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DEPARTMENT OF MINES AND TECHNICAL SURVEYS

MINES BRANCH

OTTAWA

PRELIMINARY REPORT ON COATED LIGHTWEIGHT CONCRETE AGGREGATE FROM CANADIAN CLAYS AND SHALES

PART IV

NEW BRUNSWICK, NOVA SCOTIA, AND PRINCE EDWARD ISLAND

by

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Industrial Minerals Division

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Preface

In 1949, the Mines Branch undertook an investigation to locate sources of clay and shale in Canada that would be suitable for use in the production of lightweight concrete aggregate.

In the field work that followed, samples weighing from 5 to 10 pounds were collected from what are considered to be the most important known deposits within marketable distance of well-populated areas. The samples were taken by trenching so as to obtain a true average of the deposit.

The results of the work in Alberta have been published as Part I in the Memorandum Series No. 117, in Manitoba and Saskatchewan as Part II in Memorandum Series No. 120, and in Ontario as Part III in Memorandum Series No. 121. Further field work is necessary to complete the surveys of the Provinces of Quebec, British Columbia and Newfoundland.

The field work for the present report was done during the summer of 1951 and the laboratory work during the following winter.

The aim of the laboratory work in connection with this and the other reports has been to produce the highest grade of aggregate, namely a coated aggregate, at the lowest cost by using the raw materials in their natural state. In view of the number of samples covered and the limited amounts of each, no work has been done on the suitability of the materials for the production of sinter aggregates either in the rotary kiln or sintering machine.

It should be noted, however, that many of the materials classed in the reports as being unsuited for coated aggregate manufacture might be found very satisfactory for the production of sinter aggregate. For anyone considering such production the work covered in these reports on raw materials for coated aggregate manufacture will at least eliminate the decidedly unfavourable materials and will indicate those upon which further work should be done.

The Branch wishes to thank J. Vandenbroeck, J. Cavanaugh, and H. Lowe, duputy mine inspectors at Minto, N. B., Glace Bay, N. S., and New Glasgow, N. S., who gave valued assistance in the collection of shale samples from coal mines in their respective areas. Reports and maps of The Geological Survey of Canada were of great assistance in locating outcrops.

John Convey,
Director, Mines Branch.

COATED LIGHTWEIGHT CONCRETE AGGREGATE
FROM CANADIAN CLAYS AND SHALES

PART III

ONTARIO

by

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INTRODUCTION

Definition of Lightweight Aggregate

A lightweight aggregate may be defined as an aggregation of fine and coarse particles of a material which because of its light weight, strength, low absorption, and chemical stability, can be mixed with cement to form a concrete of pre-determined characteristics. Coated lightweight aggregate has a thin, hard, smooth, outer shell or coat which gives the aggregate improved properties of high strength, low absorption, and good workability.

Types of Clay and Shale Lightweight Aggregate

Two distinct types of lightweight aggregate are made from clays and shales namely, coated type aggregate, and sinter type aggregate.

The first type is made by rapid firing in a rotary kiln. Gases released from within the clay or shale during the pyroplastic condition cause it to expand into light, cellular particles. The particles are usually well rounded due partly to the bloating action and partly to the tumbling taking place in the kiln. The quantity and quality of the fluxes in the shale allow this expansion or bloating to take place at a temperature below that at which the particles become sticky so that the product is discharged from the kiln in individual, coated particles. An ideally coated aggregate requires no crushing after firing to supply the required grade sizes.

Sinter type aggregate may be made in either the rotary kiln or sintering machine. The rotary kiln process for producing a sinter type aggregate differs from that for coated aggregate in that the product is crushed to supply the required grade sizes. Due to the quantity and quality of the fluxes present this material cannot be fired with sufficient expansion below the temperature at which sticking occurs, and as a result the individual particles agglomerate and are discharged as clinker. The sinter aggregate produced on the sintering machine, except for being harsher, is similar to the sinter product from the rotary kiln. The raw material for the sintering machine process is finely ground and mixed with a pulverized fuel, pelletized, placed on a travelling grate, and ignited. A lightweight product is formed by bloating or sintering or by a combination of both depending upon the raw material. The sintering machine type product may be made from a greater variety of raw materials than the rotary kiln sinter and coated types.

Desirable Properties of a Lightweight Aggregate

The raw material selected for the production of a lightweight aggregate must be capable of giving a product possessing the following desirable properties.

(a) High Strength to Weight Ratio

The product must be light to effect a worthwhile saving in weight and at the same time be strong enough to meet strength specifications. Variations in both the strength and weight may be effected by modifying the processing technique. As the strength of a product is increased, the weight is also increased and vice versa. Because of their strong shell and spherical nature, coated lightweight aggregate particles tend to give a product with a higher strength to weight ratio than other types. The actual maximum weights specified for a properly graded aggregate under A.S.T.M. specifications, designation C130-42 are 75 lb./cu.ft. for the fine aggregate and 55 lb./cu. ft. for the coarse aggregate.

(b) Good Workability

The smooth, spherical nature of coated clay and shale aggregate particles promotes good workability whereas aggregate particles with sharp corners make a harsh concrete mix that is difficult to work around reinforcing bars, tending to give a honeycomb structure.

(c) Low Absorption

An aggregate with a high water absorption, unless it has been pre-soaked, tends to dehydrate the cement which has a harmful effect on the setting of the concrete. Coated aggregates generally have a lower absorption than other aggregates because of the coating covering the cellular interior.

(d) Uniform Size Gradation

The product must be composed of aggregate particles of a range of sizes with sufficient fine material to permit working the mix around forms and reinforcing bars. The grading prescribed may be referred to under A.S.T.M. specifications, designation C130-42.

(e) Chemical Inertness

A lightweight aggregate should not contain chemical impurities which might react with the cement or reinforcing materials with deleterious effects.

TEST METHODS

The equipment used for the laboratory evaluation of clays and shales for lightweight aggregate consisted of a small jaw crusher, screens, a gas-fired stationary furnace (capable of up to 2700°F), a drying oven, a 5" x 5' gas-fired rotary kiln, a bulk density container, a balance sensitive to one gram, and crushing strength apparatus.

Preparatory to testing, all samples were reduced in size to -1/2"+ 1/4". Samples that were not coarse enough or were too soft to stand crushing were pelletized in a small cement mixer, dried, and screened to the above size range. Because of the shortness of the rotary kiln, all samples were dried overnight in an oven maintained at 100°C to drive off the mechanically held moisture and thus prevent decrepitation when subjected to rapid heat.

Stationary Furnace Tests

Small amounts of each sample were tested first in the stationary furnace at various temperatures and heating times. These tests facilitated the elimination of materials obviously not suited for coated aggregate manufacture and the selection of the most promising ones for testing in the rotary kiln.

By firing the materials at various retention times and temperatures it is possible to predict the relative length of vitrification range of each material and to observe the relative amount of bloating. If a material shows little surface fusion with a dull appearance when well bloated, indications are favourable for trial in the rotary kiln. On the other hand if, on increasing the temperature and firing time, the material is not bloated until the surface shows a high degree of fusion (glassy appearance) indications are that it has a short vitrification range, and will give sticking and agglomerating trouble in the rotary kiln. Materials with a very narrow vitrification range are thus eliminated from further testing but materials having intermediate properties in this respect must be tested in the rotary kiln before any conclusions can be drawn.

Stationary furnace tests permit the screening out of materials that are poor bloaters and those that are, for economical reasons, too refractory. For the purposes of this investigation all materials that failed to show any bloating when fired in the stationary furnace at 2400°F for five minutes, were classed as too refractory.

These tests also facilitate the elimination of materials that are extremely non-uniform in composition. Many materials, especially those laid down under shallow water conditions contain varying amounts of the fluxes or refractory constituents. In coal mine shales, a frequent cause of non-uniformity is the varying amounts of free carbon. Depending upon their extent these variations may mean the elimination of the material as a possible raw material.

Upon completion of the stationary furnace tests, the materials selected for the rotary kiln tests were those that had good bloating properties with a reasonably good vitrification range, were not too refractory, and showed reasonable uniformity.

Rotary Kiln Tests

The selected dried materials were processed in a 5" x 5' gas-fired, rotary kiln. Although the kiln had variable pitch and speed, all materials were processed under the same retention time conditions to give a total retention time of about six minutes. The temperature for each run was kept as close as possible to the maximum temperature permissible for each material without having agglomeration of the charge. In general, this is the temperature at which a commercial kiln producing coated aggregate would operate. It is possible to produce the same result at a lower temperature with an increased retention time but only at a great sacrifice in the volume of material handled.

It should not be assumed that the products made in the 5" x 5' rotary kiln in this investigation are the best obtainable. In view of the number of samples covered and the limited amount of each it was impossible to experiment with each sample to determine the best operating conditions. The small scale rotary kiln tests carried on in this investigation merely indicated which materials have the best possibilities for commercial rotary kiln coated aggregate.

The determining factor in whether a good bloating material is suited for coated aggregate manufacture or not is the degree of sticking and agglomeration of the particles when bloating. This property can be determined quite satisfactorily in the small kiln.

As a result of the stationary furnace and rotary kiln tests the materials were classified into five groups which are shown in the summary tables for New Brunswick and Nova Scotia on pages 20 and 33A respectively. These classifications are as follows:

1. Materials considered suitable for coated aggregate production.
2. Materials which are good bloaters but which are not considered suitable for coated aggregate production because of their relatively narrow vitrification ranges and resultant sticking and agglomerating characteristics.
3. Materials which are poor bloaters.
4. Materials which are too refractory.
5. Materials which are non-uniform and which are a combination of two or more of the above classifications.

For anyone interested in the production of sinter aggregate in the rotary kiln the logical materials for experimental work, of those collected, would be those listed in groups 1 and 2 above. Since a high bloating material is not desirable for sintering machine treatment, the possible raw materials for this type of aggregate are those listed in group 3 above.

In connection with the materials classified in table form as having good possibilities for coated aggregate manufacture, it should be remembered that this classification is based only on the quality of product. Other facts that are of decided economic importance such as amount of material available, nearness to market, and availability of fuel are discussed, if known, under the test results for each material.

It must also be kept in mind that this investigation is concerned only with the use of materials in their natural state. It is quite possible that chemical beneficiation would convert some of the unsuitable into suitable materials. Again, many materials classed as too non-uniform might prove quite suitable if finely ground and pelletized before firing. Both possibilities, of course, would increase the cost of production.

Determination of Physical Properties

Three physical properties of the aggregate were measured, namely the bulk density, the crushing strength, and the volume expansion.

The bulk density was determined in a machined metal container of 1/30 cubic foot capacity on the product crushed to -3/8 inch + 8 mesh. The standard jigging procedure as specified in A.S.T.M. designation C29-42 was followed. This size range (-3/8 inch + 8 mesh) approximates that specified in A.S.T.M. specifications, designation C130-42, and should have a bulk density value of less than 55 lb./cu. ft. to be acceptable.

The test used to determine the crushing strength, was patterned on that carried out in other laboratories. The apparatus consisted of a steel cylinder, 2 inches inside diameter, and 6 inches deep, into which the aggregate crushed to -3/8 inch + 8 mesh was poured without any tamping, to a depth of 4 1/2 inches. A steel plunger, 1 31/32 inches in diameter, was used to apply pressure to the aggregate in a Carver Hydraulic Press and the amount necessary to give a compaction of 1 inch was noted. This was then converted to lb./sq. inch.

The true value of this test has not been determined. It should, however, provide a rough method of rating a product if the result is considered along with the weight of the product. Since weight and strength vary directly, the crushing strength-to-weight ratio gives a better method of evaluation.

The volume expansion of the product was determined simply by measuring the volume of the feed before firing, and the product after firing, and by calculating the percentage increase. The volume expansion of a material affects the economy of the operation because the higher the volume expansion the less the amount of feed material required to give the same volume of product.

It should be kept in mind that the mere expansion of a clay or shale does not necessarily mean that it will make a good concrete aggregate. Considerable test work must be done on any one material to determine the maximum allowable expansion necessary to give a product of the required strength. Neither is there any substitute for actual concrete tests in evaluating the product.

RELATION OF CHEMICAL PROPERTIES TO THE BLOATING OF CLAYS AND SHALES

Review of Previous Work

T.E. Jackson[1] considered it possible that bloating of clays might be due to the evolution of oxygen as the ferric oxide passed into the ferrous oxide on combination with the silicates.

Orton and Staley[2] thought that if Jackson's theory were correct all bloating clays would contain ferric oxide and should, therefore, bloat at the same temperature. They found, however, that clays bloated at different temperatures, and moreover, that many clays which contained iron, did not bloat. They considered the cause of gas **evolution** to be chiefly the dissociation of sulphides and sulphates by silicic acid which becomes increasingly active as the temperature rises and appropriates the bases formerly combined with the sulphur. They considered that the sulphur came out of solution as sulphur dioxide and that this gas was responsible for the bloating. They also recognized that sulphur did not oxidize to sulphur dioxide and escape until after the carbon had been oxidized. In many cases, especially if the firing was rapid, by the time the carbon was oxidized the clay had become too dense to allow the sulphur dioxide to escape and bloating resulted. They treated bloating as an undesirable quality and concluded that it could be avoided by applying a deliberate and complete oxidation treatment while the clay remained porous to remove the carbon and sulphur.

Wilson[3] considered that the gases which caused bloating when the clay or shale had reached the vitrified condition might have consisted of entrapped air, steam, sulphur dioxide and trioxide, carbon dioxide or monoxide, oxygen or hydrocarbons, absorbed during firing. He treated bloating as an undesirable quality of some clays and shales, and observed that it took place to a greater degree in the fine-grained, dense materials. He regarded expansion, caused by entrapped gases in a semi-viscous body, as due to two causes:

1. Improper oxidation resulting from insufficient heating time at temperatures below the vitrification range, where the gases were chiefly formed from the carbon, sulphur, and carbonates.

2. Decomposition of contained material during and above the vitrification temperature, the most common material being calcium sulphate which produced sulphur dioxide or trioxide.

Bleininger and Montgomery[4] stated that if at any time the evolution of gaseous matter was rapid enough to produce pressure within the clay, then bloating was certain to take place, and a vesicular structure would be formed. They recognized that both the physical constitution of the clay, that is, compactness and fine grain, as well as the mode of shaping, were of as great, if not greater, importance than the amount of constituents present which form gases.

The United States Emergency Fleet Corporation[5] which developed lightweight aggregate during World War I for use in the construction of concrete ships found that the clay or shale should be rich in compounds of metallic oxides, carbon, sulphur, sodium, potassium, or other equivalent compounds, some of which, when the material is subjected to heat, will either act as a flux or give off gas.

Experiments by Jackson[6] showed that not all the sulphur was evolved at low temperatures but that complex compounds of sulphur, such as "ferrous sulpho-silicate" were formed. Jackson observed that sulphur is not retained at high temperatures without the presence of iron oxide in the clay. He believed that the bloating of clay was due to sulphur but only that sulphur retained at high temperatures in the complex compounds with iron and silica.

Sullivan, Austin and Rogers[7] when experimenting with making expanded clay building units found that, for most clays, best results were obtained when the kiln atmosphere was slightly on the reducing side. They also found that in general, high lime clays had a short bloating range and low lime clays, a longer one.

Austin, Nunes and Sullivan[8] heated various clays in a tube furnace and determined quantitatively the gases evolved during bloating. They also determined the effects on bloating of variations in heating rates, rate of air flow, and the atmosphere. These investigators found that carbon dioxide, sulphur dioxide, and water were evolved at the bloating temperature. They believed that, since most carbonates decompose at low temperatures, the carbon dioxide was formed by the oxidation of the elemental carbon that remained in the clay by reduction of the ferric oxide. They suggested that the sulphur dioxide might be evolved from the decomposition of residual calcium or magnesium sulphate or intermediate compounds formed during the firing. The water evolved was considered to have come from some mineral other than clay as clay loses its crystal lattice structure at a temperature below the bloating temperature. In general, the evolution of gases from clays varied inversely with the rate of heating, and directly with the air flow. It was shown that good bloating took place in a nitrogen atmosphere which indicated that the oxidation must come from within the clay rather than from a reaction with the atmosphere.

Conley, Wilson and Klinefelter(9) made an extensive study of the availability of raw materials, methods for producing lightweight aggregates, and on causes of bloating. Their work indicated that various compounds of iron, alkali, and alkaline earths furnished the fluxes and gases necessary to bring about bloating. Using this assumption various admixtures of such compounds were added to non-bloaters and to poor bloaters with good results in some cases. They found that the results varied decidedly depending upon the clay to which the admix was made, and that each clay required a separate study. These authors attempted to correlate the bloating properties with chemical analyses, and from their work concluded that chemical analyses were only of partial value as they did not indicate the mineral form of the impurities. They observed that the mineral form of the impurities in the clay was the key to whether a clay or shale would bloat or not.

Charles M. Riley(10) stated the two conditions necessary for bloating as follows:

1. "Enough of the material must fuse to fill the pore spaces so that gases being formed will be trapped. The fused material must, of course, be viscous enough so that the gas does not escape by bubbling through it."

2. "Some mineral or combination of minerals must be present that will dissociate and liberate a gas at the time when the mass of clay has fused to a viscous melt."

He classified materials as bloaters and non-bloaters, and by plotting the chemical analyses on a composition diagram, was able to show that one condition of bloating could be defined i.e., the condition of proper viscosity at the bloating temperature. By adding pyrite, hematite, and dolomite to non-bloating mixtures, and by bringing the composition into the area defined on the composition diagram, Riley showed that these minerals could produce the gases necessary for bloating. It was also discovered that many igneous rocks whose compositions fell within the area of bloating on the composition diagram bloated well when ground and cast into briquettes. Riley supported the earlier contentions of Jackson[1] and thought the principal reason for bloating was the evolution of oxygen during the dissociation of Fe_2O_3. He also recognized that pyrite probably dissociated to give sulphur dioxide at high temperatures, and that dolomite probably formed intermediate compounds with the other constituents which retained some of the carbon dioxide until dissociating at the bloating temperature.

APPLICATION OF CHEMICAL ANALYSES TO PROBLEM OF PRODUCING COATED AGGREGATE

As this investigation was concerned only with the highest grade of aggregate i.e., coated aggregate, the differences between materials found suitable for coated aggregate production and those that were not, were of more interest than the differences between non-bloating and bloating clays. Many materials proved to be excellent bloaters yet were found to be unsuitable for coated aggregate because of their narrow vitrification ranges, and sticking and agglomerating qualities. Following stationary furnace and rotary kiln tests all materials tested were classified into one of five groups previously mentioned under test methods.

Chemical analyses were secured of representative materials from each of the classifications except the non-uniform materials. Not included in the chemical analyses plotted were materials that had an excessively high combustible carbon content such as shown by many coal mine shales. Small amounts of carbon are probably most beneficial to bloating but excessive amounts mask the normal reactions taking place, and in the short heating time given the materials of high carbon content, only a thin surface coating of the particles showed any oxidation or bloating.

Some of the materials classed as poor bloaters would very probably be good bloaters, or be found suitable for coated aggregate manufacture, if the heating time were long enough to remove some of the excess carbon. The effect on bloating when excess carbon was removed by prolonged preheating, before subjection to bloating tests, is illustrated in Figure I, page 15. The decided improvement in the interior structure of the particles is not shown. When a material, high in combustible carbon, is not preheated, the product expands by the swelling of the combustibles rather than by bloating. With prolonged preheat treatment and removal of carbon, a bloated cellular structure and a lighter product are developed. For these reasons shales high in combustible carbon were not considered to be representative of their classification as poor bloaters.

The conditions necessary for a clay or shale to be suitable for the production of a coated aggregate are as follows:

1. The material must contain a compound that will dissociate, or form intermediate compounds that will dissociate, with the formation of a gas or gases at a temperature at which the material is in the pyroplastic condition.

2. The material when in the pyroplastic condition must have a high viscosity so that the released gases will be trapped, and so that the surface tension of the particles is great enough to draw each particle mass together, and minimize agglomeration of the particles into a clinker.

3. The material must have a wide vitrification range to allow easy temperature control below the temperature at which sticking and agglomerating become excessive.

Previous work has shown that the chemical analysis of a material is of no value in determining whether the required gas-forming compound is present or not. However, in this investigation most materials showed some evidence of gas release or bloating with the exception of the refractory materials, a large number of which would show some bloating if the temperature were carried high enough. Other investigators have shown that a fraction of one per cent of a gas-forming compound is all that is required for good bloating of a clay or shale. In view of this it is probable that Condition 1 is not so important a determining factor as the conditions of high viscosity and wide vitrification range.

The composition diagram shown in Figure 2, page 17, with alumina, silica, and total fluxes at the corners shows that the viscosity condition requires the chemical composition of a clay or shale to be within a fairly well defined area. For this diagram the volatile material and minor constituents were neglected and the analyses recalculated on the basis of 100 per cent.

The vitrification range of a clay or shale for the purposes of lightweight aggregate manufacture covers the partially fused condition and is the range in temperature between the point of incipient fusion and the point at which the viscosity has decreased to impractical working conditions. The lower limit of the vitrification range is fixed by the temperatures at which the eutectic composition of the components begins to liquefy. The upper limit is fixed by the character and quantity of the fluxes present.

The fluxes containing sodium and potassium will give a wider vitrification range than those containing calcium and magnesium because their high viscosity retards their interaction with the surrounding clay grains. Fluxes containing calcium and magnesium have a low viscosity and shorten the

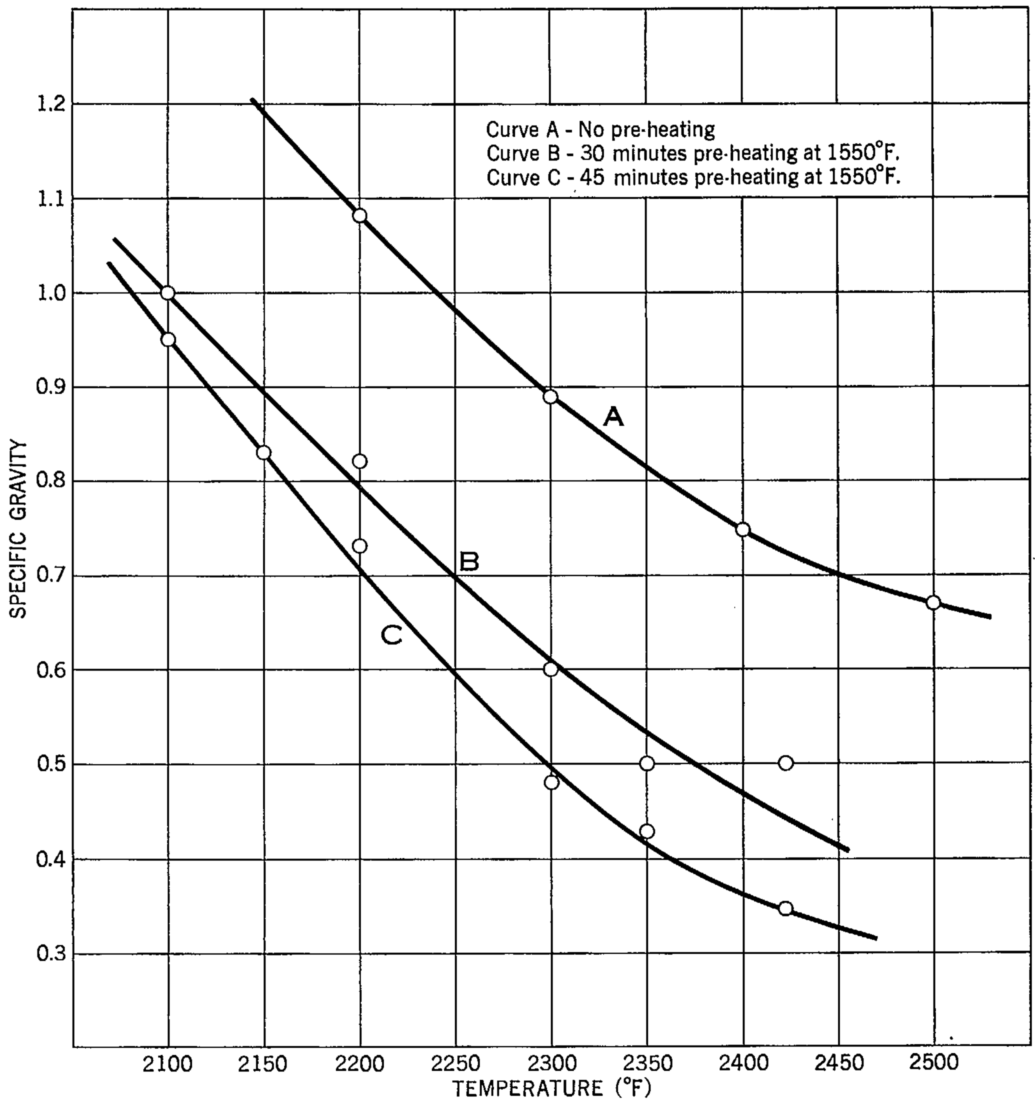


Figure 1 - Effect of preheating upon the specific gravity of bloated specimens of shale high in combustible carbon.

vitrification range. Ferric oxide is believed to be an intermediate flux. There seems reason to believe, therefore, that the vitrification range of a clay or shale should bear some relation to the proportions of the $K_2O + Na_2O$ and $CaO + MgO$ fluxes.

In Figure 3, page 19, the ratios of the $K_2O + Na_2O$ fluxes and $CaO + MgO$ fluxes have been plotted for the materials that had a wide vitrification range and were found suitable for making a coated aggregate and for the materials that were unsuitable and had too narrow a vitrification range. It is apparent from this diagram that a material, to have a wide enough vitrification range, should have an excess of the $K_2O + Na_2O$ fluxes over the CaO + Mgo fluxes. With only one exception all materials found suitable for making coated aggregate in this investigation had a value of greater than 1 for the ratio of $K_2O + Na_2O$ to $CaO + MgO$. The materials with too narrow a vitrification range had a value of less than 1.

The vitrification range of a clay or shale coated aggregate raw material has an important bearing on the size range of the feed for the rotary kiln. In most materials the extreme fine sizes start to agglomerate at a temperature below that sufficient to cause good bloating of the coarse sizes. However, if the vitrification range is wide this temperature may still be high enough to allow good bloating of the coarse sizes. Otherwise, the feed has to be separated in at least two size ranges, and each fired separately. In actual practice the vitrification range should be wide enough to allow bloating over a range of at least 50°F below the temperature at which sticking becomes excessive.

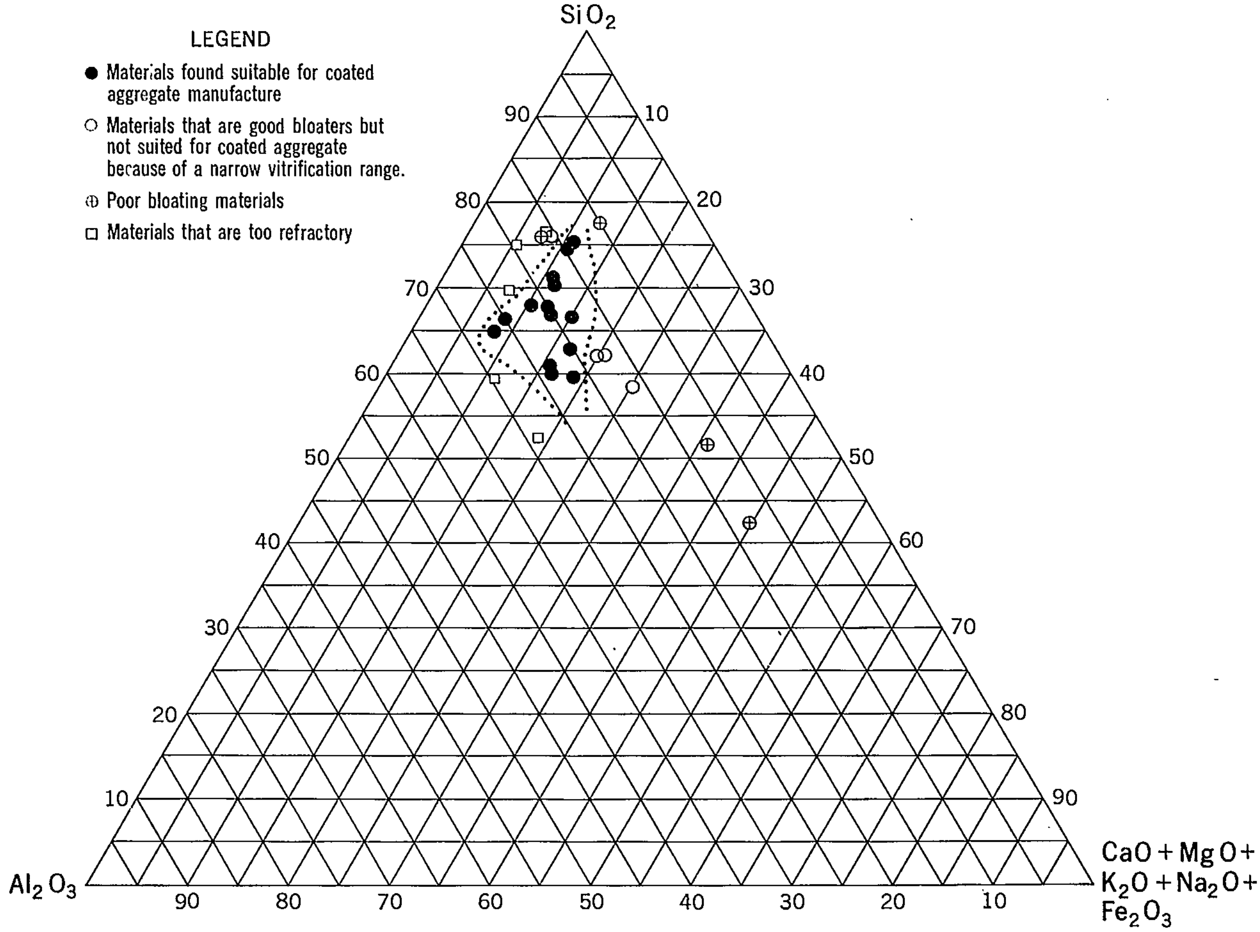


Figure 2 - Composition diagram of major oxides in clays and shales showing proportions required to produce coated aggregate. Dotted line represents approximate limits of materials suited for coated aggregate.

The chemical analysis of a clay or shale appears to be valuable for the defining of two conditions necessary for producing a coated aggregate namely, viscosity, and vitrification range, but is of no known value in determining whether or not the required gas-forming compound is present. A material, to be suitable for the production of coated lightweight aggregate, should have proportions of silica, alumina, and total fluxes as defined in the composition diagram shown in Figure 2, page 17, and an excess of the $K_2O + Na_2O$ fluxes over the $CaO + MgO$ fluxes as illustrated in Figure 3, page 19.

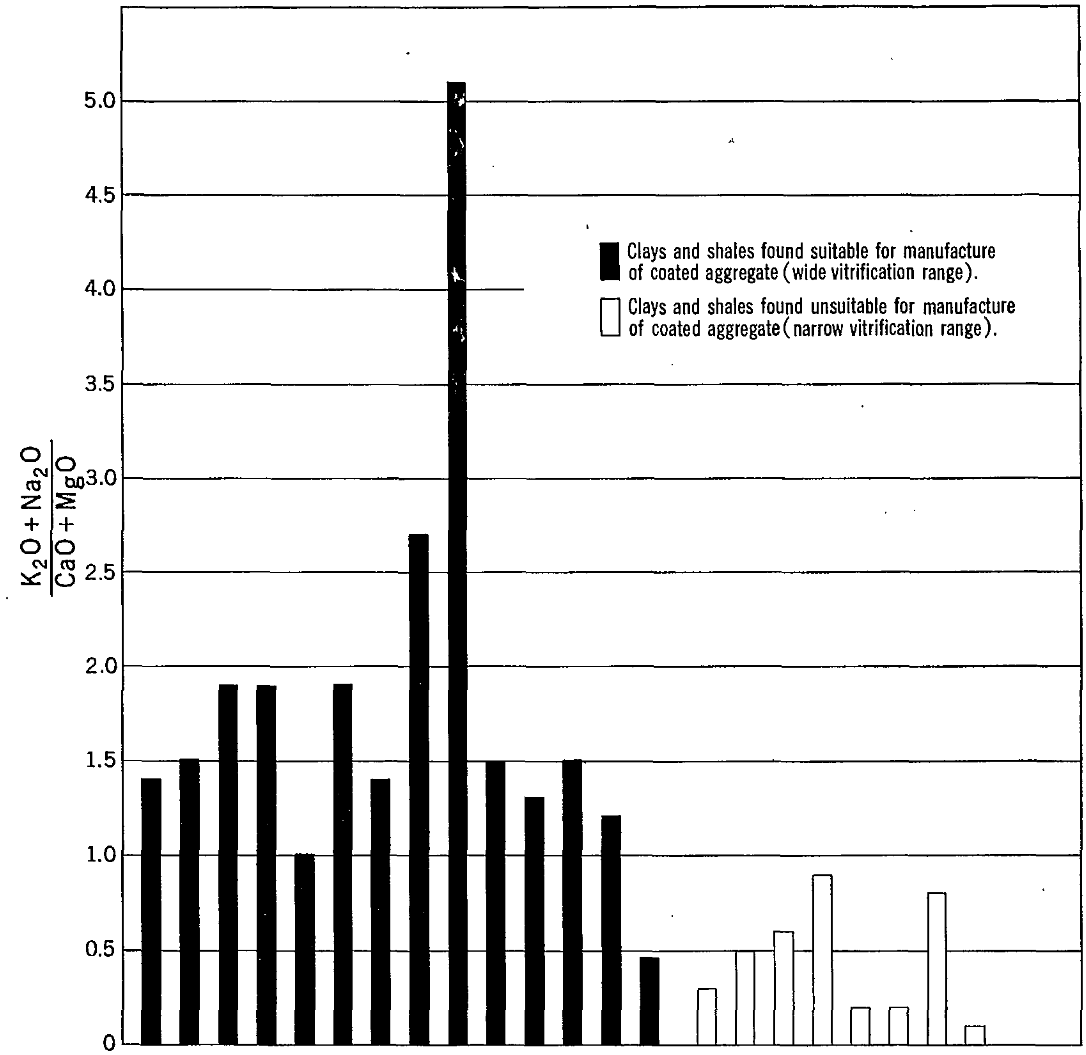


Figure 3 - Relationship of type of fluxes in clays and shales to width of vitrification range.

LOCATIONS, DESCRIPTIONS AND TEST RESULTS

OF CLAYS AND SHALES

IN

NEW BRUNSWICK

Figure 4

SUMMARY OF LIGHTWEIGHT AGGREGATE TEST RESULTS - NEW BRUNSWICK

Materials having good possibilities for coated aggregate production		Materials that are good bloaters but are not considered suitable for coated aggregate because of sticking and agglomerating characteristics		Materials that are poor bloaters		Materials that are too refractory (show no fusion or bloating when fired in stationary furnace at 2400°F for 5 minutes)		Materials that are too non-uniform in bloating qualities	
Locality	Sample No.		Sample No.	Locality	Sample No.	Locality	Sample No.	Locality	Sample No.
Minto-shale		Fredericton-shale	1,2	Chipman-shale	12	Chipman - shale	11,13	Fredericton-clay	3
Minto-shale		Fredericton-clay	4	Bathurst-clay	33			Moncton-shale	19
Minto-shale	8,9,10	Fredericton-clay	5	Bathurst-shale	35			Moncton-shale	27-28
Chipman-shale	15	Chipman-shale	14					Bathurst-shale	34
Moncton-shale	20,21,22	St. John-clay	16						
	23	Moncton-shale	17,18						
Moncton-shale	24,25,26	Moncton-shale	30,31						
Moncton-shale	29	Chatham-clay	32						

LOCATIONS, DESCRIPTIONS AND TEST RESULTS OF CLAYS AND SHALES IN NEW BRUNSWICK

The clays and shales tested from New Brunswick gave fair results in the laboratory. Of 35 samples tested, 14 taken from 7 occurrences showed good possibilities as raw materials for coated lightweight aggregate; 11 from 8 occurrences were good bloaters but had too narrow vitrification ranges; 3 from 3 occurrences proved to be poor bloaters; 2 from 1 occurrence were too refractory; and 5 samples from 4 occurrences were too non-uniform.

The 14 samples found suitable for making coated lightweight aggregate came from three localities, namely, Minto, Chipman and Moncton. Of these three localities the shales from the Moncton area gave the better product. Also, from the marketing point of view, the Moncton area is more central than the other two.

Descriptions of the occurrences sampled and the laboratory test results are given below. Approximate locations of clays and shales having possibilities for making coated lightweight concrete aggregate are marked on the map at the end of the report.

FREDERICTON

The country immediately surrounding Fredericton is underlain by gently dipping Pennsylvanian sandstones, conglomerate and reddish brown shale. Exposures of shale, however, are limited.

At the L. E. Shaw, Limited, brick plant on Woodstock road, reddish brown shale is used for the production of dry pressed brick. The shale is brought from a pit located 2 miles west of the plant. A geological section of the shale pit was noted as follows:

Sandy glacial clay	-	2 feet
Reddish-brown shale (Sample 1)	-	5 feet
Reddish-brown silty shale (Sample 2)	-	3 feet

When tested in the stationary furnace both of these samples proved to be poor bloaters and possessed a narrow vitrification range. Rotary kiln tests were considered unwarranted.

Samples were secured from an old clay pit adjacent to the L. E. Shaw, Limited, plant. A section of the pit was measured as follows:

Top soil	-	6 inches
Reddish-brown clay (Sample 4)	-	9 feet
Blue clay (Sample 3)	-	8 feet

A portion of the lower blue clay bloated well in the stationary furnace but had a narrow vitrification range. The remainder of the sample showed no bloating under the same firing conditions. A rotary kiln test on ground and pelletized feed gave a poor product.

The upper reddish-brown clay (Sample 4) bloated well in the stationary furnace but had too narrow a vitrification range to warrant a rotary kiln test.

A sample of calcareous thin-bedded clay (Sample 5) was obtained from Gardens Creek approximately two and one half miles east of Fredericton. It is reported that the clay extends to a depth of 90 feet in a neighboring well. Several acres, at least, are underlain by the deposit.

Stationary furnace tests made on this clay (Sample 5) showed it to be a good bloater but with too narrow a vitrification range.

MINTO

The Minto area is underlain by the Grand Lake formation of sandstone, conglomerate, shale and coal. The main coal seam varies in thickness from 18 inches to 24 inches so that in most underground mines about two and one half feet of the overlying shale must be removed for head room. It is reported that from one to two tons of shale are hoisted for each ton of coal mined. This has resulted in tremendous tonnages of shale lying on the waste dumps at each mine. The shale overlying the coal is uniform, light grey in colour, soapy to touch and contains fossilized plant remains. On standing in the open it disintegrates to a flaky clay. Probably the most noticeable feature of the shale dumps examined in the Minto area is their cleanliness. In contrast to mine waste dumps in other coal mining areas the shale is not mixed with any appreciable amount of sandstone, conglomerate, coal or other foreign materials.

Sample 6 was representative of 2½ feet of shale overlying the coal at the McMann mine east of Minto. This material bloated well in the stationary furnace and possessed a wide vitrification range. However, the product was highly laminated. In the rotary kiln a laminated product was obtained showing a volume expansion of 100 per cent, a bulk density of 44 lb./cu.ft.

and a crushing strength of 875 p.s.i. The average kiln operating temperature was just under the agglomerating temperature of 2050°F.

At the mine of the Newcastle Coal Company, Limited, 2¼ miles east of Minto, a grab sample (Sample 7) was taken of the shale on the dump. This material is very clean and uniform and a large supply is available. About 300 tons of shale is hoisted daily and discarded as waste.

Stationary furnace tests on this shale (Sample 7) showed a wide vitrification range and good bloating properties. The product obtained in the rotary kiln showed a volume expansion of 100 per cent, a bulk density of 47 lb./cu. ft. and a crushing strength of 954 p.s.i. The average kiln operating temperature was just below 2050°F at which temperature agglomeration started. In physical appearance the product was almost identical to the product from the shale at the McMann Mine. Although both products were laminated they seemed to be quite strong.

Samples of shale were taken at the strip mine belonging to the Miramichi Lumber Company, Limited, located 3½ miles north of Minto. A section of the pit down to the top of the coal seam was noted as follows:

Sandstone	-	4 feet
Iron-stained shale (Sample 10)	-	10 feet
Greenish-grey shale (Sample 9)	-	8 feet
Coal	-	4 inches
Light grey shale (Sample 8)	-	6 feet
Coal	-	4 inches
Light grey shale	-	1 foot

The light grey shale (Sample 8) had properties similar to the shale lying above the coal at the two previous locations. The rotary kiln product obtained was not as good as that from the two previous shales because of a drop in temperature for part of the run. The volume expansion measured 60 per cent and the bulk density 58 lb./cu. ft. The agglomerating temperature was 2050°F, the same as for the two previous materials.

The greenish-grey shale (Sample 9) bloated well in the stationary furnace and possessed a wide vitrification range. The rotary kiln product showed a volume expansion of 80 per cent and a bulk density of 56 lb./cu. ft. The crushing strength measured 3818 p.s.i. The average kiln temperature was 2080°F while agglomeration started at 2100°F. A slightly longer kiln retention time would give a lower bulk density.

The upper iron-stained shale (Sample 10) also bloated well in the stationary furnace and showed a wide vitrification range. When fired in the rotary kiln at just under the agglomerating temperature of 2050°F the shale gave a product showing a volume expansion of 50 per cent, a bulk density of 59 lb./cu. ft. and a crushing strength of 3500 p.s.i. A portion of the product showed no bloating. It is quite possible that this small amount of foreign material could be excluded by careful mining. A longer kiln retention time would give a lighter product.

The shale samples (6 to 10 inclusive) from the Minto area all gave indications of being suitable for the manufacture of coated lightweight aggregate. All possess good bloating properties and a wide vitrification range. The products formed tend to be laminated rather than well rounded but the crushing strengths are high. The effect of these laminations on the strength of the product could only be determined by actual concrete tests. If necessary, the laminated nature of the product could be eliminated by finely grinding and pelletizing the shale before feeding it to the rotary kiln.

Practically unlimited amounts of the shale, as mine waste, are readily available. Pulverized coal could serve as cheap fuel.

As with many other localities the question of availability of markets would require a great deal of study if any development were undertaken.

CHIPMAN

At Chipman, L. E. Shaw, Limited, are using red shale of the Grand Lake formation for the production of brick. A generalized section of the company's pit, located 2¼ miles north-east of Chipman, is as follows:

Topsoil	- 3 feet
Massive sandstone	- 7 feet
Greenish-grey soft shale	- 1 foot
Massive, hard, red, sandy shale (Sample 13)	- 10 feet
Red shale (Sample 12)	- 10 feet
Massive, hard, red shale (Sample 11)	- 10 feet

The two beds of hard, red, shale (Samples 11 & 13) proved to be too refractory and showed no bloating or fusion when fired in the stationary furnace at 2400°F for 5 minutes.

The intermediate shale (Sample 12), when tested in the stationary furnace, proved to be a poor bloater at temperatures approximating what is considered to be the commercial limit.

Samples were also secured from the company's old shale pit adjacent to the one described above. Sample 14 was representative of 8 feet of fairly soft red shale while Sample 15 represented 5 feet of blue shale underlying the red shale. In the stationary furnace both materials bloated well. The red shale, however, possesses a narrow vitrification range which resulted in a very poor rotary kiln product. Satisfactory bloating did not occur below 2100°F at which temperature agglomeration became quite serious. The rotary kiln product made from the blue shale (Sample 15) showed a volume expansion of 110 per cent, a bulk density of 43 lb./cu. ft. and a crushing strength of 1591 p.s.i. The average kiln temperature for this material was just below the agglomerating temperature of 2050°F. Although the product was laminated it appears to be strong and shows possibilities as a coated aggregate raw material.

ST. JOHN

The St. John area is underlain by a wide variety of consolidated rocks ranging in age from Precambrian to Triassic. The St. John Group of sediments, the Kennebecasis Formation, and the Lancaster Formation all contain quite extensive shale beds that are worthy of work by those interested in a raw material for lightweight aggregate manufacture. None of these shales were sampled in this investigation.

The unconsolidated rocks of the area are boulder clay, stratified gravels and marine clays and sands.

A deposit of marine clay at Little River on Courtenay Bay has been used for the manufacture of brick by the Anderson Brick and Tile Company, Limited. The clay is a reddish-brown colour, very fine grained and plastic. A few pebbles were noted near the top of the 5-foot section available for sampling.

In the stationary furnace this material (Sample 16) proved to be a good bloater but had a narrow vitrification range. It was not considered worthy of a rotary kiln test.

MONCTON

Pennsylvanian and Mississippian shales outcrop abundantly a few miles northwest of Moncton.

Approximately 4 miles northwest of the city, reddish-brown Pennsylvanian shale is well exposed in the banks of the West Branch of Hall Creek and in a road cut on Highway 33. A section of the exposure in the road cut was noted as follows:

Topsoil	- 2 feet
Weathered, reddish-brown shale (Sample 18)	- 4 feet
Reddish-brown shale (Sample 17)	- 8 feet

Both of the above samples proved to be good bloaters in the stationary furnace but each had a narrow vitrification range. Rotary kiln tests were not made.

Mississippian shales of the Moncton group are well exposed in at least two quarries along the road south of Stiles Village. The shale, hard and relatively thin bedded, is quarried for secondary road material.

Sample 19 represented 5 feet of hard, rusty-weathering, dark grey shale taken from the most southerly quarry about one and one half miles by road south of Stiles Village. At this point the shale is relatively flat-lying but with local contortions. Overburden amounts to about 2 feet of topsoil and reworked shale. When tested in the stationary furnace and rotary kiln this material proved to be too non-uniform. Approximately 60 per cent of the sample bloated very well with a wide vitrification range while the remainder showed no bloating. The rotary kiln product gave a volume expansion of 50 per cent, a bulk density of 57 lb./cu. ft. and a crushing strength of 1273 p.s.i. The kiln operating temperature was just below 2000°F, at which temperature agglomeration started.

Shale belonging to the same group is well exposed in a quarry about one-half mile northwest of the previous location. At this point the shale, lying close to the edge of a ridge of pre-carboniferous diorite, has been tilted to an angle of about 70 degrees. The shale is hard, highly fractured and heavily iron stained. It has a light greenish-grey colour and occurs in beds of about ½ inch to 1 inch thickness. From 2 to 5 feet of topsoil and reworked shale cover the deposit.

In the quarry, four samples were taken, each across a stratigraphic width of 10 feet. Stationary furnace tests indicated that the continuous 40-foot width of shale was extremely uniform. It bloated well and possessed a wide vitrification range. The rotary kiln products were well rounded, uniform, light and strong. Volume expansions for the four samples ranged from 100 to 110 per cent, bulk densities from 37 to 49 lb./cu. ft. and crushing strengths from 786 p.s.i. to 1750 p.s.i. Kiln operating temperature for the four tests was kept as close to 2050°F as possible at which temperature slight agglomeration started. In view of these test results this shale, as represented by Samples 20, 21, 22, and 23, is very well suited for the manufacture of coated lightweight aggregate. A large supply of shale appears to be readily available and it is one of the best raw materials tested from the Maritime Provinces.

At Stiles Village quarrying operations have exposed steep dipping, hard but highly fractured, light-grey shale which is believed to belong to the Albert formation of Mississippian age. A stratigraphic width of approximately 200 feet of shale covered by about 3 feet of overburden was exposed in the pit. Samples 24, 25, and 26, taken in the face of the pit, represent a 30-foot section of the shale. In the stationary furnace each of these samples bloated well and showed a wide vitrification range. However, all three samples contained some foreign material that did not bloat. In the rotary kiln the three samples gave good products except for the presence of some unexpanded material. The products showed volume expansions of 15, 30, and 60 per cent, bulk densities of 49, 43, and 40 lb./cu. ft. and crushing strengths of 1432, 958, and 1082 p.s.i. The kiln operating temperature for the three runs was kept as close as possible to 2000°F at which temperature slight agglomeration started. This shale is also considered as offering good possibilities as a coated lightweight aggregate raw material. However, efforts would have to be made to exclude the non-expandable material from the kiln feed.

Dark grey, almost black, steep-dipping shale of the Albert formation was noted in outcrops on the north side of Indian Mountain approximately one and one half miles by road north of Stiles Village. Two samples were taken from two outcrops about one-quarter mile apart. Sample 27 represented a width of 5 feet and Sample 28, a width of 20 feet. In the stationary furnace both materials proved to be exceptionally non-uniform in bloating properties and did not warrant rotary kiln tests.

Just south of Memramcook West, about 12 miles south-east of Moncton, samples were secured of shales belonging to both the Albert and Memramcook formations.

Outcrops of greenish-grey shale of the Albert formation were noted in a road ditch one-half mile south of the Moncton highway and one-half mile west of the road leading to St. Joseph. Overburden in the immediate area is light, consisting of about 6 inches of topsoil. The number of exposures suggests that a large tonnage is available. This material (Sample 29) proved to be a good bloater with a wide vitrification range. A good product was also obtained in the rotary kiln. The volume expansion measured 80 per cent, the bulk density 49 lb./cu. ft., and the crushing strength 1432 p.s.i. The average kiln operating temperature was 2030°F and agglomeration started when the temperature was increased beyond 2050°F.

Red shale of the Memramcook formation is exposed in the banks of a small creek about one-half mile directly north of the previous location. A section of an exposure was measured as follows:

Topsoil	-	2 feet
Weathered, reddish-brown shale (Sample 31)	-	5 feet
Hard, reddish-brown shale (Sample 30)	-	13 feet

Both of these materials proved to be good bloaters in the stationary furnace but both possessed a narrow vitrification range. A rotary kiln test made on Sample 30 gave a poor product. Satisfactory bloating of this material did not take place without serious sticking trouble due to its narrow vitrification range.

CHATHAM

A sample of clay formerly used for the production of brick (Sample 32) was secured from the farm of W. Appleby, South Nelson, 6 miles Southwest of Chatham. The above sample was a grab sample from a clay pile in the pit which is now overgrown with grass and trees.

This material bloated well in the stationary furnace but possessed too narrow a vitrification range to warrant a rotary kiln test.

BATHURST

Reddish-brown, fine grained, plastic clay appears to be quite widespread at Bathurst where it was noted in several scattered basement excavations. Sample 33 representing a 7-foot width, was taken in a railroad cut just south of Bathurst station.

Stationary furnace tests on this clay showed that it was a poor bloater and possessed a very narrow vitrification range. Rotary kiln tests were not made.

At Stonehaven, 25 miles by rail northeast of Bathurst, shales of the Clifton formation are well exposed in the sea cliffs. A section near the Stonehaven warf was noted as follows:

Topsoil	- 2 feet
Red shale (Sample 35)	- 15 feet
Sandstone	- 3 to 5 feet

Greenish-grey shale (Sample 34) - 15 feet

Sandstone to sea level

The greenish-grey shale (Sample 34) proved to be non-uniform in bloating properties. While a large portion of the sample bloated well and possessed a wide vitrification range, the remainder showed no bloating. The rotary kiln product showed a volume expansion of 20 per cent, a bulk density of 59 lb./cu. ft., and a crushing strength of 2454 p.s.i. The average kiln temperature was just below 2100°F at which temperature agglomeration started. In view of its non uniformity this material would not be recommended for use in making coated lightweight aggregate.

The upper red shale (Sample 35), when tested in the stationary furnace, proved to be a poor bloater with a narrow vitrification range.

LOCATIONS, DESCRIPTIONS AND TEST RESULTS

OF CLAYS AND SHALES

IN

NOVA SCOTIA

Figure 5

SUMMARY OF LIGHTWEIGHT AGGREGATE TEST RESULTS - NOVA SCOTIA

Materials having good possibilities for coated aggregate production		Materials that are good bloaters but are not considered suitable for coated aggregate because of sticking and agglomerating characteristics		Materials that are poor bloaters		Materials that are too refractory (show no fusion or bloating when fired in stationary furnace at 2400°F for 5 minutes)		Materials that are too non-uniform in bloating qualities	
Locality	Sample No.	Locality	Sample No.	Locality	Sample No.	Locality	Sample No.	Locality	Sample No.
Elmsdale-clay	7	Parrsboro-shale	3,4,5,6	Sydney-Glace Bay-shale	12	New Glasgow-shale	19	Parrsboro-shale	1,2
Elmsdale-slate	8			New Glasgow-shale	17	New Glasgow-shale	20	Sydney-Glace Bay-shale	9,10
						New Glasgow-shale	26	Sydney-Glace Bay-shale	11
						New Glasgow-shale	27	Sydney-Glace Bay-shale	13
								Sydney-Glace Bay-shale	14
								Sydney-Glace Bay-shale	15
								Sydney-Glace Bay-shale	16
								New Glasgow-shale	18
								New Glasgow-shale	21,22,23
								New Glasgow-shale	24,25

LOCATIONS, DESCRIPTIONS AND TEST RESULTS OF CLAYS AND SHALES IN NOVA SCOTIA

The clays and shales from Nova Scotia gave poor results in the laboratory. Of 27 samples tested, only 2 samples from 2 occurrences showed good possibilities as coated lightweight aggregate raw materials; 4 from 1 occurrence proved to be good bloaters but possessed too narrow vitrification ranges; 2 from 2 occurrences were poor bloaters; 4 from 4 occurrences were too refractory; and 15 samples from 10 occurrences were considered too non-uniform.

It may be seen that the largest number of materials tested fell into the non-uniform classification. This group was composed almost wholly of shales associated with coal at the mines in the Sydney, Glace Bay and New Glasgow areas.

The two materials with promising laboratory results came from the Elmsdale area about 30 miles north of Halifax. One of these was a clay and the other a slate, both being in large supply. This same slate formation occurs at Halifax and it might prove advantageous to investigate the suitability of the slate which is exposed there.

PARRSBORO

Large amounts of steeply-dipping, contorted, dark grey to black Pennsylvanian shales were observed in outcrops at Moose River about 8 miles east of Parrsboro. A 10-foot width of the shale was sampled in two five-foot sections (Samples 1 and 2).

Stationary furnace tests indicated that both of these materials were too non-uniform. Only a small part of each sample possessed favorable bloating properties.

Large amounts of red Triassic shale are exposed in the vicinity of Five Islands approximately 15 miles east of Parrsboro. A section of an exposure on the farm of A. McBurnie, Five Islands, was noted as follows:

Topsoil	- 6 inches
Gravel	- 10 feet
Weathered red shale with scattered rock pebbles	- 2 feet
Soft red shale (Sample 6)	- 4 feet
Soft purple shale (Sample 5)	- 3 feet
Hard red shale with few sand beds (Samples 3 & 4)	- 35 feet
Concealed to creek level	- 3 feet

All of the above samples (3 to 6), when tested in the stationary furnace, proved to be good bloating materials but all had a narrow vitrification range. For this reason rotary kiln tests were not made.

ELMSDALE

Elmsdale is located 32 miles by rail north of Halifax and midway between Halifax and Truro. L. E. Shaw, Limited, operates a brick and tile plant at Elmsdale using a very fine grained, plastic, reddish-brown, clay and slate of the Halifax formation.

A section in the face of the clay pit was noted as follows:

Topsoil (peaty material)	- 1 foot
Weathered reddish-brown clay (Sample 7)	- 1½ feet
Reddish-brown clay (Sample 7)	- 10 feet

The laboratory tests showed that the above clay was a good bloater with a wide vitrification range. A rotary kiln test made on pelletized feed gave a good product showing a volume expansion of 75 per cent, a bulk density of 49 lb./cu. ft., and a crushing strength of 2864 p.s.i. The average kiln temperature for the test was 2090°F while agglomeration took place when the temperature was increased beyond 2100°F. The clay shows good possibilities as a coated lightweight aggregate raw material and a large reserve is readily available.

A grab sample (8) was taken from the company's slate quarry at Grand Lake approximately 10 miles south of the plant. In the stationary furnace and rotary kiln this material generally bloated very well. A small portion of the sample, however, did not expand. The rotary kiln product showed a volume expansion of 75 per cent, a bulk density of 48 lb./cu. ft., and a crushing strength of 955 p.s.i. The average kiln temperature was just below 2050°F at which temperature agglomeration began.

This slate (Sample 8) is considered to possess possibilities for the manufacture of a coated lightweight aggregate but efforts would have to be made to secure a deposit of uniform firing qualities.

SYDNEY-GLACE BAY

Large tonnages of Pennsylvanian shale of the Morien coal bearing series are hoisted daily at the numerous mines in the Sydney-Glace Bay area. Tremendous amounts of the shale have also accumulated over the years on the mine waste dumps. All of the waste dumps contain sandstone and coal in varying amounts. These foreign materials were not included in the samples taken from the waste dumps unless intimately associated with the shale. In other words, the samples taken for testing were considered to be representative of the shale that could be obtained from the mine if care were taken in its selection.

At the No. 24 mine of the Dominion Coal Company at Caledonia, approximately 250 tons of waste shale, containing small amounts of sandstone and coal, are hoisted daily. The shale overlies the Emery seam. Two samples of this material were taken for lightweight aggregate tests. One of these (Sample 9) was representative of the weathered shale and the other (Sample 10) of the fresh shale on the dump. Both of these materials proved to be non-uniform but showed good overall volume expansion. The weathered shale gave a product with a volume expansion of 40 per cent, a bulk density of 45 lb./cu. ft., and a crushing strength of 2545 p.s.i., while the fresh shale gave a product with a volume expansion of 90 per cent, a bulk density of 52 lb./cu. ft., and a crushing strength of 3500 p.s.i. The strength and weight properties appeared quite good but the products were non-uniform and laminated, showing no rounding of the individual particles, and for a large part of the material, no expansion. For these reasons both samples are classed as being too non-uniform.

At the No. 1 B mine of the Dominion Coal Company at O'Neil Point, Glace Bay, approximately 400 tons of shale overlying the Harbour and Phelan seams are removed daily. A grab sample (Sample 11) was taken of the shale on the waste dump which contains considerable sandstone and coal. Stationary furnace tests on this shale showed that it was non-uniform with only a part of the sample bloating well. This was confirmed in a rotary kiln test.

At Gardiner Mines, the No. 25 mine of the Dominion Coal Company hoists about 250 tons of shale daily from above the Gardiner seam. A grab sample (Sample 12) of this shale from the waste dump proved to be a poor bloater in the stationary furnace. A rotary kiln test was not considered warranted.

At New Waterford, grab samples of waste shale were obtained from the No. 12 (Sample 13) and No. 18 (Sample 14) mines of the Dominion Coal Company. Both of these shales proved to be highly carbonaceous and too non-uniform for consideration as coated lightweight aggregate raw materials.

The Princess mine of Old Sydney Collieries, Limited, at Sydney Mines, removes about 100 tons of waste shale daily from above the Harbour seam. Stationary furnace tests made on this shale (Sample 15) indicated that it also was too non-uniform. A portion of the sample bloated well while the remainder showed no expansion.

Approximately 15 feet of shale is removed as overburden at the Lloyds No. 7 strip mine of Old Sydney Collieries, Limited, at Alder Point. A section of the pit to the top of the coal seam was noted as follows:

Topsoil and sandstone	- 8 feet
Rusty-weathering shale with a narrow sandstone bed (not included) Sample 16	- 15 feet
Buff weathering sandstone	- 30 feet

This shale (Sample 16) also proved to be too non-uniform in bloating qualities when tested in both the stationary furnace and rotary kiln. The rotary kiln product showed a volume expansion of only 10 per cent, a bulk density of 66 lb./cu. ft., and a crushing strength of 5091 p.s.i.

The prospects for the use of coal mine shales of the Sydney-Glace Bay area for manufacturing a coated lightweight aggregate do not appear favourable due largely to their non-uniformity in bloating qualities. Even the portions of the samples that showed expansion gave a non-rounded aggregate with a weak, laminated structure. Another consideration is that this area is well supplied with expanded blast furnace slag aggregate which can be produced at a lower cost than expanded shale aggregate.

NEW GLASGOW

The New Glasgow area is underlain by Paleozoic rocks ranging in age from Lower Ordovician to Middle Pennsylvanian. The Stellarton Series of shale, sandstone and conglomerate, of Pennsylvanian age, is the most important formation in the area as it contains all the economical productive coal seams of the Pictou coal field. There are also two clay products plants at New Glasgow using the shale of this formation.

L. E. Shaw Company, Limited, obtain shale for the manufacture of brick and tile from a pit on McLellan Brook. A section of the face of the pit was noted as follows:

Black oil shale (Sample 19)	- 10 feet
Dark grey, thin-bedded shale with few siderite concretions (Sample 18)	- 9 feet
Light grey thin-bedded shale with few siderite concretions (Sample 17)	- 10 feet

The light grey shale (Sample 17) proved to be a poor bloater when fired in the stationary furnace at temperatures up to 2400°F for 5 minutes.

The dark grey shale (Sample 18) proved to be too non-uniform. A portion of the sample bloated into a laminated product while the remainder showed no bloating. In spite of this non-uniformity the rotary kiln product showed an overall volume expansion of 100 per cent, a bulk density of 50 lb./cu. ft., and a crushing strength of 1591 p.s.i.

The upper black oil shale (Sample 19) proved to be too refractory. It showed no bloating or fusion when fired in the stationary furnace at 2400°F for 5 minutes.

Standard Clay Products, Limited, operates a sewer pipe plant at New Glasgow using shale from a pit on McLellan Brook about one-half mile east of L. E. Shaw Company's pit. A section of the pit is as follows:

Brown glacial clay and reworked oil shale	- 8 to 10 feet
Black oil shale (Sample 20)	- 4 feet
Soft, grey shale with few siderite concretions (Samples 21, 22 & 23)	- 22 feet

The oil shale (Sample 20) behaved like the oil shale of the L. E. Shaw Company's pit, inasmuch as it was too refractory.

All three samples (21, 22, & 23) of the grey shale proved to be too non-uniform. At least half of each sample showed no bloating under time-temperature conditions that caused bloating of the remainder of the sample.

Samples of waste mine shale were obtained from the large waste dumps at the McBean mine (Sample 24) at Thorburn, and from the Allan mine (Sample 25) at Stellarton, both of which belong to Acadia Coal Company, Limited. Both of these shales proved to be too non-uniform. Portions of each bloated well while the remainder of the samples showed no bloating under the same firing conditions.

At Westville, samples were obtained of the waste shale at the Drummond No. 1 and Drummond No. 2 mines which are owned by the Intercolonial Coal Company, Limited. At the Drummond No. 1 mine the waste is a light grey shale (Sample 26) taken from both above and below the coal seam. At the Drummond No. 2 mine the waste is black oil shale (Sample 27) obtained from above the coal seam. Both materials proved to be too refractory and showed no appreciable bloating or fusion when fired at 2400°F for 5 minutes.

LOCATIONS, DESCRIPTIONS AND TEST RESULTS

OF CLAYS AND SHALES

IN

PRINCE EDWARD ISLAND

LOCATIONS, DESCRIPTIONS AND TEST RESULTS OF CLAYS AND SHALES IN PRINCE EDWARD ISLAND

At the present time all the aggregate used for concrete work on Prince Edward Island is imported from New Brunswick and Nova Scotia.

The latest census figures place the population of Prince Edward Island at 97,787 and Charlottetown, the largest centre, at 15,689. Some authorities estimate that this population would support a commercial-sized rotary kiln aggregate plant with a daily capacity of 150 cubic yards only with difficulty, unless the neighbouring provinces of New Brunswick and Nova Scotia supplied a sufficiently large additional market.

Prince Edward Island is underlain by red shale, sandy shale and sandstone, probably of Permian age. Shallow deposits of boulder clay and marine clay also occur widely.

In order to obtain preliminary information on the firing qualities of the Island's red shale, six samples were taken from two shale outcrops in the vicinity of Charlottetown. None of these materials showed favourable prospects as coated lightweight aggregate raw materials and further work would be necessary to locate a suitable raw material. Two of the samples tested proved to be good bloaters but had a narrow vitrification range, while the remaining four were poor bloaters.

A description of the localities sampled and the laboratory results is given below.

GALLOWS POINT

Gallows Point is on the east side of Hillsborough Bay about 15 miles by road southeast of Charlottetown. On the west side of Gallows Point, red shale outcrops in low cliffs, a section of which was measured as follows:

Topsoil and reworked shale	- 2 feet
Weathered red shale (Sample 2)	- 5 feet
Hard red shale (Sample 1)	- 4½ feet
Reddish-brown sandstone to sea level	

There appears to be a large amount of the shale available and overburden is very light. Further east of this outcrop, however, it is reported that the shale is capped by impure limestone and sandstone.

When tested in the stationary furnace both of these samples showed poor bloating qualities. Rotary kiln tests were not made.

LOBSTER POINT

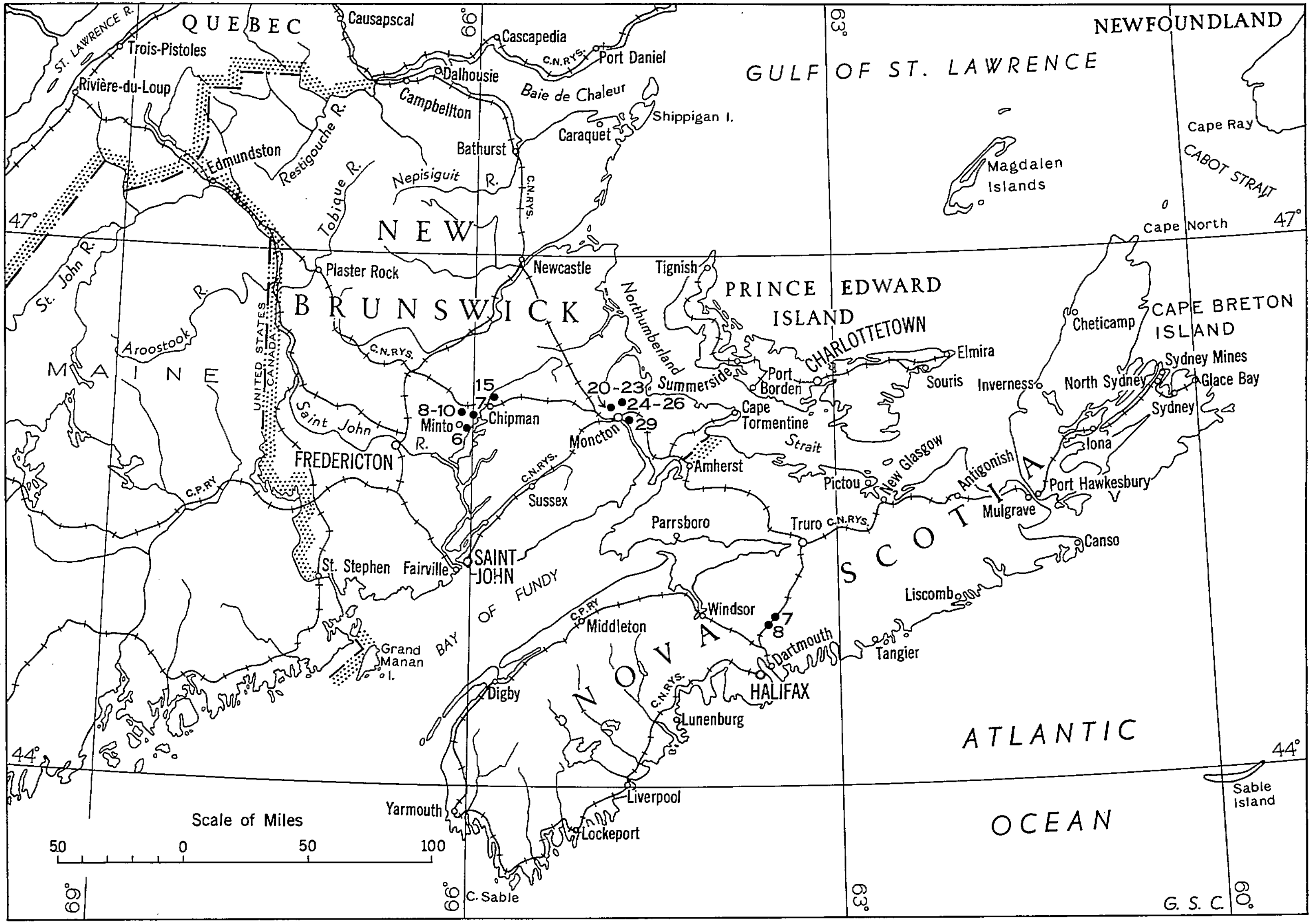
Lobster Point is on the north shore of Hillsborough Bay about four miles by road south of Charlottetown.

At this location about 40 feet of red sandy shale is exposed in the shore cliff between two beds of hard red sandstone. The beds are gently dipping and the upper sandstone bed has been eroded away over a small area. A section of the exposure measured from the point where the lower contact of the upper sandstone bed comes to the surface was noted as follows:

Soft, red, sandy shale (Sample 3)	- 10 feet
Hard red sandy shale (Sample 4)	- 5 feet
Hard red sandy shale with narrow sandstone beds (not included in sample)(Samples 5 & 6)	- 26 feet

The upper 15 feet of sandy shale represented by Samples 3 and 4 proved to have poor bloating qualities and a narrow vitrification range when tested in the stationary furnace.

The lower 26 feet of sandy shale bloated well in the stationary furnace but also had a narrow vitrification range. As a check on these results Sample 5 was given a rotary kiln test. The product showed no volume expansion and it was evident that the vitrification range was too narrow to allow satisfactory bloating below time-temperature conditions that caused serious sticking and agglomeration.



Map of New Brunswick, Nova Scotia and Prince Edward Island showing approximate locations of clays and shales with possibilities for making coated lightweight concrete aggregate.

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