moderately pure limestone, it may not be economically feasible to mine it at all.

Many marbles in the Parry Sound area meet all of the above requirements except for the first - purity. Although some deposits clearly contain zones of very coarse-grained, clean calcite, the bulk composition of the deposits tends to be of lower quality. This was clearly demonstrated in the Lount Township occurrence, Con. 1, lot 26; at the former Burcal Mines Ltd. pit in Spence Township, and at the former Cononaco Mines Ltd. pit in Hagerman Township, Con. A, lot 33. In each case the amount of impurities proved to be greater than initially indicated. While it may be technologically feasible to produce reasonably high quality products from these marbles (for example, neither Burcal nor Cononaco employed magnetic or

flotation circuits in their mills), it may not be economically feasible to pass such a great amount of waste through the mill. It remains therefore to identify a deposit of reasonable purity, if the production of high quality products is to be considered. There is no geological or technical reason why any of several deposits described in this report could not be developed as sources of agricultural limestone, aggregate or tailings ponds neutralizers.

The prospective developer should attempt to get a good estimate of the purity of the deposit at an early stage. This is best done by stripping fairly large areas and washing off the exposed limestone. Sections can then be measured across the deposit to ascertain the proportion of inclusions present, and the purity of the marble itself. Bulk samples can then be collected for analysis. If results are satisfactory, drilling might be warranted to ensure that the deposit maintains its grade and width at depth.

Some market research should also be undertaken by prospective developers to determine whether a large enough market exists in the local area capable of supporting the production of low value products from these deposits. The possibility still remains that some occurrences may contain purer material which could be capable of producing higher value products.

Future work planned by the author for the coming field season entails completing the regional survey, visiting and sampling occurrences not yet checked. No detailed mapping of individual marble occurrences is planned. A pilot beneficiation test could be considered to evaluate the improvements possible by wet processing the marble, and to determine the potential quality of the ground product.

LIMESTONE (CRYSTALLINE MARBLE) IN THE PARRY SOUND - HUNTSVILLE AREA, ONTARIO

C. Marmont. (1).

INTRODUCTION

This report describes some of the results of the second year's work in a three-year programme to evaluate the industrial minerals potential of the District of Parry Sound and parts of the districts of Muskoka and Nipissing. The programme is funded under the terms of the Canada-Ontario Mineral Development Agreement (COMDA). This report discusses work performed on limestone (crystalline marble). Separate reports cover work conducted on feldspar, including anorthositic rocks (calcium feldspar), and pegmatite (potash feldspar and soda spar); and building stone (gneiss). The results of the 1986 programme have been presented by Marmont and Johnston (1987).

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The purpose of investigating limestone in this area is to determine the distribution of calcitic and magnesian varieties; to locate areas containing a minimal amount of mineral and rock impurities, and which are of a size potentially capable of sustaining some level of economic exploitation; to indicate the means of processing the marble; and to outline the industrial and agricultural applications for which it is potentially suited.

Carbonate rocks find a wide range of industrial applications as a consequence of their physical and chemical characteristics. The raw material for these products may be unmetamorphosed limestone ($CaCO_3$) or dolomite ($CaCO_3.MgCO_3$); carbonatite (an igneous carbonate rock commonly containing significant amounts of niobium, phosphorus and rare-earth elements); or marble (metamorphic crystalline dolomite, limestone or carbonatite). These raw materials may be processed for diverse uses (Scott and Dunham, 1984):

A/ Construction Industries.

Some varieties are cut and polished for use as dimension stone, some are crushed for use in landscaping, terrazzo flooring and facings on prefabricated concrete panels. Much is used as aggregate in concrete and in road building. Sources for dimension stone applications should be attractive in colour and/or texture, contain few fractures or joints, generally be fine grained (the grains in coarser grained varieties may not be tightly held together and the rock may crumble), and contain minimal amounts of silicate minerals (the contrast in hardness between silicates and carbonate hinders the development of a good polish). Crushed varieties need not be particularly pure, but should be bright.

B/ Filler and Extender Industries

Crushed and pulverized carbonates find considerable use as fillers and extenders in a wide range of materials. The purest grades of brilliant white go into paint, plastics and putty, less pure grades into carpet backing and asphalt products. The desirable properties of pulverized carbonate in these applications include whiteness, low abrasiveness (ie. lack of silicate impurities), inertness in non-acid applications, compatibility with paint pigments, and ability to modify flow characteristics in certain plastics (Harben and Bates, 1984).

C/ Chemical Applications

A considerable amount of high calcium limestone is calcined to produce lime (CaO) for cement manufacture. Some lime is converted to hydrated lime (Ca(OH)2). Lime has a very wide range of uses: it is used as a flux in steel making; in alkalies, soda ash and other chemical products; in glassmaking; as a soil stabilizer and acid neutralizer in agriculture, mine tailings ponds, etc; as a scrubber to remove sulphur dioxide from flue gases; in treating pulp for paper manufacture; in sugar refining. For these applications purity is the most important requirement, and low magnesium content is usually preferred, particularly in North America.

During 1986, fieldwork focussed on the detailed geology of two formerly producing marble properties (Cononaco Mines Ltd. in Hagerman Township, and Burcal Mines Ltd. in Spence Township) in order to understand those operations and the reasons for their cessation. It seems that more non-carbonate mineral impurities were present than perceived initially; and that the simple dry milling systems employed (crushing-grinding-classifying) could not adequately purify the material. However, it was concluded that modern milling processes could probably produce a medium- to high-grade filler material from these marbles (Holz, 1983). Purer deposits than the two mined may exist and form better starting materials for future ventures.

The object of the 1987 field season was therefore to compile the regional distribution of the marble units; to determine their regional chemical characteristics (calcic or magnesian carbonate); the size of the different occurrences; and their purity, ie. the amounts of acid-insoluble disseminated silicates and lithic inclusions.

During the year, a specific request was received regarding the suitability of local limestones as a source of agricultural lime. A report was compiled on this subject and released for viewing in October, 1987 (Open File Map 72, Marmont, 1987). That report has been revised and is incorporated in this report.

GENERAL GEOLOGICAL INFORMATION.

In the Parry Sound - Huntsville area most of the carbonate occurrences are found in the Parry Sound Domain (Davidson et al., 1982), although minor occurrences are known in the underlying and overlying tectonic units. All are marble tectonic breccias, metamorphosed to upper amphibolite or granulite facies. They contain variable amounts of disseminated silicate mineral impurities and variable proportions of lithic inclusions (Marmont and Johnston, 1987). Map No. 1 accompanying this report shows the location of known limestone or marble (*) bands in the area, and the sites of samples analysed. This map has been compiled largely from previous information (Satterly, 1942; Lacy, 1961; Hewitt, 1967 and Davidson et al., 1982). Additional detail has been provided in the Dunchurch-Arnstein area by the mapping of Bright (1987) and McRoberts and Tremblay (1988).

Analytical results are shown in appendices 1 and 2.

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* Since industrial and agricultural users of calcitic and dolomitic rock use the term "limestone" no matter whether the rock is a sediment or a metamorphic "marble", the term "limestone" will be used in this report to refer to any carbonate rock or its ground-up product.

The "limestones" in the Parry Sound area are, geologically speaking, really marbles; that is, metamorphosed limestones. This means that the original limestone beds, which were deposited on an ancient seafloor as fine-grained, chalky sediments similar to those of southern Ontario and Manitoulin Island, have been recrystallised under conditions of extremely high temperature and pressure to form coarse-grained crystalline marble. During this metamorphism, the marbles of the Parry Sound District became contaminated with non-carbonate mineral grains such as quartz, feldspar, olivine, tremolite, diopside, garnet, scapolite, apatite, mica and serpentine amongst others. In addition, rock fragments from overlying and underlying rock units were incorporated into the marble bands in the course of folding and shearing which accompanied the "Grenville Orogeny" - an ancient period of mountain building. These rock and mineral impurities are clearly visible in most limestone outcrops in the area, and are the main reason why no sustained development has taken place in the past. Furthermore, in contrast to the extensive, flat-lying limestones of southwestern Ontario, most local limestones occur as relatively thin bands which pinch and swell, and dip below overlying country rocks. To exploit them would necessitate the removal of large volumes of waste rock. The complex and relatively unpredictable geology makes quarrying difficult, and the mineral and rock impurities put the local marbles at an economic disadvantage when compared with the larger, cleaner deposits in southern and eastern Ontario.

RESULTS OF 1987 WORK.

REGIONAL SURVEY RESULTS.

Map No. 1 in the back pocket shows the distribution of the known marble units in the Parry Sound Domain, and indicates the sites from which samples were collected for lithogeochemical analysis. Most occurrences are poorly exposed and/or appear to have widths of only a few metres or tens of metres. The small occurrences also appear to contain a higher proportion of mineral and lithic inclusions than do the larger occurrences.

Representative samples of marble were collected from sites which contained low to moderate amounts of lithic inclusions. A whole rock analysis was performed on each sample to characterize its major (and, in 1987, its trace) element composition. In addition, the amount of acid insoluble material was determined, and the Ca, Mg, Fe, Mn and Sr contents of the carbonate fraction were determined by Atomic Absorption Spectroscopy or DC plasma-AES. Attempts made in 1986 to determine the composition of the acid insoluble fraction, and non-carbonate carbon contents were thwarted by the small amount of such material left after dissolution of the carbonate. In practice the presence of graphite is best estimated visually in the field, and the composition of the silicate phases best determined petrographically, since it is the physical characteristics of these minerals which are of most relevance to processing of the marble and its potential applications.

All of the limestone samples analysed contain scattered sand-sized grains of silicate minerals, but no non-carbonate rock fragments or inclusions. Therefore these samples indicate only the composition of the limestone component of the limestone breccia bands. If the bands were quarried, the inclusions of gneissic rock would have to be separated by some means in order to maintain the degree of purity indicated by the analyses shown in appendix 1. All of these limestone samples have similar geological characteristics; most are calcitic, but some in Christie and McDougal townships are dolomitic.

Appendix 1 lists the analytical results of samples collected during the 1986 and 1987 field seasons.

DISCUSSION OF RESULTS

Acid Insoluble Residue.

Most industrial applications for carbonate rocks require a material of high chemical and/or physical purity. In the case of high value filler grade products, silicates may act as an undesirable abrasive; graphite will readily smear and severely reduce the brightness of the ground product.

A review of the analytical results presented in this report indicates considerable, and apparently random, variation in the purity of the marbles, as expressed by the acid insoluble values, ranging from less than 5% up to 40%. Many samples returned surprisingly high acid insoluble residues. This is probably due to the presence of light-coloured silicate minerals such as quartz, feldspar and scapolite, whose presence is not so visible in hand sample as darker diopside, olivine, chondrodite and serpentine. The wide variation in purity at individual sites (eg. Starratt, Ryerson Township; Hagerman Township, Con. A, lot 33) is not surprising, since bands with different composition are readily visible in the field. Furthermore, significant error may be introduced during sampling and analysis because of the "nugget effect" of the silicates erratically dispersed through the carbonate. All of these factors combined demand that the user interpret these data with some caution: in order to evaluate a given marble occurrence with a reasonable degree of confidence, a bulk sample taken from the whole width of the deposit is necessary. This problem is discussed further in the section describing the marble occurrence in Con. 1, lot 26, in Lount Township.

Several sites appear to contain small amounts of acid insoluble material, but, as just mentioned, a larger sample might tell a different story. The larger occurrences which contain relatively low levels of impurities are described individually in a following section.

Magnesium

Samples containing more than 2% magnesium are limited to the southwestern part of the Parry Sound Domain. Dolomite has previously been reported from the marble occurrence at Seguin River in Christie Township (Satterly, 1943). Other occurrences containing minor amounts of magnesium may contain magnesian calcite or minor amounts of dolomite. Magnesian samples from Hagerman Township, Con. A, lot 33 and Con. B, lot 32 (eg sample 86CCM-0157) contain brucite and traces of periclase rather than dolomite.

Strontium

Some surprisingly high values of strontium were discovered in many samples. From the limited data available, the strontium values appear to be lowest in the western part of the Parry Sound Domain, and highest in the north and east. The reasons for the high strontium values and their distribution is not known. In the Minden area, Easton (1987) has described some marbles and associated rusty paragneiss and meta-volcanic rocks which contain high levels of strontium, zirconium, yttrium and niobium. He interprets these as an alkaline volcanic and sub-volcanic suite, in which the marbles could be silico-carbonatites. Many of the Parry Sound marbles breccias contain heterolithic inclusions such as anorthosite and syenite; and rusty paragneisses are not uncommon, either flanking or included within the marbles *. However, the Parry Sound marbles contain very low values of zirconium, yttrium and niobium (maximum 18 ppm). Strontium is commonly associated with limestones and marls, and its presence in the Parry Sound marbles probably reflects the original sediments' composition. The strontium values are not a concern for agricultural applications.

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* Footnote: one such inclusion at the former Cononaco Mines Ltd. pit in Hagerman Township, consists of 85% titanaugite, 7% pyrrhotite, 7% calcite, 1% hercynite and minor graphite.

OTHER ELEMENTS

Barium values range up to 700 ppm and show reasonably good correlation with the strontium results.

High lanthanum and cerium values from sample 87CCM-0381 south of Maple Island probably reflect the occurrence of allanite in sheared pegmatite veins in the footwall of the marble band.

No unusual values have been obtained for other elements in the marble samples analysed to date. In fact the values for the base metals and other elements are remarkably low. The analytical results of trace elements are shown in appendix 3.

DETAILED STUDIES

This section describes the main features of the larger marble occurrences. The data are somewhat uneven, reflecting the variable amount of information available for each occurrence. However, because of their size, degree of exposure, and accessibility, the marble occurrences described below represent some of the more prospective sites in the area.

MAPPED OCCURRENCES

Pawlech Occurrence, Spence Township, Con. 5, lot 33.

The Pawlech marble occurrence forms a low ridge over 500 metres long and 200 metres wide, with a relief of up to ten metres. As it is readily accessible and appeared to be more inclusion-free than the former Cononaco Mines and Burcal Mines properties studied the previous year, it was mapped in detail. Map No. 2 in the back pocket shows the outcrop distribution and geology of the Pawlech occurrence. The overburden is a thin veneer of soil and grass generally no more than a few centimetres thick.

The map indicates that although the marble is extensive across the whole ridge, small inclusions are erratically distributed throughout the body. The inclusions consist of varieties of metabasite and granite, and undeformed granitic pegmatite. Large inclusions are limited to the west edge of the ridge, and to the southern end, particularly south of the road. Most are tens of centimetres to a few metres in size.

Within the exposed areas of marble, disseminated silicate minerals are not as prevalent as at some other occurrences. The marble rarely appears to contain more than 5% mineral impurities.

On the basis of this mapping programme it is possible to obtain a crude estimate of the grade and tonnage of marble which is readily accessible at the Pawlech occurrence. The area of the marble unit is approximately four hectares (40,000 square metres), which translates into approximately 120,000 tonnes per vertical metre. This amount is reduced by perhaps 15% in the form of lithic inclusions, leaving approximately 100,000 tonnes per vertical metre of calcitic marble grading 94% calcium carbonate (on the basis of visual estimates and only one analytical result, see appendix 1). Stripping, washing and surface sampling of this occurrence would permit a reasonable estimate of its grade, and the amount of included waste rock fragments.

OTHER OCCURRENCES

Only the Pawlech occurrence was mapped in detail during 1987. However, several others were visited which appear to be of a size and purity capable of sustaining some degree of economic exploitation, albeit perhaps only for low value products such as agricultural limestone. These are described briefly below.

Ferguson Township, Con. 8, lot 12.

Photograph No. 1 shows this marble pit, which is exposed about 500 metres west of the "Bunny Trail" some 8 km north of

Photo 1. View of limestone pit, Ferguson Township, Con. 8, lot 12.

Waubamik. The pit is about 50 metres wide, 80 metres long and contains coarse-grained calcitic marble with tabular layers of metabasite. The latter define a strike of 180 degrees and an easterly dip of 30 degrees. Lesser amounts of white, fine- to medium-grained inclusions of pyroxene-bearing granite also occur. Together, the inclusions constitute some 10-15% of the total rock volume. The marble is generally a fairly bright white colour, but is locally pink. The mafic bands are generally 20-50 cm thick and several metres to tens of metres long, and would be readily separated from the marble. To the south, the marble unit disappears under a swamp. Its northward extent is not known. Analytical results indicate that the marble is fairly clean (see appendix 1).

Hagerman Township, Con. B, lot 32.

This marble occurrence was briefly mentioned by Marmont and Johnston (1987). The occurrence is exposed in two areas about 300 metres east of Highway 124: a southern portion some 140 m long and 80 m wide, and a northern pear-shaped portion with maximum dimensions of 60 by 50 metres. Three discontinuous channel samples were collected from a section across the strike of the southern part of the stripping, and one composite sample was collected from the northern part. These analyses (see appendix 1) indicate acid insoluble values ranging from 4 to 8

Photo 2. View of Limestone Pit, Hagerman Township, Con. B, lot 32.

the pit is 15%. The southern portion of the stripped area could therefore be inferred to contain some 33,000 tonnes of rock per vertical metre, of which approximately 85% is marble grading approximately 94% carbonate.

Lount Township, Con. 1, lot 26.

This occurrence was described by Marmont and Johnston (1987). The results of analyses of representative grab samples collected by the authors in 1986 and 1987 are listed in appendix 1. The occurrence of marble is impressive in the field: very few inclusions are apparent, over an area of several hectares.

Diamond drilling results obtained by Burcal Mines Ltd. in 1969 indicated reserves in the order of one to six million tons, and random sampling of core suggested a grade of 93.95% calcite (Source Mineral Deposit Record, No. 1279). However, metallurgical work performed by Pominex Ltd. in 1980 indicates that the average grade is around 76% $CaCO_3$ (Assessment Files, Resident Geologist's office, Dorset). These values are from four composite samples of fourty-four core samples of five-foot lengths taken over a drilled length of 218 feet (66.5 m) from

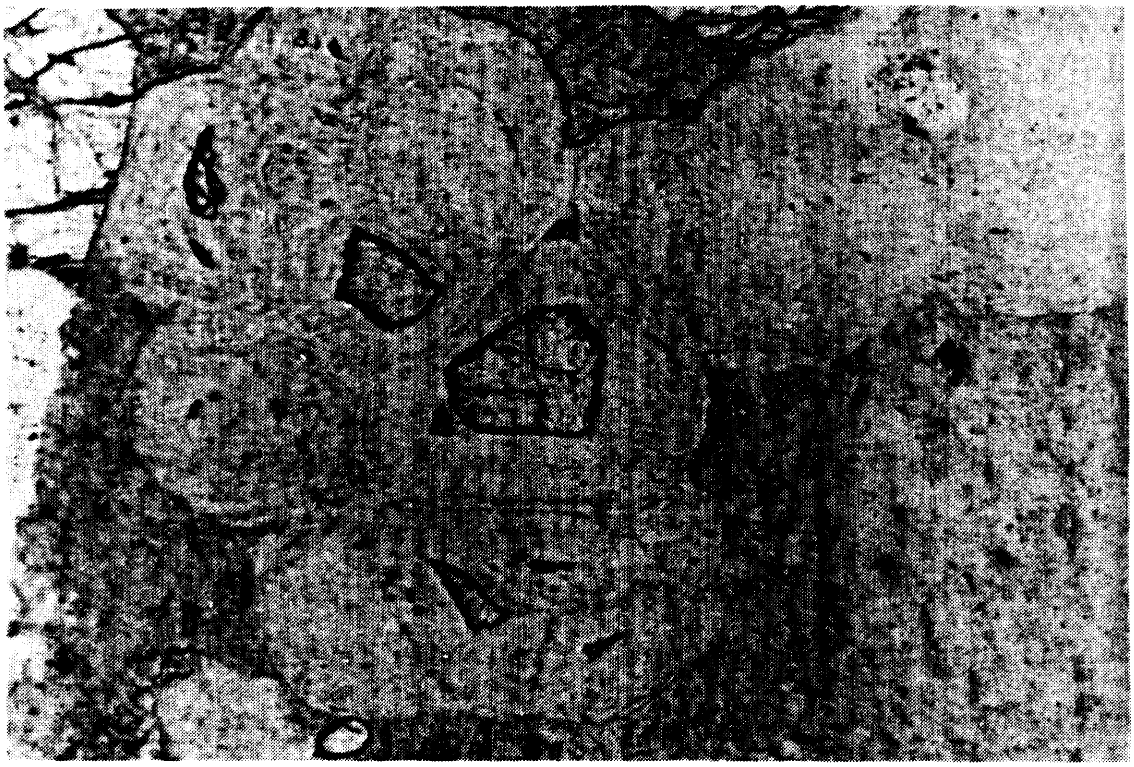
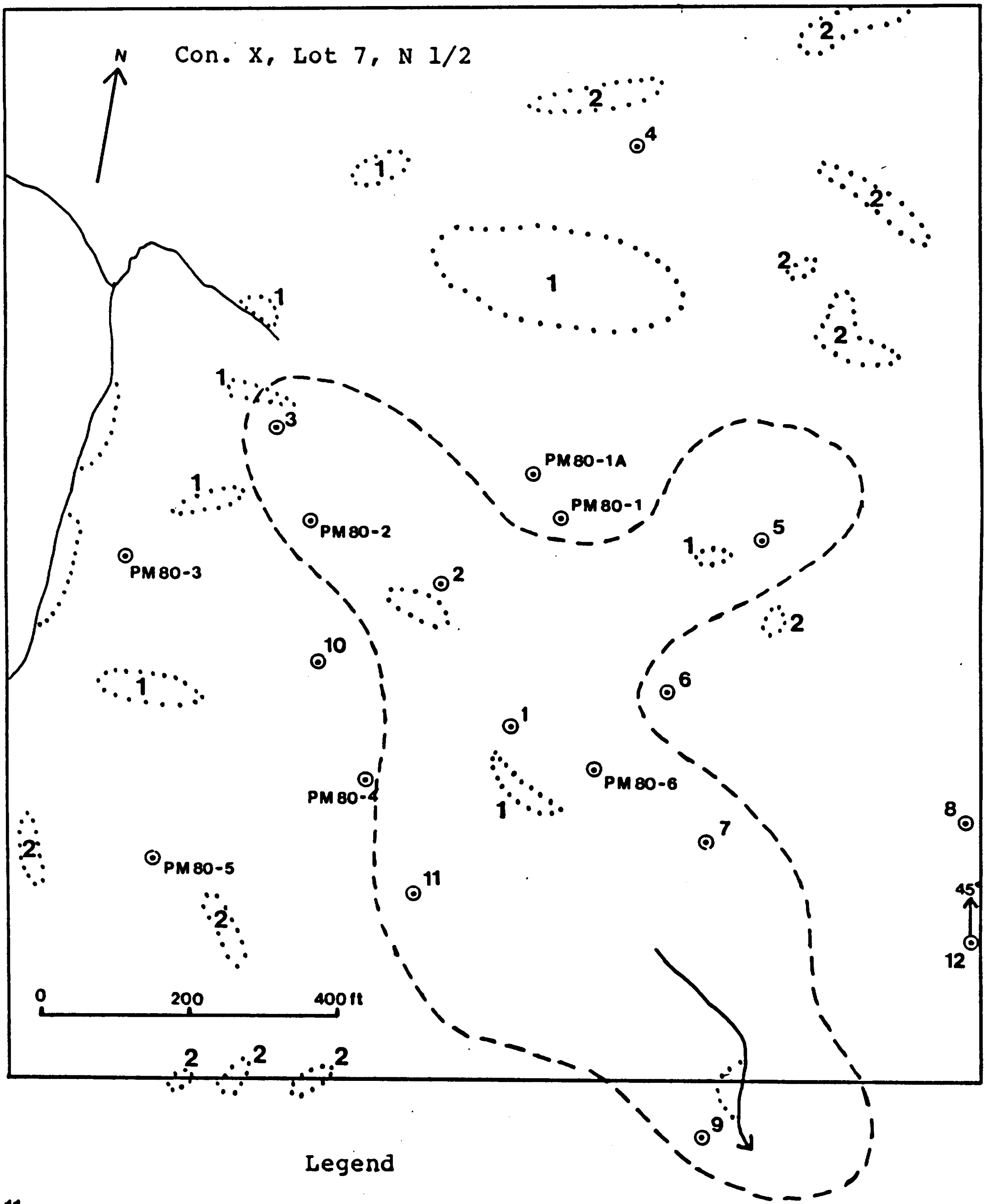


Photo 3. Remnant periclase cores in brucite; with serpentine in calcitic marble, Hagerman Township, Con. A, lot 33.

hole number PL 80-9. These results are lower than the author's own (albeit less rigorous) sampling of surface material, and petrographic examination of rock samples. The latter revealed that lithic inclusions consist of a diopside-bearing granodiorite, scapolite-diopside metagabbro, and diorite. The disaggregated mineral components of these rocks form the bulk of the disseminated silicate mineral impurities. The discrepancy between Pominex's bulk sampling results and visual estimates of purity reflect the fact that the disseminated silicates - quartz, feldspar, scapolite and diopside are all colourless to white and not readily visible in hand specimen. A summary of mineral dressing tests performed on the Pominex drill core is contained in Marmont and Johnston, 1986.

McVittie Property, McKellar Township, Cons. 9 and 10, lot 7.

This prospect has been described by Marmont and Johnston (1987). Diamond drilling programmes completed in 1973-74 and 1980 indicated significant reserves of marble which contained between 8 and 10 percent of mafic inclusions. Two visits were made to the prospect during 1987. The northern part of the area, where the drilling was performed, is accessible by bush road from McKellar, but the southern area is most easily accessible via Oliver Lake by canoe (Map No. 1). Exposure is rather limited, and the best estimate of the prospect's



Legend

O11 Burcal Mines Ltd. Diamond Drill Hole, 1973-74.
OPM80-5 Pominex Ltd. Diamond Drill Hole, 1980.
---- Outline of reserve area
······ Limit of outcrop
1 Marble
2 Metabasite

Source: Assessment Files, Resident Geologist's Office, Dorset.

Figure 1: Diamond Drill Plan, McVittie Prospect, McKellar Township, Concession X, Lot 7, District of Parry Sound.

potential is provided by the data from the two diamond drilling programmes (Assessment Files, Resident Geologist's Office, Dorset). From the results of Burcal Mines Limited's 1973-74 drill programme, Jerome (1974) calculated reserves of approximately 5,000,000 tons to a depth of 150 feet (45 m). This block of rock includes 13.6% waste material in the form of gneissic inclusions, the balance being marble averaging 91.6% calcium carbonate. Six holes were drilled in the same area in 1980 by Pominex Ltd. Although no analytical results are available, drill logs seem to indicate a higher proportion of impure marble and gneiss than recorded by the Burcal drilling results, and graphite was noted throughout.

Some of the coarsest and cleanest calcitic marble (>95% carbonate) yet seen by the author occurs on the shore at the northwest end of Oliver Lake. An analysis of this material is shown in appendix 1 (sample number 87CCM-0253). Some trenching has been done in the area, but no sizeable exposures of marble occur in this area.

Starratt Occurrence, Ryerson Township, Con. 5, lots 28-30.

This occurrence was noted by Satterly (1943) to be one of the more promising marble prospects in the area. The band forms a southward closing syncline, the western limb of which forms a prominent ridge rising some 20-30 metres above the surrounding land. A small pit exposes the marble on the north side of concession road 4. The marble in this pit is fairly clean, with bands of disseminated pyroxene, graphite and larger clasts of plagioclase feldspar. Petrographic examination also revealed the presence of scapolite, titanite, and minor tremolite and trace opaque minerals. The band appears to be about 110 metres wide at this point, but exposure is not good. However, from the lie of the land the overburden appears to be very thin, and that marble would appear to underlie a large portion of the upper part of the ridge. In the footwall on the western side of the ridge are inclusions of hornblende-biotite diorite whose orientation defines a strike of 165 degrees and a vertical to steep easterly dip.

The same band is exposed further north along the road between lots 30 and 31. Here it is friable and crumbly, coarse-grained (8-10 mm), and weathers to a buff colour. The largest exposure here is about 40 metres wide in a ridge up to 6 metres high. The marble contains inclusions of granodiorite and pegmatite, and their dissaggregated mineral products.

The eastern limb of the syncline is poorly exposed across a width of 75 m beside the concession road. Analytical results from samples obtained from the Starratt occurrences are listed in appendix 1.

Burcal Mines Limited, Spence Township, Con. 14, lot 18.

This former calcitic marble mine has been described by Marmont and Johnston (1987). Subsequent to the completion of that report, Mr. James Wade of James Wade Engineering Ltd., Toronto, who purchased the assets of Burcal Mines Limited in 1975, kindly supplied the author with additional diamond drilling information. These data are summarized as follows:

Consolidated Canadian Faraday Ltd. (CCF) obtained an option on the property in 1973. Nine drill holes for a total of 1323 feet tested the "Gray Lease" (parts of Con. 14, lots 18 and 19). An additional hole tested the southern extension of the marble on lot 19, Con. 13. As a result of this work, CCF calculated reserves of 593,333 tons of ore grading 77.939% total carbonates over an area 500 feet long by 222 feet wide, to a depth of 100 feet. Mineral dressing tests indicated recoveries in the range of 88-92% utilizing electromagnetic and flotation processes. The premium product of this process was thought to be suitable for the filler industry yielding an analysis of:

$CaCO_3$	96.68		
$MgCO_3$	1.8		
Al_2O_3	0.18		
Fe_2O_3	0.40		
SiO_2	0.48	Brightness	91.0

It was noted that the "Gray Lease" marble contained relatively little graphite, which adversely affects brightness. Additional information on the mineral dressing testwork is provided in Marmont and Johnston, 1987.

During 1987 the author visited and sampled several nearby marble occurrences, but none was sufficiently clean to warrant more detailed work. All contain a high proportion of lithic inclusions.

AGRICULTURAL LIMESTONE (AGLIME) STUDY

INTRODUCTION

Following a specific enquiry directed to the office of the Resident Geologist, Algonquin District, in Dorset, research was undertaken to determine whether local marbles are suitable for agricultural applications. The conclusion reached was that local limestones are suitable for agricultural applications. However, prospective quarry operators should be aware of potential complications arising from rock and mineral impurities, and erratic variations in the continuity and thickness of limestone bands.

The presence of limestone in the Parry Sound District has been known since the late nineteenth Century, and it has been exploited in the past for agricultural applications: small kilns operated in Lount, Hagerman, Croft and McDougall townships early in the 20th century to produce lime for agricultural use.

Because of its lower cost, crushed limestone is generally used to lime fields, rather than slaked lime, even though the latter has a faster acid neutralizing action, and, weight for weight, has a greater neutralizing capacity than crushed limestone. The current report deals only with crushed limestone.

A limestone is a rock composed largely of the mineral calcite ($CaCO_3$ - calcium carbonate). Some calcites contain a few percent of magnesium and are referred to as magnesian calcite/limestone. When there is abundant magnesium available, a distinct mineral is formed, known as dolomite - $Ca,Mg(CO_3)_2$. The pure magnesium carbonate mineral is known as magnesite.

DISCUSSION OF RESULTS

The short answer to the question, "Is local limestone suitable for agricultural liming?", is "Yes". The following paragraphs describe the chemical characteristics of the limestone, and discuss some of the potential problems involved in exploiting them.

Samples of limestone from the Arnstein area were submitted to the Department of Land Resource Science, Ontario Agricultural College, University of Guelph for analysis of their calcium and magnesium carbonate contents, acid insoluble fraction (waste material), and determination of their neutralizing value. All samples were crushed to minus 60 mesh before analysis. The results are shown in table 1. In addition, numerous samples of limestone were collected for analysis from other parts of the Parry Sound area during 1986 and 1987. These results are shown in appendix 1. The neutralizing values have been calculated for all these samples and are also listed in appendix 1.

Many of the neutralizing values shown in appendix 1 compare favourably with the NEUTRALIZING VALUES of currently available commercial limestone products (see appendix 4). Direct comparison, however, between the AGRICULTURAL INDEX of the Parry Sound samples and currently available commercial products is not possible until a local commercial product has been produced, because the Agricultural Index is a measure of the PARTICLE SIZE of a limestone (smaller particles have a greater surface area available for reaction than do larger particles, and consequently dissolve more quickly), as well as its NEUTRALIZING VALUE (a measure of the calcium and magnesium carbonate contents of the limestone). Thus, until the grain size distribution of a new product is known, its agricultural index cannot be determined.

The method of calculating the neutralizing value and the Agricultural Index is appended to this report, and is also explained in publications of the Ontario Ministry of Agriculture and Food (OMAF) listed in the references at the end of this report. In addition, figures 1 and 2 have been constructed as a fast alternative to calculating these values from chemical analyses.

The Ontario Ministry of Agriculture and Food recommends a minimum Agricultural Index of 75.

In the case of local impure limestones, it may be practicable to accept a lower quality product, with a higher waste silicate mineral content rather than spend money attempting to upgrade the purity of the limestone by crushing and screening. When serving local markets, the cost of transporting the waste material may be bearable, but naturally this will become more critical as the material is trucked over greater distances. The waste mineral silicates are natural components of local soils and are not detrimental to the land. Appendix 6 lists, and shows the locations of quarries supplying agricultural limestone in central and southern Ontario, as listed by the

Ontario Ministry of Agriculture and Food. Two other operating quarries-Dymond Clay Products in Haileybury and Bolender's at Eagle Lake are also shown.

Because magnesium has a lower atomic weight than calcium, magnesian limestones and dolomites may have neutralizing values greater than 100. Thus, weight for weight, magnesian varieties have a greater neutralizing effect than calcitic ones. Some land in the Powassan area is deficient in magnesium, and in this area dolomitic limestone is recommended as a cure for both acid soil and magnesium deficiency. Furthermore, some crops can be grown locally with great success without the addition of lime (appendix 5). Farmers should consult their local OMAF Agricultural Representative for additional guidance on the desirability of liming and/or fertilizing specific crops in each particular area.

Table 1. Neutralizing Value of Limestone Samples from the Arnstein Area.

Sample Number	%Ca	%Mg	Acid Ins.	Neutralizing Value
87CCM-0250	41	<0.1	4	96
87CCM-0251	38	<0.1	6	94
87CCM-0253	41	<0.1	1	99
87NAW-0008	35	<0.1	15	85

87CCM-0250 East Mills Township, Con. 7, Lot 23, 100 m east of Quarry.

87CCM-0251 East Mills Township, Con. 7, Lot 23, Le Grou Lake Rd. Quarry.

87CCM-0253 Pringle Township, Quarry, Con. 11, Lot 23.

87NAW-0008 Pringle Township, Con. B, Lot 168.

Conclusions

Limestones in the Parry Sound area are suitable for use in agricultural applications in that their chemical composition is appropriate for neutralizing acidic soils. Whether they can be successfully exploited will depend on the economics of quarrying, crushing (possibly removing impurities), and transportation.

Transportation costs from Dundas to the northern part of the Parry Sound District are in the order of $16.00 per tonne, while from Orillia they are around $13.00 per tonne. The present limestone transportation subsidy of 70% of the transportation cost has a maximum of $1,200.00. If a farmer required, say, 300 tonnes of limestone, the balance of his transportation bill would still be between $2,400 and $3,600. If local sources of limestone could be utilised, total transport costs could be in the range of $2.00 - $5.00 per tonne (ie $600-$1500 for 300 tonnes); a significant saving to the farmer.

Local sources of supply have additional advantages over more distant sources: smaller truckloads can be obtained on demand by the farmer, and spread onto the fields, rather than being brought by tandem-trailer and dumped for subsequent rehandling and spreading.

Before it can be marketed as agricultural limestone, a new product must be shown to comply with the provisions of the Fertilizer Act, and be tested by the Plant Products Branch of Agriculture Canada, Haileybury, which checks the agricultural index and tests for the presence of toxic heavy metals. Samples collected during 1987 were tested for heavy metals and none proved significant (results are shown in appendix 2).

Additional benefits may arise as a result of the development of local limestone pits. Local pits will create more employment and spending in the local community. Major reductions in haulage costs should reduce the farmers' costs significantly, permitting him to purchase more lime, perhaps for use on fields that would otherwise fall into disuse. Increased productive acreage would again result in more local employment.

Development of local limestone pits for agricultural purposes may stimulate the upgrading of processing facilities to produce pulverised limestone for non-agricultural applications, for example, in cement, as a flux, mineral filler, etc.

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APPENDICES

APPENDIX 1.

Major Element Chemistry and Neutralizing Values of Limestones in the Parry Sound Area.

Chemical Analyses and Neutralizing Values of Some Limestones in the Parry Sound Area

a	b	c	d	e	f	g	h	i	j
		Carbonate composition expressed as percentage of whole rock							
Sample Number	Acid Insoluble	Carbonate CO2	CaO	MgO	Fe2O3	MnO	Sr(ppm)	Total	Neutralizing Value
86CCM-0114	24.30	31.60	34.00	10.60	0.85	0	189	101.37	87.01
86CCM-0116	0.62	47.10	30.40	20.60	1.12	0.20	67	100.05	105.41
86CCM-0117	2.13	43.10	51.20	3.40	0.04	0.01	484	99.93	99.83
86CCM-0118	11.60	38.50	43.80	4.60	0.37	0.01	447	98.92	89.60
86CCM-0160	8.06	42.30	48.00	1.80	0.21	0.01	183	100.40	90.15
86CCM-0161	5.97	41.60	50.00	2.40	0.43	0.08	680	100.55	95.21
86CCM-0162	9.89	38.60	51.00	0.20	0.03	0.05	2054	99.98	91.53
86CCM-0034	0.68	43.60	53.50	1.80	0.04	0.01	1025	99.73	99.97
86CCM-0037	1.25	43.20	53.00	1.80	0.14	0.01	984	99.50	99.07
86CCM-0155	1.35	43.30	52.50	2.10	0.15	0	1167	99.52	98.93
86CCM-0156	10.90	37.60	46.00	7.50	0.30	0	528	102.35	100.73
86CCM-0157	18.70	26.20	31.00	17.20	0.48	0	I.S.	93.58	98.04
86CCM-0166	3.59	41.60	52.60	1.20	0.33	0.01	1127	99.44	96.87
86CCM-0167	6.40	40.50	50.80	1.20	0.24	0.01	1198	99.27	93.66
86CCM-0073	14.10	37.90	50.50	0.30	0.40	0	2405	103.44	90.89
86CCM-0169	2.79	43.20	50.80	3.00	0.50	0.02	210	100.33	98.13
86CCM-0137	2.02	43.80	44.20	9.20	0.21	0.02	212	99.47	101.74
86CCM-0164	0.50	43.80	58.60	0.60	0.03	0.02	479	103.60	106.09
86CCM-0062	40.60	25.00	32.00	0.50	1.34	0	954	99.54	58.36
86CCM-0065	0.30	43.80	54.60	1.20	0.01	0.01	993	100.02	100.44
86CCM-0066	1.70	43.20	55.00	1.10	0.13	0	1041	101.23	100.91
86CCM-0067	12.50	38.60	51.00	0.70	0.48	0	750	103.36	92.77
86CCM-0074	4.40	41.80	52.00	1.20	0.64	0.01	1015	100.15	95.80
86CCM-0075	8.11	39.80	50.00	1.00	0.47	0.01	934	99.48	91.73
86CCM-0076	9.14	39.90	48.80	1.40	0.43	0.02	909	99.78	90.58
86CCM-0263	2.38	42.90	54.00	1.60	0.30	0.01	1022	101.29	100.36

Analyses by Ontario Geological Survey, Geoscience Laboratories, Toronto, Ontario.

Cation determinations by AAS.

CO2 by Coulometry

j = (1.785 x d) + (2.483 x e) ie normalizes carbonate CaO and MgO content of whole rock sample to CaCO3 equivalent.
(Where one % of CaCO3 = one unit of neutralizing value.)

Chemical Analyses and Neutralizing Values of Some Limestones in the Parry Sound Area.

a	b	c	d	e	f	g	h	i	j
Sample Number	Acid Insoluble	Carbonate Composition Expressed as Percentage of Whole Rock CaO	MgO	Fe2O3	MnO	Sr(ppm)	CO2	Total	Neutralizing Value
87CCM-0250	11.60	45.78	0.206	0.368	0.015	1820	36.51	94.66	82.27
87CCM-0252	8.00	47.88	2.719	0.615	0.026	578	41.04	100.33	92.26
87CCM-0253	12.20	47.74	0.632	0.395	0.015	3750	38.53	99.89	86.83
87CCM-0332	4.60	51.94	1.051	0.386	0.013	1530	42.28	100.43	95.37
87CCM-0332	9.60	45.78	0.675	0.483	0.025	687	37.09	93.72	83.44
87CCM-0333	16.20	43.68	0.836	0.852	0.034	701	35.81	97.49	80.08
87CCM-0335	15.80	44.52	0.322	0.805	0.023	2160	35.89	97.57	80.31
87CCM-0337	31.60	35.84	0.361	1.559	0.063	505	29.52	99.00	64.91
87CCM-0338	4.60	52.08	0.347	0.302	0.014	1760	41.58	99.10	93.87
87CCM-0339	19.80	43.82	0.433	1.316	0.037	2510	35.74	101.40	79.34
87CCM-0342	19.40	42.00	0.504	1.027	0.037	1960	34.23	97.39	76.26
87CCM-0343	27.00	40.88	0.056	0.768	0.018	3300	32.72	101.77	73.15
87CCM-0344	25.40	39.20	0.043	0.452	0.028	2730	31.21	96.60	70.12
87CCM-0349	5.80	48.58	1.560	0.265	0.014	874	40.13	96.44	90.63
87CCM-0351	7.40	49.00	3.233	0.782	0.043	271	42.57	103.06	95.53
87CCM-0352	3.40	52.50	0.478	0.049	0.013	265	41.91	98.38	94.95
87CCM-0355	15.00	47.88	0.625	0.516	0.026	388	38.70	102.79	87.06
87CCM-0356	13.10	44.10	0.492	0.824	0.028	1490	35.75	94.45	79.98
87CCM-0357	13.00	44.52	1.000	0.539	0.018	1370	36.48	95.69	81.99
87CCM-0358	19.20	44.80	0.734	0.363	0.017	892	36.31	101.52	81.83
87CCM-0359	21.00	42.56	0.771	0.967	0.036	994	34.93	100.36	77.92
87CCM-0360	6.60	47.32	0.811	0.601	0.022	1010	38.51	93.96	86.52
87CCM-0368	4.80	51.66	0.262	0.403	0.032	1160	41.21	98.49	92.91
87CCM-0373	4.00	50.12	3.631	0.146	0.014	170	43.53	101.46	98.52
87CCM-0374	6.40	51.38	1.053	0.889	0.037	918	42.12	101.97	94.38
87CCM-0375	5.80	49.14	0.415	0.310	0.018	2170	39.35	95.25	88.79
87CCM-0378	12.00	47.18	0.504	0.552	0.023	2240	38.04	98.52	85.51
87CCM-0379	15.00	45.08	0.595	0.432	0.028	312	36.42	97.59	81.99
87CCM-0380	3.60	53.90	0.555	0.100	0.014	196	43.13	101.32	97.64
87CCM-0381	9.20	45.64	2.089	0.330	0.014	1330	38.43	95.84	86.69
87CCM-0383	6.00	42.84	6.400	0.285	0.022	606	40.91	96.51	92.38
87CCM-0384	6.00	45.78	4.609	0.246	0.010	717	41.24	97.96	93.19
87CCM-0385	4.60	43.96	5.306	0.450	0.035	696	40.68	95.11	91.67
87CCM-0386	5.20	48.02	0.930	0.307	0.022	1020	39.03	93.61	88.07
87CCM-0387	7.90	49.98	0.963	0.307	0.018	1480	40.60	99.92	91.65
87CCM-0388	5.00	51.24	1.607	0.286	0.017	1460	42.28	100.58	95.50
87CCM-0390	21.40	40.60	0.429	0.528	0.030	1440	32.77	95.90	73.58
87CCM-0399	16.20	41.72	0.295	0.682	0.018	2220	33.59	92.73	75.24
87CCM-0400	10.40	47.74	0.270	0.569	0.019	2100	38.23	97.44	85.93
87CCM-0402	18.60	42.14	0.589	1.263	0.027	2020	34.56	97.38	76.72
87CCM-0407	30.20	37.94	0.104	0.423	0.012	1900	30.27	99.14	68.02
87CCM-0409	32.80	38.78	0.116	0.160	0.008	2570	30.80	102.92	69.55
87CCM-0411	21.70	40.32	0.517	0.408	0.015	2740	32.58	95.82	73.29

Analyses by Bondar-Clegg and Co. Ltd., Ottawa.

* Determined by Department of Land Resource Science, Ontario Agricultural College, University of Guelph.

Columns c, d, e, f, g determined by DC Plasma-AES.

Column h calculated from columns c to g, assuming all five elements occur as carbonate.

Column j = (c x 1.786) + (d x 2.48)

Sample Locations (see also Map No. 1 in back pocket)

86CCM-0034 Hagerman Tp. Con. A, lot 33.
86CCM-0037 Hagerman Tp. Con. A, lot 33.

86CCM-0062 Spence Tp., Con. 14, lot 18; Burcal Mines Ltd.
86CCM-0065 Spence Tp., Con. 14, lot 18; Burcal Mines Ltd.
86CCM-0066 Spence Tp., Con. 14, lot 18; Burcal Mines Ltd.
86CCM-0067 Spence Tp., Con. 14, lot 18; Burcal Mines Ltd.

86CCM-0073 Lount Tp., Con. 1, lot 26.

86CCM-0074 Burcal Mines Ltd., Burks Falls Mill; 1/4" crushed marble.
86CCM-0075 Burcal Mines Ltd., Burks Falls Mill; coarse powder.
86CCM-0076 Burcal Mines Ltd., Burks Falls Mill; fine powder.

86CCM-0114 Christie Tp., Con. 11, lot 9.
86CCM-0116 Christie Tp., Con. 11, lot 9.
86CCM-0117 Christie Tp., Con. 11, lot 9.
86CCM-0118 Christie Tp., Con. 11, lot 9.

86CCM-0160 Croft Tp., Con. 11, lot 34.

86CCM-0161 Ferrie Tp., Con. 7, lot 32.
86CCM-0162 Ferrie Tp., Con. 7, lot 32.

86CCM-0155 Hagerman Tp. Con. A, lot 33.
86CCM-0156 Hagerman Tp. Con. A, lot 33.
86CCM-0157 Hagerman Tp. Con. A, lot 33.

86CCM-0166 McDougal Con. 12, lot 16; Cononaco Mines Ltd., Waubamik Mill, coarse product.
86CCM-0167 McDougal Con. 12, lot 16; Cononaco Mines Ltd., Waubamik Mill, fine product.

86CCM-0169 McDougall Tp., Con. 2, lot 18.
86CCM-0137 McDougal Tp., Con. 11, lot 5.

86CCM-0164 McKenzie Tp., Con. 2, lot 2.

86CCM-0263 Spence Tp., Con. 5, lot 26.

87CCM-0250 East Mills Tp., Con. 7, lot 23.
87CCM-0251 East Mills Tp., Con. 7, lot 23.

87CCM-0252 Pringle Tp., Con. 11, lot 23.

87CCM-0253 McKellar Tp., Con. 9, lot 7.

87CCM-0332 Foley Tp., Con. 11, lot 29.
87CCM-0333 Foley Tp., Con. 11, lot 29.

87CCM-0335 Ryerson Tp., Con. 5, lots 29, 30.
87CCM-0337 Ryerson Tp., Con. 5, lot 28.
87CCM-0338 Ryerson Tp., Con. 5, lot 28.
87CCM-0339 Ryerson Tp., Con. 5, lot 30.
87CCM-0342 Ryerson Tp., Con. 5, lot 31.

87CCM-0343 Spence Tp., Con. 11, lot 15.
87CCM-0344 Spence Tp., Con. 11, lot 15.

87CCM-0349 Hagerman Tp., Con. A, lot 33.

87CCM-0351 Ferguson Tp., Con. 8, lot 12.
87CCM-0352 Ferguson Tp., Con. 8, lot 12.

87CCM-0355 McKellar Tp., Con. A, lot 14.
87CCM-0356 McKellar Tp., Con. 7, lot 20.
87CCM-0357 McKellar Tp., Con. 7, lot 20.
87CCM-0358 McKellar Tp., Con. 7, lot 21.
87CCM-0359 McKellar Tp., Con. 6, lot 23.
87CCM-0360 McKellar Tp., Con. 14, lot 18.

87CCM-0368 Croft Tp., Con. 2, lots 15, 16.
87CCM-0373 Croft Tp., Con. 5, lots 20, 21.
87CCM-0374 Croft Tp., Con. 6, lots 20, 21.
87CCM-0375 Croft Tp., Con. 8, lot 32.

87CCM-0378 Hagerman Tp., Con. 8, lot 33.
87CCM-0379 Hagerman Tp., Con. 8, lot 35.
87CCM-0380 Hagerman Tp., Con. A, lot 61.

87CCM-0381 McKenzie Tp., Con. 1, lot 1.

87CCM-0383 Hagerman Tp., Con. 2, lot 7.
87CCM-0384 Hagerman Tp., Con. A, lot 29.
87CCM-0385 Hagerman Tp., Con. B, lot 32.
87CCM-0386 Hagerman Tp., Con. B, lot 32.
87CCM-0387 Hagerman Tp., Con. B, lot 32.
87CCM-0388 Hagerman Tp., Con. B, lot 32.

87CCM-0390 Ferrie Tp., Con. 7, lot 31.

87CCM-0399 Lount Tp., Con. 1, lot 26.
87CCM-0400 Lount Tp., Con. 1, lot 26.
87CCM-0402 Lount Tp., Con. B, lot 138.

87CCM-0407 East Mills Tp., Con. 5, lot 1.

87CCM-0409 Pringle Tp., Con. 10, lot 19.
87CCM-0411 Pringle Tp., Con. 11, lots 23, 24.
87NAW-0008 Pringle Tp., Con. B, lot 168.

APPENDIX 2.

Analytical Results, Marbles in the Parry Sound Domain:

Whole Rock Major Element Analyses.

ANALYTICAL RESULTS

Marbles in the Parry Sound Domain: Whole Rock Major Element Analyses

SAMPLE NUMBER	TiO2	Al2O3	Fe2O3	MnO	MgO	CaO	Na2O	K2O	P2O5
87-CCM-0250	0.052	1.073	0.54	0.019	0.618	48.72	0.152	0.292	<0.002
87-CCM-0251	0.024	0.589	0.51	0.024	2.655	47.88	0.068	0.118	<0.002
87-CCM-0252	0.042	1.510	0.39	0.016	0.451	47.60	0.241	0.560	<0.002
87-CCM-0253	0.015	0.331	0.28	0.012	0.623	53.48	0.036	0.172	<0.002
87-CCM-0332	0.027	1.319	0.50	0.028	0.609	46.62	0.311	0.258	<0.002
87-CCM-0333	0.071	2.412	0.99	0.040	1.355	43.40	0.480	0.458	<0.002
87-CCM-0335	0.065	2.342	0.63	0.023	0.189	44.94	0.553	0.630	<0.002
87-CCM-0337	0.209	4.516	1.82	0.071	0.687	36.68	1.327	0.364	0.010
87-CCM-0338	0.024	0.951	0.34	0.015	0.322	54.32	0.071	0.074	<0.002
87-CCM-0339	0.091	3.059	1.06	0.038	0.306	49.98	0.798	0.931	<0.002
87-CCM-0342	0.090	2.692	0.96	0.037	0.380	50.82	0.627	0.582	<0.002
87-CCM-0343	0.131	3.206	1.22	0.044	0.592	51.66	0.695	0.726	0.012
87-CCM-0344	0.104	3.019	1.03	0.064	0.471	47.74	0.563	0.807	<0.002
87-CCM-0349	0.006	0.150	0.24	0.015	1.123	61.74	0.031	<0.001	<0.002
87-CCM-0351	0.035	0.746	0.65	0.042	2.681	58.38	0.114	0.053	<0.002
87-CCM-0352	0.004	0.083	0.09	0.013	0.207	56.28	0.017	<0.001	<0.002
87-CCM-0355	0.047	1.882	0.68	0.032	0.899	50.40	0.460	0.244	<0.002
87-CCM-0356	0.127	2.479	1.32	0.041	0.964	52.22	0.434	0.467	<0.002
87-CCM-0357	0.078	1.697	0.72	0.025	1.335	52.92	0.232	0.233	<0.002
87-CCM-0358	0.029	2.140	0.57	0.025	1.349	49.14	0.481	0.425	<0.002
87-CCM-0359	0.106	3.398	1.27	0.046	1.371	52.50	0.727	0.343	<0.002
87-CCM-0360	0.059	1.326	0.88	0.031	1.019	54.32	0.219	0.247	<0.002
87-CCM-0368	0.021	0.494	0.59	0.040	0.256	54.60	0.073	0.119	<0.002
87-CCM-0373	0.009	0.089	0.16	0.017	3.644	57.40	0.019	0.008	<0.002
87-CCM-0374	0.031	0.631	1.09	0.043	1.401	58.80	0.061	0.195	<0.002
87-CCM-0375	0.021	0.714	0.29	0.020	0.296	50.40	0.120	0.210	<0.002
87-CCM-0378	0.051	1.688	0.71	0.029	0.517	48.58	0.268	0.389	<0.002
87-CCM-0379	0.072	1.922	0.76	0.038	0.981	46.90	0.422	0.318	<0.002
87-CCM-0380	0.007	0.095	0.13	0.015	0.340	54.32	0.014	0.012	<0.002
87-CCM-0381	0.043	0.914	0.41	0.019	3.009	46.76	0.074	0.260	<0.002
87-CCM-0383	0.039	0.456	0.32	0.025	7.293	46.62	0.024	0.022	<0.002
87-CCM-0384	0.027	0.570	0.30	0.012	5.217	45.92	0.055	0.127	<0.002
87-CCM-0385	0.015	0.400	0.38	0.035	4.280	46.34	0.047	0.068	<0.002
87-CCM-0386	0.011	0.421	0.29	0.022	0.554	50.40	0.023	0.057	<0.002
87-CCM-0387	0.014	0.364	0.30	0.017	0.822	54.32	0.046	0.088	<0.002
87-CCM-0388	0.017	0.261	0.26	0.016	1.180	54.04	0.021	0.072	<0.002
87-CCM-0390	0.019	0.345	0.28	0.016	1.114	45.78	0.037	0.085	<0.002
	0.081	2.431	0.92	0.025	0.471	48.58	0.481	0.329	<0.002
87-CCM-0399	0.057	1.930	0.70	0.022	0.307	49.00	0.367	0.344	<0.002
87-CCM-0400	0.041	1.335	0.58	0.020	0.175	50.68	0.256	0.274	<0.002
87-CCM-0402	0.085	2.189	0.93	0.027	0.346	45.22	0.458	0.397	<0.002
87-CCM-0407	0.101	3.084	1.17	0.025	0.958	38.92	0.223	1.028	<0.002
87-CCM-0409	0.062	3.864	0.61	0.018	0.373	38.50	0.332	1.150	<0.002
87-CCM-0411	0.045	2.047	0.41	0.017	0.444	43.40	0.351	0.643	<0.002
87-CCM-0432	0.011	0.252	0.36	0.025	0.228	52.64	0.030	0.056	<0.002
87-CCM-0433	0.012	0.185	0.17	0.014	0.401	51.10	0.014	0.047	<0.002

APPENDIX 3.

Analytical Results, Marbles in the Parry Sound Domain:

Trace Elements.

ANALYTICAL RESULTS

Marbles in the Parry Sound Domain: Trace Elements

SAMPLE NUMBER	Ag	As	Ba	Bi	Cd	Ce	Co	Cr	Cu	Ga	La	Mo	Nb	Ni	Pb	Rb	Sb	Sc	Sn	Sr	Ta	Te	Tl	V	W	Y	Zn	Zr
87-CCM-0250	<0.5	<5	237	<3	<1	<5	2	2	26	3	18	9	<1	<1	9	<20	5	2	<20	1860	<10	<10	<10	13	<10	8	27	13
87-CCM-0251	<0.5	<5	110	<3	<1	<5	<2	<1	7	<2	16	2	<1	<1	8	<20	6	1	<20	500	<10	13	15	4	<10	6	9	9
87-CCM-0252	<0.5	8	246	<3	<1	<5	<2	1	14	4	17	2	1	<1	9	<20	<5	2	24	3560	<10	10	<10	7	<10	7	18	11
87-CCM-0253	<0.5	<5	40	<3	<1	<5	<2	<1	8	<2	14	5	1	<1	11	<20	<5	1	<20	1570	<10	<10	<10	5	<10	9	9	<1
87-CCM-0332	<0.5	<5	124	<3	<1	<5	<2	<1	4	3	17	1	2	<1	11	<20	6	2	<20	764	<10	12	<10	6	<10	8	12	2
87-CCM-0333	<0.5	<5	105	<3	<1	<5	3	6	12	4	17	8	2	2	13	<20	7	3	<20	960	<10	15	16	15	<10	12	25	14
87-CCM-0335	<0.5	<5	338	<3	<1	<5	3	4	15	5	19	11	2	<1	22	<20	<5	2	22	2650	<10	13	<10	11	<10	14	23	25
87-CCM-0337	<0.5	8	122	<3	<1	<5	6	3	42	6	18	8	1	5	11	<20	<5	5	<20	687	<10	14	<10	20	<10	16	28	12
87-CCM-0338	<0.5	<5	48	<3	<1	<5	<2	3	4	<2	16	11	2	2	7	<20	<5	1	<20	1980	<10	<10	<10	4	<10	13	7	9
87-CCM-0339	<0.5	<5	725	<3	<1	<5	5	7	18	5	20	11	<1	2	10	<20	<5	3	<20	3000	<10	15	<10	19	<10	15	15	15
87-CCM-0342	<0.5	<5	266	<3	<1	<5	<2	9	17	5	18	5	1	3	14	<20	<5	3	<20	2360	<10	12	<10	16	<10	13	14	17
87-CCM-0343	<0.5	7	268	<3	<1	<5	3	11	14	5	22	4	3	5	15	<20	5	4	<20	4510	<10	17	<10	26	<10	18	33	25
87-CCM-0344	<0.5	24	300	<3	<1	<5	<2	11	11	4	22	4	3	3	23	<20	<5	3	<20	3340	<10	13	<10	19	<10	15	83	29
87-CCM-0349	<0.5	<5	122	<3	<1	<5	<2	<1	2	<2	13	9	<1	<1	7	<20	7	<1	22	911	<10	<10	<10	2	<10	4	8	<1
87-CCM-0351	<0.5	<5	28	<3	<1	<5	2	<1	15	<2	14	9	1	<1	13	<20	6	2	<20	286	<10	<10	15	14	<10	5	16	8
87-CCM-0352	<0.5	<5	13	<3	<1	<5	<2	<1	2	<2	13	3	<1	<1	8	<20	6	<1	<20	250	<10	<10	<10	1	<10	3	4	<1
87-CCM-0355	<0.5	<5	97	<3	<1	<5	<2	<1	7	<2	19	5	1	<1	7	<20	<5	2	<20	472	<10	15	<10	6	<10	9	9	14
87-CCM-0356	<0.5	<5	266	<3	<1	<5	<2	·2	19	<2	22	<1	2	2	11	<20	<5	4	<20	1740	<10	16	<10	26	<10	14	45	16
87-CCM-0357	<0.5	<5	113	<3	<1	<5	<2	2	15	3	19	<1	3	4	11	<20	<5	2	<20	1650	<10	16	12	16	<10	11	9	13
87-CCM-0358	<0.5	<5	120	<3	<1	<5	<2	3	12	<2	18	8	3	3	11	<20	<5	1	<20	1010	<10	14	<10	8	<10	11	31	22
87-CCM-0359	<0.5	<5	122	<3	<1	<5	<2	20	20	6	21	<1	3	14	18	<20	<5	4	<20	1200	<10	13	17	24	11	13	19	16
87-CCM-0360	<0.5	<5	76	<3	2	<5	<2	14	24	<3	19	<1	2	14	24	<20	<5	3	<20	1070	<10	<10	14	22	<10	14	71	16
87-CCM-0368	<0.5	<5	56	<3	<1	<5	<2	8	14	<2	21	<1	2	4	21	<20	5	1	<20	1180	<10	<10	<10	10	<10	9	57	5
87-CCM-0373	<0.5	<5	11	<3	<1	<5	<2	<1	3	<2	16	<1	1	<1	<4	<20	5	<1	<20	167	<10	<10	24	2	<10	9	<1	<1
87-CCM-0374	<0.5	<5	30	<3	<1	<5	<2	<1	4	<2	21	<1	1	1	8	<20	6	2	<20	979	<10	<10	<10	12	<10	13	6	8
87-CCM-0375	<0.5	<5	384	<3	<1	<5	<2	<1	4	<2	17	<1	2	<1	7	<20	<5	1	<20	2150	<10	<10	<10	5	<10	6	12	11
87-CCM-0378	<0.5	<5	555	<3	<1	<5	<2	3	12	<2	19	8	2	<1	5	<20	5	2	<20	2440	<10	<10	<10	10	<10	8	35	13
87-CCM-0379	<0.5	<5	387	<3	1	<5	<2	<1	4	<2	20	<1	2	<1	7	<20	<5	3	<20	347	<10	<10	<10	7	<10	10	15	13
87-CCM-0380	<0.5	<5	30	<3	<1	<5	<2	<1	2	<2	16	6	1	<1	<4	<20	<5	<1	<20	210	<10	<10	<10	1	<10	3	<1	<1
87-CCM-0381	<0.5	<5	234	<3	<1	616	<2	<1	4	3	454	<1	3	1	10	<20	<5	3	<20	1360	<10	12	23	8	<10	10	18	13
87-CCM-0383	<0.5	<5	33	<3	<1	<5	<2	<1	3	<2	17	<1	2	1	8	<20	12	1	<20	629	<10	15	39	4	<10	6	6	13
87-CCM-0384	<0.5	<5	322	<3	<1	<5	<2	2	5	<2	17	8	2	<1	9	<20	8	1	<20	652	<10	11	29	4	<10	5	6	7
87-CCM-0385	<0.5	<5	77	<3	<1	<5	<2	3	7	<2	15	3	3	<1	19	<20	7	1	<20	705	<10	<10	18	2	<10	4	108	6
87-CCM-0386	<0.5	<5	87	<3	<1	<5	<2	<1	7	<2	26	<1	3	<1	15	<20	8	1	<20	1040	<10	<10	<10	1	<10	6	20	10
87-CCM-0387	<0.5	<5	139	<3	<1	<5	<2	<1	7	<2	15	<1	2	<1	13	<20	10	1	<20	1650	<10	<10	<10	1	<10	5	6	7
87-CCM-0388	0.5	<5	178	<3	<1	<5	<2	<1	7	<2	17	<1	4	<1	12	<20	12	1	<20	1500	<10	<10	21	2	<10	5	10	6
87-CCM-0390	<0.5	6	174	<3	<1	<5	<2	<1	8	<2	17	4	3	<1	9	<20	8	1	<20	2050	<10	<10	15	2	<10	5	9	6
87-CCM-0399	0.5	<5	251	<3	<1	<5	<2	6	16	<2	17	<1	4	3	8	<20	<5	3	<20	3120	<10	<10	<10	13	<10	11	13	13
87-CCM-0400	<0.5	<5	193	<3	<1	<5	3	<1	10	<2	20	6	3	1	10	<20	<5	2	<20	2540	<10	<10	<10	6	<10	15	10	8
87-CCM-0402	<0.5	<5	221	<3	1	<5	<2	7	18	<2	24	<1	4	10	13	<20	<5	3	<20	2700	<10	11	<10	15	<10	17	6	32
87-CCM-0407	<0.5	<5	180	<3	<1	<5	4	10	44	<2	43	5	4	3	17	<20	<5	4	<20	2840	<10	11	<10	17	<10	13	42	45
87-CCM-0409	<0.5	<5	541	<3	<1	<5	<2	5	10	2	17	<1	4	<1	44	<20	<5	2	<20	3160	<10	14	<10	6	<10	11	15	22
87-CCM-0411	<0.5	<5	327	<3	<1	<5	2	2	9	<2	17	4	4	<1	34	<20	6	2	<20	3140	<10	<10	<10	5	<10	8	22	29
87-CCM-0432	<0.5	<5	51	<3	<1	<5	<2	<1	3	<2	15	<1	3	<1	35	<20	10	1	26	221	<10	<10	<10	<1	<10	5	14	3
87-CCM-0433	<0.5	<5	35	<3	<1	<5	<2	<1	6	<2	14	<1	2	<1	40	<20	9	<1	<20	131	<10	<10	<10	<1	<10	4	<1	2

APPENDIX 4.

Calculation of Agricultural Index.

CALCULATION OF AGRICULTURAL INDEX

The Agricultural Index is a measure of the PARTICLE SIZE (fineness efficiency factor) of a limestone (larger particles react more slowly than finer particles), and its NEUTRALIZING VALUE (a measure of the calcium and magnesium carbonate contents of the limestone).

Figures 2 and 3 have been compiled in order to permit the ready estimation of neutralizing value and agricultural index of any limestone, if analyses of the calcium and magnesium contents are known.

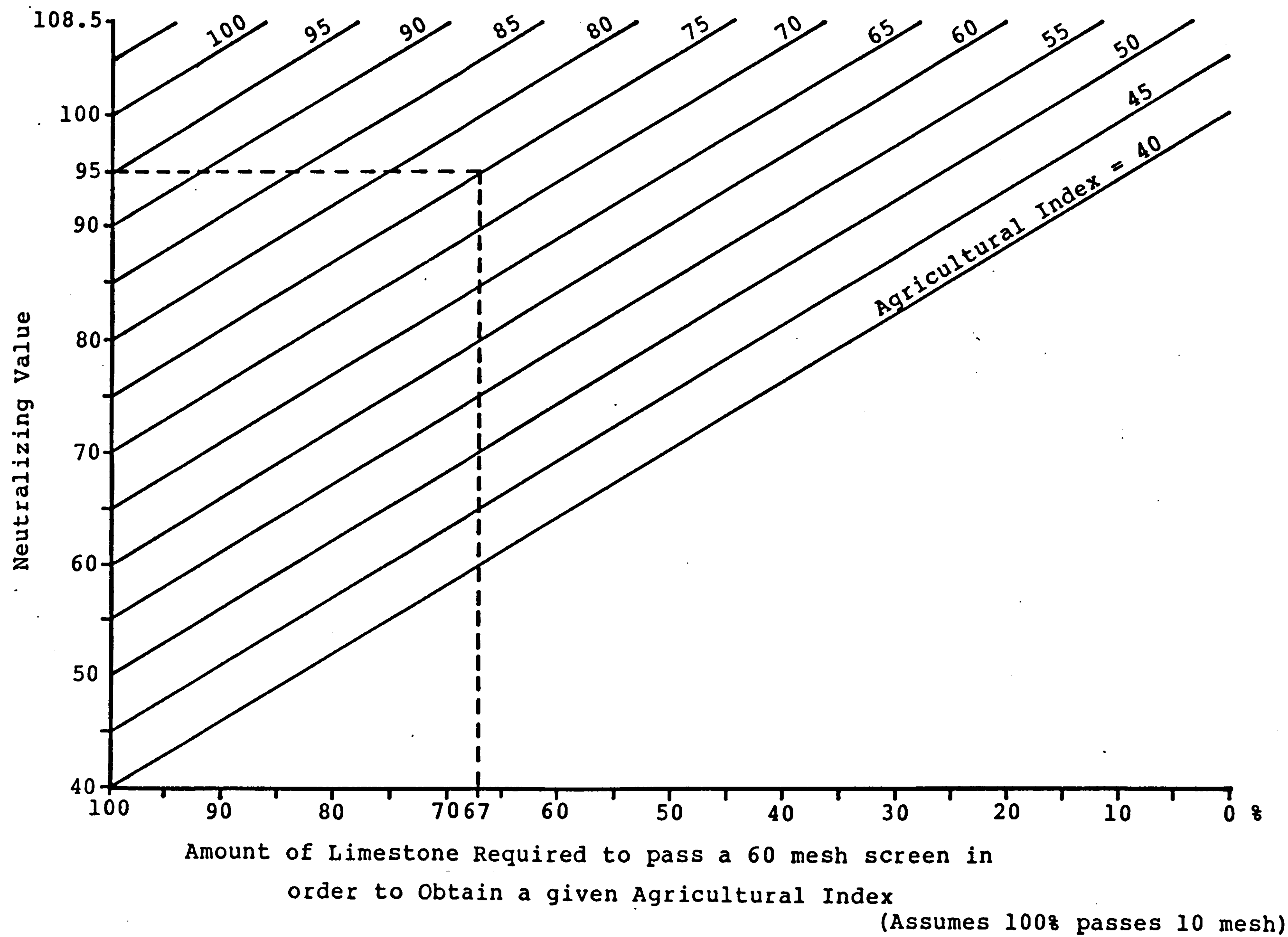
Figure 2 (back pocket) is a graph showing the relationship between the calcium and magnesium contents of a limestone and its neutralizing value. For example, a limestone (eg. 86CCM-0137, appendix 1) containing 9.0% magnesium oxide and 30.7% calcium oxide in carbonate form will have a neutralizing value of 99.5. The graph permits estimation of the neutralizing value from analyses citing elemental, oxide or carbonate values.

Figure 3 shows the relationship of the neutralizing value and fineness efficiency factor (particle size distribution) in determining the Agricultural Index. This can be used as a guide when calculating the degree of processing necessary to obtain a specific agricultural index from a limestone whose neutralizing value is known. For example, if a given limestone has a neutralizing value of 95 and an agricultural index of 75 is required, then if all the limestone is crushed to -10 mesh, no more than 33% must remain on the 60 mesh screen; ie 67% must pass through the 60 mesh screen.

(It is likely that the purity of the -60 mesh material would be greater than that of the whole rock, or even of the -10 +60 material, because the silicate mineral impurities are much harder than the carbonate minerals and so will not be crushed as readily, and many silicate grains will probably remain on the 60 mesh screen).

As an alternative to using figures 2 and 3, they can be calculated by following the steps described below.

Figure 3 Relationship of Particle Size and Neutralizing Value to Agricultural Index



1. NEUTRALIZING VALUE (NV):

A limestone composed of 100% calcite has a neutralizing value of 100 (see figure 2). Because magnesium has a lower atomic weight than calcium, a limestone containing magnesium carbonate has, weight for weight, a greater neutralizing effect than a purely calcitic limestone. Dolomite has a neutralizing value of 108.5. The formula for calculating the neutralizing value (NV) is as follows:-

$$NV = (wt\%\ CaCO_3) + (1.187 \times wt\%\ MgCO_3)$$

Most analyses do not list values for $CaCO_3$ and $MgCO_3$, but instead quote CaO and MgO, or even Ca and Mg.

In the case of CaO and MgO, the following formula is used:

$$NV = (1.785 \times wt\%\ CaO) + (2.483 \times wt\%\ MgO)$$

In the case of Ca and Mg, the following formula is used:

$$NV = (2.497 \times wt\%\ Ca) + (4.117 \times wt\%\ Mg)$$

2. FINENESS EFFICIENCY FACTOR.

A limestone consisting entirely of calcium carbonate which is crushed to -60 mesh will have a neutralizing value of 100% and an Agricultural Index of 100. This means that all of the material is available to act in a neutralizing capacity, and will be dissolved relatively quickly, probably within one year. The same rock crushed to +60 mesh and -10 mesh will also have a neutralizing value of 100%, but will dissolve more slowly and its neutralizing effect will proceed over a longer period of time: perhaps two to three years. Such material is assigned a "fineness efficiency (or effectiveness) factor" of 40% relative to the -60 mesh material. This translates, in the case of a pure limestone, into an Agricultural Index of 40. Material coarser than 10 mesh is assigned an efficiency factor of zero, indicating that it will have a very minor neutralizing effect in the short term. However, over the years, this coarser material will gradually dissolve, having a small acid-neutralizing effect.

The Ontario Ministry of Agriculture and Food recommends a minimum Agricultural Index of 75. Such a limestone will be a mixture of -60 mesh, -10 +60 mesh, and, possibly, +10 mesh material.

The fineness efficiency is calculated as follows:-

	Particle Size % of Sample	x	Effectiveness Factor	
Coarser than 10 mesh (2mm)	10	x	0.0	= 0
10 mesh to 60 mesh	40	x	0.4	= 16
Passing 60 mesh (0.25mm)	50	x	1.0	= 50
			Fineness Efficiency	= 66

The factor of 40% for the -10 +60 mesh material implies that all of the limestone will dissolve in two and one half years.

3. AGRICULTURAL INDEX.

This combines the neutralizing value and fineness efficiency factor as follows:-

$$\text{Ag. Index} = \frac{\text{Neutralizing Value} \times \text{Fineness Efficiency}}{100}$$

The calculations described above use conversion factors which are far more precise than the results of the chemical analyses which they manipulate. In practice, estimates from the graphs in figures 2 and 3 will yield values well within the limits of analytical error.

APPENDIX 5.

Soil Acidity and Liming;

Ontario Ministry of Agriculture and Food Factsheet, Agdex 534, November 1985.

Ministry of Agriculture and Food
Ontario

ORDER NO. 85-105
NOVEMBER 1985
AGDEX 534

Factsheet

SOIL ACIDITY AND LIMING

(Revision of Factsheet "Soil Acidity and Liming", November 1978)

T.E. Bates and T.H. Lane, Department of Land Resource Science, Ontario Agricultural College University of Guelph and R.W. Johnston, Ridgetown College of Agricultural Technology

The pH scale ranging from 0 to 14 is used to indicate acidity and alkalinity. A pH of 7.0 is neutral, values below 7.0 are acid, and those above are alkaline. The lower the pH, the more acid is the soil. The higher the pH, the more alkaline.

The pH values of some common items are: pure water, 7.0; lemon juice, 2.2 to 2.4; orange juice, 3.4 to 4.0; fresh milk, 6.3 to 6.6; mild soap solution, 8.5 to 10.0; most Ontario soils, 4.5 to 8.0

IMPORTANCE OF pH IN SOILS

Soil pH is important chiefly because of the many effects it has on biological and chemical activity. The effect of pH on plant growth can be very large but is usually indirect through biological and chemical factors.

Acid soils are low in calcium and frequently in magnesium. Calcium is the most important neutralizing element. As calcium and magnesium are depleted by leaching and plant uptake, hydrogen and aluminum ions become more prevalent, and the soil becomes acid.

Phosphorus in soils is commonly considered to be most available at pH values near 6.5, with the availability decreasing at both lower and higher pH values. However, soil test and fertilizer response studies in Ontario indicate that even many of the high (up to pH 7.9) pH soils contain adequate amounts of plant available phosphorus.

Aluminum, iron, maganese, boron, copper and zinc are more available to plants in acid than in neutral or slightly alkaline soils. When a soil is made less acid (more alkaline) by liming, the availability of manganese in particular can decrease substantially. It is, therefore, important not to apply more lime than necessary.

Iron, manganese, zinc, copper and boron are essential to plant growth, but are required in very small amounts. In excess, they may be toxic and result in reduced crop yields. If deficient, they can also reduce yields. Aluminum is not needed for plant growth and can be quite toxic to plants. Molybdenum is one element essential for plants which is more available in alkaline (high pH) soils.

Soil pH affects crops in other ways. Legumes, such as alfalfa, trefoil, clovers and soybeans, have bacteria living in nodules on their roots which take nitrogen from the air and change it into a form used by plants. Some strains of the bacteria thrive best at pH values above 6.0. Hence this range is best for certain legume crops. Potato scab is more prevalent at soil pH values above 5.5 than at lower values, although potato plants grow well in high pH soils. Club root in cole crops such as cabbage is less prevalent at pH values of 7.2 or higher. Black rootrot in tobacco is more prevalent at pH values above 6.4. Some plants such as rhododendrons and blueberries grow well only at pH values well below 6.0 and appear to suffer from iron and/or manganese deficiencies at higher pH values. There is also evidence that fungi associated with healthy root development on these plants require a low pH. On the other hand, most field crops grow best in the pH range of 5.5 to 8.0. Aluminum and manganese are frequently at toxic levels for common field and vegetable crops at soil pH values below 5.5 (Table 3).

HOW SOILS BECOME ACID

Soils are alkaline when they are high in basic ions, mainly calcium and magnesium and to a lesser extent potassium and sodium. Most soils in southern Ontario were formed from materials high in calcium and magnesium and were therefore alkaline when formed. Many soils in northern Ontario were formed on materials low in bases such as granite, and these soils tend to be acid with hydrogen and aluminum present in place of the basic ions.

As leaching removes calcium, magnesium and potassium from soils over hundreds or thousands of years the natural trend is for soils to become more acid. The addition of acid forming fertilizers, chiefly nitrogen greatly increases the rate at which soils become acid (Table 1). The effect of nitrogen fertilizer on soil pH in Ontario is also shown in Table 2.

Acid rain contributes to the acidity of Ontario soils but simple calculations show that the acidity caused by rainfall in Ontario in a year is less than the acidity resulting from 2 kg of nitrogen per hectare applied in fertilizer.

Many Ontairo soils with pH values above 7.0 contain small particles of calcium and magnesium carbonate which replenish the supply of basic ions as calcium and magnesium are removed by leaching and crop removal. The addition of nitrogen fertilizers has essentially no effect on the pH of these soils, and will not have until the calcium and magnesium carbonate have been depleted. On most of these soils this will take many years.

Table 1. Lime Required to Neutralize the Acidity Generated by Some Common Fertilizer Materials*

Material	Analysis %	Each 100 kg (lb)** of fertilizer material	Each kg (lb)** of Nitrogen (N) supplied by the fertilizer material
Ammonium nitrate	34-0-0	60	1.8
Urea	45-0-0	81	1.8
Anhydrous ammonia	82-0-0	148	1.8
Aqua ammonia	20-0-0	36	1.8
Nitrogen solution	28-0-0	50	1.8
Sulfate of ammonia	21-0-0	110	5.4
Monoammonium phosphate	12.5-50-0	65	5.0
Diammonium phosphate	18-46-0	90	5.0
Superphosphate	0-20-0	0	0
Triple superphosphate	0-46-0	0	0
Muriate of potash	0-0-60	0	0
Sulfate of potash	0-0-50	0	0
Sulfate of potash magnesia	0-0-21 (10Mg)	0	0

*Adapted from Andrews, "The Response of Crops and Soils to Fertilizers and Manures", 2nd Ed., 1954.
**Either kilograms or pounds may be used in this table provided the same units are used in both columns.

Table 2. Effect of Nitrogen Applied Annually to Corn on Soil pH of the Top 15 cm (6 in.) Layers on Two Soils after Five and Fifteen Years

Annual nitrogen rate kg/ha	Soil pH
	Sandy loam soil* 5 years
0	6.4
112	6.0
224	5.4
336	4.6
	Clay loam soil** 15 years
0	5.4
298	4.7
332	4.4
0 (Alfalfa)	5.2

*Personal communication W.I. Findlay, Agriculture Canada, Harrow, Ontario.
**E.F. Bolton, J.A. Aylesworth and W.I. Findlay, 1970, Can. J. Soil Sci. 50: 260-261.

AREAS OF ACID SOILS IN ONTARIO

The largest area of acid soils in southern Ontario has been in Haldimand county and the regions of Niagara North and South. Smaller localized areas extend into Wentworth, Halton and Peel counties and westward into Norfolk, Elgin, Kent and Essex. The sandy soils of the Lake Erie counties have become increasingly acid in recent years, with some of the lowest pH values in the province (as low as 3.2) now appearing in these soils. Prescott, Russell and Frontenac counties in Eastern Ontario have an appreciable proportion of acid soils, with smaller areas in adjacent counties. All districts of northern Ontario have a high proportion of acid soils with the exception of Rainy River and the clay belts of Temiskaming and Cochrane.

LOW pH SPOTS

There have been frequent occurrences of pH spots in farm fields in southwestern Ontario where the average pH of the field indicates no lime required. These areas usually occur where there are course-textured (sandy) spots in fields that are predominantly fine textured (clay or clay loam). Areas having a pH as low as 3.2 have been observed in fields where the average pH was above 6.0.

It is recommended that soil tests be made every two to three years to check pH, as well as fertility levels. Where the soil texture is not uniform in a field, the coarser-textured areas (or any problem area) should be sampled separately.

CORRECTION OF SOIL ACIDITY

Acid soils usually result in poor yields of crops so liming these soils to neutralize the acidity is frequently essential for profitable crop production (Table 3). In the example shown in Table 3 the application of 7 t of lime/ha returned $108/ha over the cost of lime in the first year based on corn at $118/t and lime at $25/t spread. With the lime paid for in the first year the 2.4 tonnes/ha yield increase in subsequent years would be entirely profit. The lime is expected to last for at least five and commonly 10 years.

Table 3. The effect of dolomitic limestone on corn yields, soil pH, and soil magnesium levels on an acid sandy loam soil, 1975-1978*

Rate of Limestone t/ha	Grain yield t/ha	Soil pH 1st Year	Soil pH 4th Year	Soil Mg ppm 1st Year
0	5.0	4.3	4.5	33
7	7.4	5.5	5.7	175
13	8.0	6.0	5.8	200+
20	7.9	6.3	6.3	200+
27	8.1	6.4	6.5	200+

From R.W. Johnston, Ridgetown College of Agricultural Technology

To correct soil acidity ground limestone should be broadcast and worked into the soil at rates determined by soil test.

Table 4 shows the soil pH values below which lime is recommended and the "target" soil pH to which soils should be limed for different crops. In Ontario most crops grow quite well at pH values higher than the target pH to which lime is recommended.

Table 4. Soil pH Below Which Lime is Recommended for Ontario Field Crops

Crops	Soil pH Below Which Lime is Recommended	Target Soil pH*
Coarse and Medium Textured Mineral Soils (sands, sandy loams, loams and silt loams)		
Perennial legumes, oats, barley, wheat triticale, beans, peas, canola, flax	6.1	6.5
Corn, soybeans, rye, grass hay, pasture and tobacco.	5.6	6.0
Fine Textured Mineral Soils (clays and clay loams)		
Alfalfa	6.1	6.5
Other perennial legumes, oats, barley, wheat, triticale, soybeans, beans, peas, canola, flax.	5.6	6.0
Corn, rye, grass hay, pasture and tobacco.	5.1	5.5
Organic Soils (peats and mucks)		
All field crops	5.1	5.5

**Where a crop is grown in rotation with other crops requiring a higher pH (for example corn in rotation with wheat or alfalfa) it is recommended that the soil be limed to the higher pH.*

THE BUFFER pH

Different soils with any one pH value, for example 5.2, will require different amounts of lime to bring the pH to a particular desired level depending chiefly on the clay and organic matter content. The soil pH is used to determine which soils need to be limed but a separate soil test, the buffer pH, is run on soils needing lime to determine the amount of lime required. For soils needing lime (based on soil pH) table 5 may be used to determine from the buffer pH the amount of lime required to reach the "target" soil pH value required for a specific crop.

LIME APPLICATION AND TILLAGE

Lime is not effective unless it is mixed with the soil. It should be applied evenly and worked in 15 cm (6 inches) deep. Lime recommendations presented here should raise the pH of the top 15 cm of a soil to the listed target pH. If the soil is ploughed to a greater depth than 15 cm, proportionately more lime is required to reach the same target soil pH.

LIME QUALITY

Two main factors affect the value of a particular lime for soil application. One of these is the amount of acid a given quantity of the lime will neutralize when it is totally dissolved. This is called the "neutralizing value" and is expressed as a percentage of the neutralizing value of pure calcium carbonate. A lime which will neutralize 90% as much acid as pure calcium carbonate is said to have a neutralizing value of 90. In general, the higher the calcium and magnesium content of a lime the higher the neutralizing value.

The second factor which affects the value of lime as a neutralizer of acidity is the particle size. Limestone gravel has much less surface area to react with acid soil than finely powdered limestone and, hence, it neutralizes acidity much more slowly; so slowly that it is of little value. The calculation of a fineness rating for ground limestone is illustrated in Table 6.

Table 5. Lime Requirements to Correct Soil Acidity Based on Soil pH and Buffer pH

Buffer pH	Target soil pH = 6.5 Lime if soil pH below 6.1	Target soil pH = 6.0 Lime if soil pH below 5.6	Target soil pH = 5.5 Lime if soil pH below 5.1
Lime required - t/ha (Based on an Agricultural Index of 75)			
7.0	2	0	0
6.9	2	0	0
6.8	2	0	0
6.7	2	2	0
6.6	3	2	0
6.5	3	2	0
6.4	4	3	2
6.3	5	3	2
6.2	6	4	2
6.1	7	5	2
6.0	9	6	3
5.9	10	7	4
5.8	12	8	4
5.7	13	9	5
5.6	15	11	6
5.5	17	12	8
5.4	19	14	9
5.3	20	15	10
5.2	20	17	11
5.1	20	19	13
5.0	20	20	15
4.9	20	20	16
4.8	20	20	18
4.7	20	20	20
4.6	20	20	20

Table 6. Example Calculation of the Fineness Rating of a Liming Material

Particle Size	% of Sample		Effectiveness Factor		
Coarser than no. 10 sieve[1]	10	x	0	=	0
No. 10 to no. 60 sieve	40	x	0.4	=	16
Passing through no. 60 sieve	50	x	1.0	=	50
Fineness Rating				=	66

[1]A no. 10 Tyler sieve has wires spaced 2.0 mm, and a no. 60 Tyler sieve spaced 0.25 mm apart

THE AGRICULTURAL INDEX IS USED TO COMPARE LIMING MATERIALS

Some means of combining the Neutralizing Value and the Fineness Rating is needed to compare various liming materials that are available. The index which has been developed in Ontario to do this is called the "Agricultural Index".

$$\text{The Agricultural Index} = \frac{\text{neutralizing value x fineness rating}}{100}$$

The Agricultural Index can be used to compare the relative value of different limestones for neutralization of soil acidity[1]. Lime with a high Agricultural Index is worth proportionately more than lime with a low index because it may be applied at a lower rate. If two ground limestones, A and B, have Agricultural Indices of 50 and 80 respectively, the rate of application of lime A required for a particular soil will be 80/50 times the rate required for lime B. Lime A spread on your farm is worth 50/80 of the price of lime B per tonne.

ADJUSTING APPLICATION RATES

Recommendations from the Ontario soil test service are based on lime with an Agricultural Index of 75. If you know the Agricultural Index of the lime you will use, you can calculate a rate of application specifically for liming material of that quality. This can be done using the following equation:

$$\text{Rate of Lime application from soil test report} \times \frac{75}{\text{Agr. Index of your lime}} = \text{Recommended rate of application of your lime}$$

For example if you have a lime requirement by soil test of 9 t/ha, and your most suitable source of limestone from a quality and price standpoint has an Agricultural Index of 90, you should apply 9 x 75/90 = 7.5 t/ha.

When you buy lime you should insist that the supplier provides the Agricultural Index or the information required to calculate it. You need this information to determine the application rate. The supplier is required by law to provide the neutralizing value and particle size.

LIMING MATERIALS

Calcitic limestone is almost pure calcium carbonate. Dolomitic limestone contains considerable magnesium carbonate and, on acid soils, is a good source of magnesium for plant growth. Usually the least expensive and the most effective way of supplying magnesium to soils needing lime is by applying dolomitic lime (high in magnesium) as shown in Tables 3 and 7. For soils used for growing tobacco, only dolomitic lime is recommended.

[1]The Agricultural Index does not provide information about magnesium content. Dolomitic lime should be used on soils low in magnesium.

Table 7. The effect of Ground Dolomitic Limestone and Potash Fertilizer on Magnesium Content of Corn Seedlings on a Sandy Loam Soil with pH 4.5*. (Limestone applied May 27, 1976, corn sampled June 24, 1976)

Dolomitic Lime t/ha	Potash (K_2O) - kg/ha 0	45	90	134	180	Ave.
	Plant Magnesium - %					
0	0.27	0.30	0.22	0.21	0.23	0.25
7	0.73	0.58	0.46	0.41	0.37	0.51
13	0.75	0.62	0.57	0.49	0.46	0.58
20	0.90	0.62	0.55	0.54	0.52	0.63
Ave.	0.66	0.52	0.47	0.41	0.40	

**R. W. Johnston Ridgetown College of Agricultural Technology*

"Liquid lime" is advertised and occasionally sold in Ontario often at very high costs in relation to the neutralizing value. This is very fine ground limestone suspended in water. It is equivalent to finely ground dry lime in availability and would have a "fineness" rating of 100. When diluted with water the neutralizing value will be low per unit of weight resulting in the need for high rates of application. Note that in the fineness rating lime passing through a 60 mesh screen is considered to be 100% effective. Limestone ground finer than this is not considered to be any more effective. When limestone is heated to form calcium or magnesium oxide it is called "burned lime", and when moisture is applied to the burned lime it becomes "hydrated lime" (calcium or magnesium hydroxide).

Burned and hydrated lime have a higher neutralizing value and are also faster-acting than ground limestone. However, they are caustic and will burn plants. If used, they should be applied at least one month before seeding. Both of these forms are usually considerably more expensive than ground limestone.

Another liming material used occasionally is marl. Marl which occurs in some swamps is soft calcium-carbonate mixed with varying amounts of clay and organic matter. Usually it is more economical to buy ground limestone than to dig marl from a swamp, and then dry and crush it.

LOWERING SOIL pH

On soils with pH values below 7.0 it is possible to lower the pH (make the soil more acid) by adding sulfur or aluminum sulfate, but this is not necessary for most crops and it hastens the time when lime will be required. If the soil pH is above 7.0 it is not advisable and also usually quite impractical to lower the soil pH because of the very large amounts of sulfur or aluminum sulfate required.

APPENDIX 6.

Sources of Agricultural Limestone for Ontario, prepared by the Ontario Ministry of Agriculture and Food.

SOURCES OF AGRICULTURAL LIMESTONE FOR ONTARIO

Revised July, 1987

This guide was prepared from information submitted by the limestone companies to a survey by the Fertilizer and Limestone subcommittee of the Ontario Soil Management Research Committee.

The information is intended to assist government and industry personnel to help Ontario farmers obtain agricultural limestone.

Only haulers and spreaders listed by the limestone companies are provided. Other spreaders may be available in the area.

If there are any questions regarding the limestone analysis or specifications, please contact the appropriate company for their latest chemical analysis information. The OMAF Calculated Agriclutural Index was prepared from the information provided by the company.

1. A. L. Blair

   Moose Creek, Ontario
   Telephone: (613) 538-2271
   Quarry Address: St. Albert, Ontario
   Telephone: (613) 987-5377
   Type of Lime: Calcitic
   Limestone Guaranteed Minimum Analysis:
   100% pass 10 mesh, 68.28% pass 60 mesh
   OMAF Calculated Agricultural Index 76.2%
   Hauling by company, spreading arranged by farmer.

2. Alexander Centre Industries Limited

   P.O. Box 1000, Copper Cliff, Ontario, POM 1NO
   Telephone: (705) 674-4291
   Quarry Address: Fisher Harbour, 7 miles north of Little Current, Manitoulin Island. Telephone: (705) 674-4291
   Type of Lime: Calcitic
   Limestone Guaranteed Minimum Specifications:
   24% calcium; 7% magnesium; 85% neutralizing value, 88% pass 10 mesh, 22% pass 100 mesh
   OMAF Calculated Agricultural Index 41 (minimum)
   Hauling only by Fisher Construction, P.O. Box 1000, Copper Cliff, Ontario. Telephone: (705) 674-4291

3. Beachvilime Limited

P.O. Box 190, Ingersoll, Ontario, N5C 3K5
Telephone: (519) 423-6283
Quarry Address: Oxford County Road #6, Ingersoll
Telephone: (519) 423-6283
Type of Lime: Calcitic
Limestone Guaranteed Minimum Specifications:
35.5% calcium; .19% magnesium; 91% neutralizing value,
95% pass 10 mesh, 30% pass 100 mesh
OMAF Calculated Agricultural Index 65
Hauling: Contact office for list of carriers.
Spreading: Anderson Lime Service - 427 Book Road East,
R. R. #2, Ancaster, Ontario, L9G 3L1
Telephone: (416) 648-4776
Carver Lime Service - R. R. #8, Brantford, Ontario
L3T 5M1
Telephone: (519) 752-4981

4. Cayuga Materials & Construction Co. Limited

R. R. #7, Simcoe, Ontario, N3Y 4K6
Telephone: (519) 426-7880
Quarry Address: R. R. #4, Cayuga, Ontario, NOA 1EO
Telephone: (416) 522-0921
Type of Lime: Dolomitic
Limestone Guaranteed Minimum Specifications:
19.2% calcium; 11.8% magnesium; 102% neutralizing value,
99.6% pass 10 mesh, 34.2% pass 60 mesh
OMAF Calculated Agricultural Index 62%
Hauling and Spreading:
Anderson Lime Service - 427 Book Road, Ancaster, Ontario
Telephone: (416) 648-4776
Allen Carver Ltd. - R. R. #8, Brantford, Ontario
Telephone: (519) 647-3448
Crumbs Lime Service - R. R. #2, Dunnville, Ontario
Telephone: (416) 774-4745

5. Chromasco - A Division of Timminso Limited

Haley, Ontario, KOJ 1YO
Telephone: (613) 432-3621
Quarry Address: as above at Haley
Type of Lime: Dolomitic
Limestone Guaranteed Minimum Specifications:
22% calcium; 13% magnesium; 107% neutralizing value
90% pass 10 mesh, 75% pass 60 mesh.
OMAF Calculated Agricultural Index 87%
Hauling and Spreading:
Wm. J. McLaughlin - Haley, Ontario
Telephone: (613) 432-5669 - hauls only
Agra Spread All - Shawville, Quebec, JOX 2YO
Telephone: (819) 647-2627

6. Cutler-Magner Company

12th Avenue West and Waterfront, P.O. Box 16807, Duluth, Minnesota, 55802, U.S.A.
Telephone: (218) 722-3961
Type of Lime: Calcitic
Typical Chemical Analysis:
37% calcium; .3% magnesium; 95% neutralizing value, 100% pass 40 mesh, 99.8% pass 80 mesh
OMAF Calculated Agricultural Index 94
Hauling: contact company.

7. Dufferin Aggregates Limited

620 Wilson Avenue, Downsview, Ontario, M3K 2A4
Telephone: (416) 630-4422
Quarry Address: P.O. Box 68, Milton, Ontario, L9T 2Y3
Telephone: (416) 878-6051 or (416) 821-8921
Type of Lime: Dolomitic
Limestone Guaranteed Minimum Specifications:
18.2% calcium; 11.9% magnesium; 95.2% neutralizing value
79.3% pass 10 mesh, 44.2% pass 100 mesh
OMAF Calculated Agricultural Index 62%
Hauling and Spreading:
Casey Muilwyk, R. R. #1, Paris, Ontario
Telephone: (519) 442-6585.

8. Gormley Aggregates Limited

P.O. Box 39, Gormley, Ontario, L0H 1G0
Telephone: (416) 888-1931
Quarry Address: Brechin, Ontario
Telephone: (705) 484-0073
Type of Lime: Calcitic
Limestone Guaranteed Minimum Specifications:
25% calcium; 1% magnesium; 87% neutralizing value,
96% pass 10 mesh, 37% pass 60 mesh
OMAF Calculated Agricultural Index 48.5%
Hauling and Spreading:
Allan Carver Ltd., R. R. #8, Brantford, Ontario, L3T 5M1

9. Kingsville Coal & Dock Co. Ltd.

111 Park Street, Kingsville, Ontario, N9Y 1N6
Telephone: (519) 733-2301
Quarry Address: U.S. Steel Corporation, P.O. Box #360008M
Pittsburgh, P.A., 15251, U.S.A.
Telephone: (412) 433-4475
Type of Lime: Dolomitic
Limestone Guaranteed Minimum Specifications:
97% pass 8 mesh, 33% pass 100 mesh
OMAF Calculated Agricultural Index - Not available, contact company
Hauling and Spreading:
Vanroboys Enterprises, R. R. #6, Thamesville, Ontario, N0P 1K0

10. H.J. McFarland Construction Co. Ltd.

Moodie Drive, P.O. Box 11068, Nepean, Ontario, K2H 7T5
Telephone: (613) 829-1170
Quarry Address: Moodie Drive, Nepean, Ontario, K2H 7T5
Telephone: (613) 829-1770
Type of Lime: Calcitic
Limestone Guaranteed Minimum Specifications:
31.3% calcium; 2.1% magnesium; 84.1% neutralizing value, 80.4% pass 10 mesh, 40.3% pass 60 mesh
OMAF Calculated Agricultural Index 47.3%
Hauling by Tandem and Semi-Trailer only. No spreading.

11. McKean Quarries Ltd.
Box 340, Collingwood, L9Y 3Z7
Telephone: (705) 445-2300
Quarry Address: 3 miles west of Duntroon on Simcoe Road 63
Type of Lime: Dolomitic
Limestone Guaranteed Minimum Specifications:
29.0% calcium, 21.2% magnesium; 104% neutralizing value
OMAF Calculated Agricultural Index - Not available, contact company
Hauling and spreading by McKean's.

12. Owen Sound Dolomite, A Division of Miller Paving Ltd.

950, 4th Street East, Owen Sound, Ontario
Telephone: (519) 376-6140
Quarry Address: E.C. King Contracting, Sydenham Township
Telephone: (519) 371-0417
Type of Lime: Dolomitic
Limestone Guaranteed Minimum Specifications:
20% calcium, 15% magnesium; 104% neutralizing value
100% pass 10 mesh, 99% pass 60 mesh
OMAF Calculated Agricultural Index 103%
Hauling only by Owen Sound Dolomite.

13. Nelson Aggregate Co.

(a) P.O. Box 1070, Station B, Burlington, Ontario, L7P 3S9
Telephone: (416) 335-5250
Quarry Address: West Street North, R. R. #4, Orillia, L3V 6H4
Telephone: (705) 325-2264
Type of Lime: Calcitic
Limestone Guaranteed Minimum Specifications:
22% calcium; 4.4% magnesium; 94% neutralizing value, 96% pass 10 mesh, 28% pass 60 mesh
OMAF Calculated Agricultural Index 52%
Hauling: Tandem or tractor trailer loads available for delivery only.

13. Nelson Aggregate Co.

(b) P.O. Box 1070, Station B, Burlington, Ontario, L7P 3S9
Telephone: (416) 335-5250
Quarry Address: Yonge Street off Mountain Street, Beamsville, Ontario
Telephone: (416) 563-8226
Type of Lime: Dolomitic
Limestone Guaranteed Minimum Specifications:
20% calcium; 14% magnesium; 97% neutralizing value
97% pass 10 mesh, 46% pass 60 mesh
OMAF Calculated Agricultural Index 64%
Hauling and Spreading:
Jim Waites
Allen Carver, R. R. #8, Brantford
Willard Storm, R. R. #1, Sherkston, Ontario
Telephone: (416) 894-3220
Anderson Haulage, 427 Book Road East, R. R. #2, Ancaster
Telephone: (416) 648-4776

14. Steep Rock

R. R. #4, Perth, Ontario
Telephone: (613) 267-5367
Quarry Address: As above
Limestone Guaranteed Minimum Specifications
40% calcium, 0.35% magnesium; 99% neutralizing value
100% pass 10 mesh, 100% pass 60 mesh
OMAF Calculated Agricultural Index 99%
Hauling and spreading not available, pick up at plant.

15. Steetley Lime & Aggregates

R. R. #2, 447 Moxley Road South, Dundas, Ontario, L9H 5E2
Telephone: (416) 527-2744
Quarry Address: as above
Type of Lime: Dolomitic
Limestone Guaranteed Minimum Specifications:
20% calcium, 12% magnesium, 103% neutralizing value,
100% pass 10 mesh, 45% pass 60 mesh
OMAF Calculated Agricultural Index 69%
Hauling and Spreading: (* means hauling only)
Anderson Lime Service, 427 Book Road East, Ancaster, Ontario
Telephone: (416) 648-4776
Rene Blain Trucking, Box 71, Tilbury, Ontario
Telephone: (519 682-2694
Campbell's Lime Service, R. R. #8, Brantford, Ontario
Telephone: (416) 647-3448
Casey Muilwyk, R. R. #1, Paris, Ontario
Telephone: (519) 442-6585
Kent County Fertilizers, Box 820, Blenheim, Ontario
Telephone: (519) 676-3181

* Reg Miller Transport, Box 41, Sundridge, Ontario
Telephone: (705) 384-5301
Orford Farmers Co-op, Muirkirk, Ontario
Telephone: (519) 678-3381
Setteringtons Fertilizer, 12 Seacliffe Drive East, Leamington
Telephone: (519) 326-3249
W.G. Thompson, Box 250, Blenheim, Ontario
Telephone: (519) 676-5411
Vanroboys Enter., R. R. #6, Thamesville, Ontario
Telephone: (519) 692-3269

16. Vineland Quarries & Crushed Stone Limited

P.O. Box 100, Thorold, Ontario, L2V 3Y8
Telephone: (416) 227-4142
Quarry Address: Victoria Avenue, Vineland, Ontario
Telephone: (416) 562-4163
Type of Lime: Dolomitic
Limestone Guaranteed Minimum Specifications:
20% calcium; 11.8% magnesium; 96.8% neutralizing value
87% pass 10 mesh, 77% pass 100 mesh
OMAF Calculated Agricultural Index 78%
Hauling and Spreading:
Willard Storm, R. R. #1, Sherkston, Ontario
Telephone: (416) 894-3220

This report was prepared by John Schleihauf, Plant Industry Branch, Ontario Ministry of Agriculture and Food, Guelph Agriculture Centre, Guelph, Ontario, N1H 6N1. (519) 823-5700.

The report will be revised annually following the Fertilizer and Limestone subcommittee meeting.

Appendix 7.

Specifications of Agricultural Limestone Used in the Parry Sound area, and adjacent parts of Muskoka and Nipissing Districts.

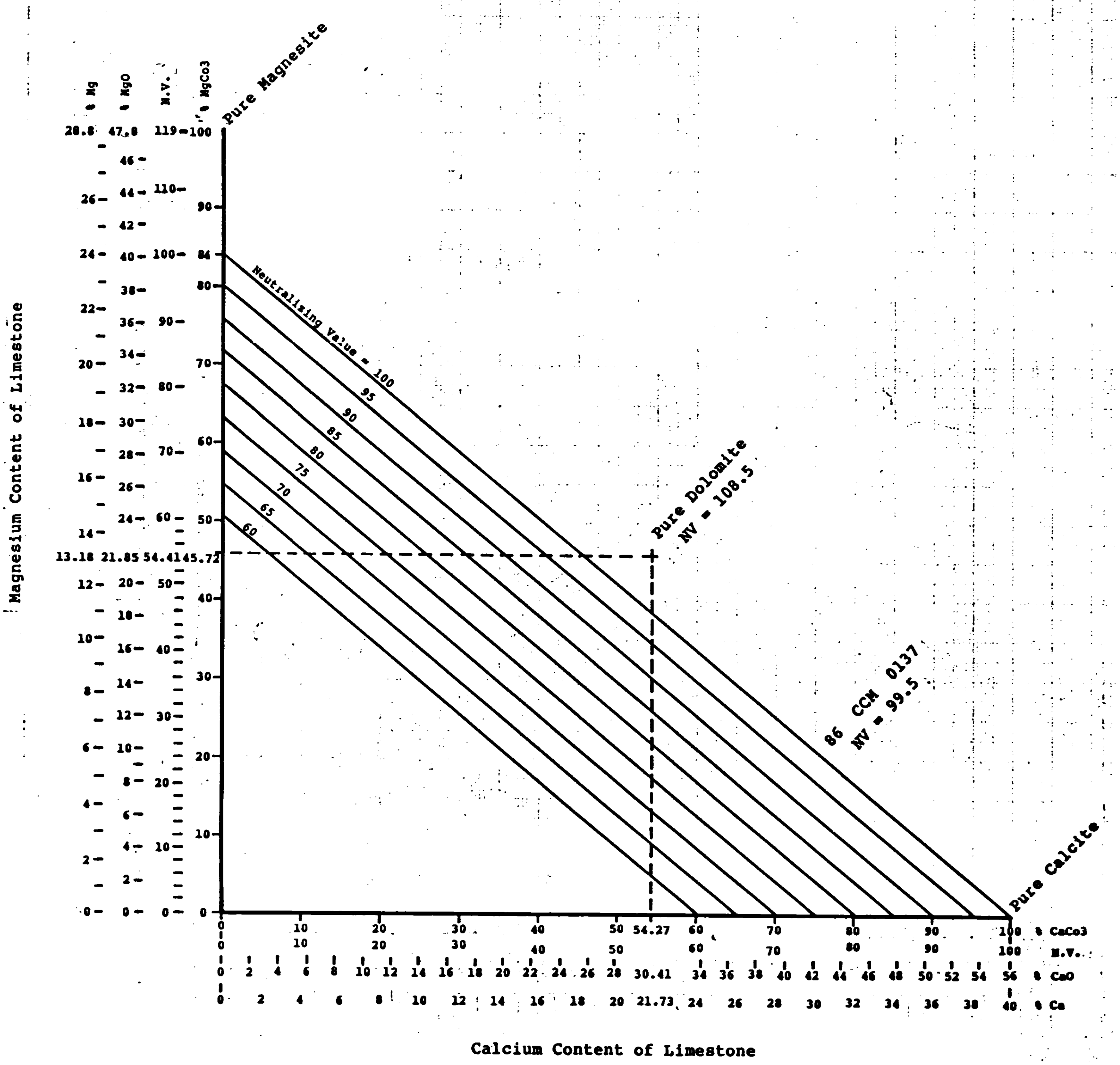
Specifications of Agricultural Limestones Used in the Parry Sound Area *

Producer	Ref No. *	Type of Lime	Percent Passing 10#	Percent Passing 60#	%Ca	%Mg	NV	Ag. Index
Chromasco	5	Dolomitic	90	75	22	13	107	87
McKean Quarries Ltd, Collingwood	11	Dolomitic	--	--	22	13	104	Not Av. (Contact Co.)
Owen Sound Dolomite	12	Dolomitic	100	99	20	15	104	103
Nelson Aggregate	13a	Calcitic	96	28	22	4.4	94	52
Steetley Lime, Dundas	15	Dolomitic	100	45	20	12	103	69
Dymond Clay "" Products,Haileybury		Calcitic			>50			75

* Source: Sources for Agricultural Limestone for Ontario, OMAF, Revised July, 1987.

"" Source: Dymond Clay Products.

Figure 2 Relationship of Calcium and Magnesium Contents of Limestone to Neutralizing Value



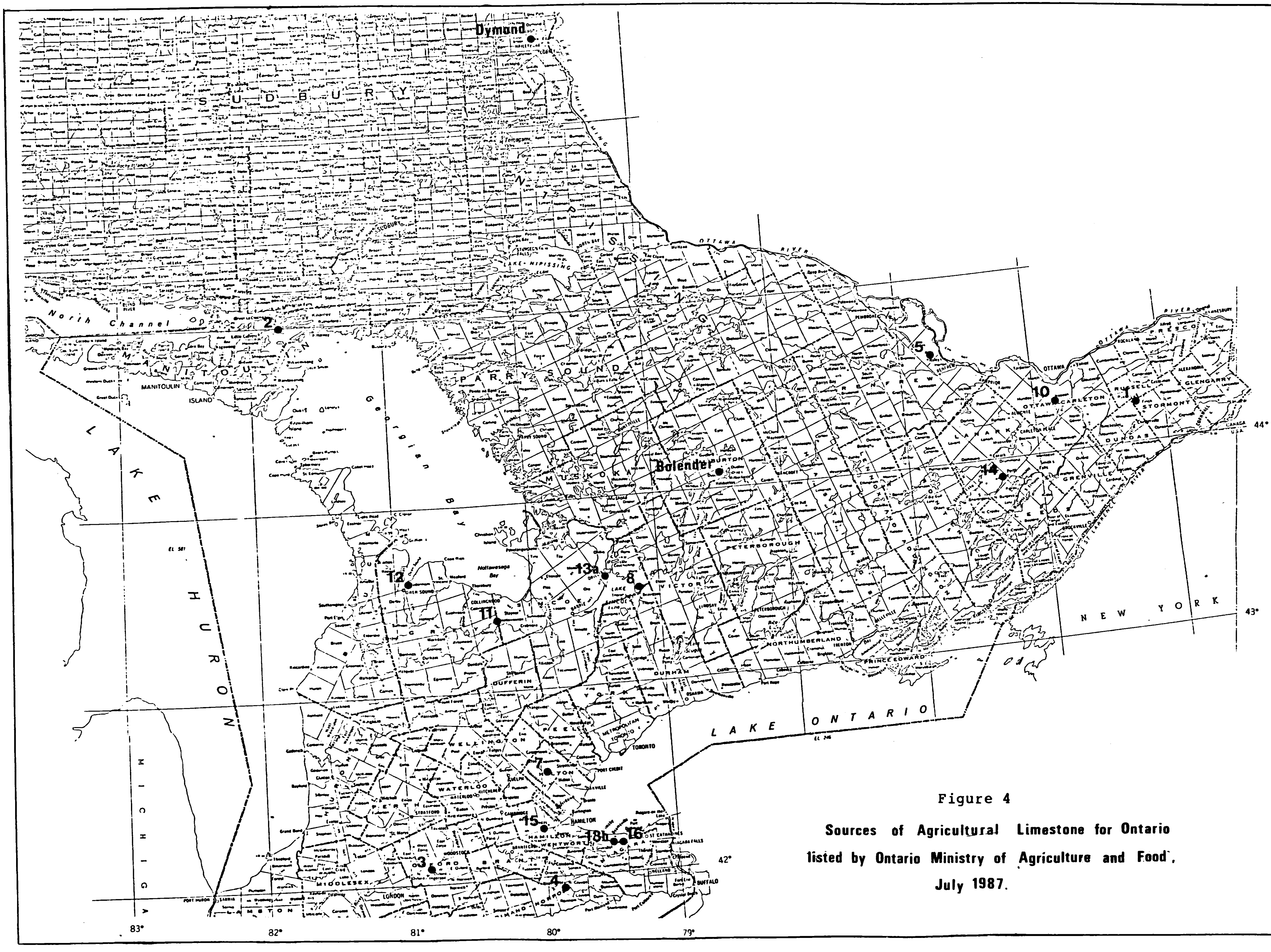


Figure 4

Sources of Agricultural Limestone for Ontario listed by Ontario Ministry of Agriculture and Food, July 1987.

SOURCES OF INFORMATION

Basemap compiled from maps 600480 Parry Sound N., and 600490 Parry Sound S; by the Ontario Ministry of Transportation and Communications, scale 1:100 000.

Precambrian Geology of the Whitestone Lake Area, District of Parry Sound; Ontario Geological Survey, Map P.3095, Geological Series-Preliminary Map, by E.G. Bright, 1987; scale 1:15 840 or 1 inch to 1/4 mile.

A tectono-metamorphic framework for part of the Grenville Province, Ontario; by A. Davidson, N.G. Culshaw and L. Nadeau, p. 175-190 in Current Research, Part A, Geological Survey of Canada, Paper 82-1A, 1982.

Geology and Mineral Deposits of the Parry Sound-Huntsville Area; Ontario Department of Mines, Geological Report 52, 65 p., by D.F. Hewitt, 1967.

Geology of the Dunchurch Area, Ontario; Geological Society of America, Bulletin, Volume 71, p. 1713-1718, by W.C. Lacy, 1960.

Ferrie River Area, Parry Sound District; Ontario Geological Survey, Geological Series-Preliminary Map, by G.D. McRoberts and M.L. Tremblay, in press.

Mineral Occurrences in Parry Sound District; Ontario Department of Mines, Annual Report for 1942, Volume 51, Part 2, 86 p. by J. Satterly, 1943.

Limestone (Marble) Occurrences

in the

Parry Sound Domain,

District of Parry Sound, Ontario.

Scale 1: 100 000 N.T.S 31 E

MAP 1

Geology of the Gene Pawlech
Marble Occurrence,
Spence Township, Concession 5, Lot 33,
District of Parry Sound, Ontario.
N.T.S. 31 E/12
MAP 2
LEGEND
la clean marble (<5% non-carbonate minerals)
lb impure marble (>5% non-carbonate minerals)
2a melanocratic metabasite: pyroxene, amphibole, plagioclase, scapolite gneiss
2b leucocratic metabasite: plagioclase, scapolite, pyroxene, amphibole
3 garnetiferous metabasite
4 granitic pegmatite
5 quartzite
6 pyroxene/amphibole/biotite granite
7 titanite-bearing pyroxene-plagioclase granitoid gneiss
la i marble with unsubdivided lithic inclusions
la,i2 marble with inclusions of metabasite
ph = phlogopite
gf = graphite
di = diopside
fp = feldspar
pc = plagioclase
sc = scapolite
= foliation, strike,dip
x = small outcrop
= limit of outcrop
= fence
= road
Δ = boulder
= bedding
0 10 20 30 40 50 m
Scale 1:500
N (mag)
to North Seguin
to Broadbent
B.L.
junk heap
200 N
300 N
400 N
500 N
600 N
100 E
50 E
50 W