MINES BRANCH

DEPARTMENT OF MINES

OTTAWA - CANADA

RAW MATERIALS FOR THE MANUFACTURE OF ROCK WOOL IN THE NIAGARA PENINSULA OF ONTARIO

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Memorandum Series
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M. F. Goudge.*

Rock wool, one of the most effectual and satisfactory insulating materials on the market, is a furnace product made from a self-fluxing siliceous and argillaceous dolomite in which the acidic and basic constituents are present in such proportions that their fluxing action is nearly balanced.

In the process of manufacture the rock, with coke as fuel, is charged to a small cupola furnace where it is melted to a very fluid condition. The operating temperature in different plants is reported to range from 2800° to 3300°F. The molten rock coming in a small stream from the furnace is atomized by a blast of steam under a pressure of 80 to 100 pounds. Each small globule of molten rock as it is hurtled through the air, trails behind it a very thin, pliable, glassy fibre. These fibres constitute the rock wool of commerce. In appearance rock wool much resembles sheep's wool, but unlike the latter it cannot be woven. Rock wool is sometimes sold in bulk but more often is processed in various ways and sold in "granulated" form, in "blankets", and, when treated with a binder, in blocks and sheets under the name of rock cork.

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Its principal use is as an insulating material, but it also forms the main ingredient in an acoustic tile. On account of its resistance to corrosion it is used as packing for acid carboys. As an insulating material rock wool is rated as one of the most effectual of those available in commercial quantity; it has a wide range of application in this connexion, being stable up to a temperature of 1000°F, and in addition is fireproof, vermin proof and odourless.

Glass wool (made from glass), and slag wool (made from certain metallurgical slags), are kindred products both in composition and uses, in that each is principally composed of complex amorphous silicates, or glass. Thus the name glass wool could properly be applied to all, but the differentiating terms are preferable in that they indicate the origin of the product. Slag wools usually contain a much higher percentage of sulphur compounds compared to glass wools and rock wools. The presence of sulphides is considered by some as detrimental in cases where the wool is to be subjected to moisture. The term "mineral wool" is used in the United States to include both rock wool and slag wool. In England the name "silicate cotton" is similarly employed.

Discovery of Deposits of Wool Rock in Ontario.

No rock wool has been produced in Canada, as heretofore no deposits of dolomite combining the qualities necessary for its manufacture were known. But in the course of the survey of the limestone resources of Canada now being conducted by the Mines Branch, similarity was noted between the chemical composition of wool rock, as the natural rock suitable for the making of rock wool is usually called, and that of certain dolomites and dolomitic shales in the Niagara peninsula of Ontario. Laboratory investigations of the properties of these dolomites and shales were undertaken and the results indicate that in several localities those rocks are suitable for the manufacture of rock wool. The investigational work completed to date is very little compared with what yet remains to be done, but results obtained are so promising that it was deemed advisable to issue this preliminary report to point out the possibilities which exist, in the hope that those interested in making rock wool in Canada will carry the work further.

As a result of experimental work donducted by the writer in the laboratories of the Ore Drossing Division, it has been found that rocks or mixtures of rocks from the Niagara peninsula having a chemical composition within the following limits have definite possibilities as raw material for rock wool manufacture:

	Min.	Max.
Silica	24%	32%
Ferric oxide	2	3
Alumina	8	12
Calcium oxide	16	21
Magnesium oxide	10	13
Volatile matter	26	29

These limits are merely indicative, and in stating them it is not meant to imply that all material which does not come within them is unsuitable. Additional research work may be expected to throw more light upon the respective proportions of various constituents desirable to produce the best product, and also upon the effect of the presence of constituents other than those above mentioned such as potash and soda.

Types of Deposits.

The rock deposits in the Niagara peninsula which laboratory tests indicate are suitable for rock wool manufacture may be divided into two classes:

1. Those that will yield a material of the correct chemical composition which may be utilized without admixture of other material excepting fuel.

2. Those that yield a material which in itself is not suitable but which when mixed with material from another nearby deposit will give a furnace charge of suitable composition.

Deposits of the first class are to be found along the face of the Niagara escarpment between the Niagara river and Thorold. Those of the second class occur at a number of places along the escarpment between the Niagara river and Hamilton. The escarpment in this vicinity averages about 300 feet in height and in general presents a fairly steep face. The various formations of rock which compose the cliff lie horizontally. The base is red Queenston shale, the top is Lockport dolomite. Between are a number of minor formations of siliceous dolomite, sandstone and shale. Certain of these dolomite and shale formations yield the materials suitable for the making of rock wool.

Area between the Niagara River and Thorold.

Between the Niagara river and Thorold the suitable rock comes just beneath the Lockport dolomite, the latter forming the cap rock on the brow of the escarpment to a depth of from 12 to 30

feet. The wool rock includes a belt of impure, greyish blue, fine-grained dolomite 6 to 9 feet thick, and a formation of dark blue, dolomitic shale immediately underlying it. The dolomite belt is commonly referred to as natural cement rock and was formerly mined at St.Davids and Thorold for the making of natural cement. The shale formation, which is geologically known as the Rochester shale, is 40 to 60 feet in thickness. The upper part of the shale has a chemical composition requisite in the raw material for rock wool but the lower portion contains too great a proportion of silica and alumina; however by mixing it with the cement rock, which contains too high a proportion of calcium and magnesium carbonates to be suitable in itself, it is probable that the entire combined thickness of the two formations may be utilized.

Both the cement rock and the shale are well exposed at the following points: In the gorge of the Niagara river (cement rock 6 feet thick, dolomitic shale 60 feet); on the property of Queenston Quarries Ltd., St.Davids (cement rock 6 feet thick, shale 55 feet); in Walker Bros. quarry east of Thorold (cement rock 9 feet, shale thickness not determined); in the excavation for the weir on the Welland canal ¼ mile west of Walker Bros. quarry (cement rock 6 feet thick, shale 40 feet); in the abandoned quarries known as the Battle quarries immediately east of Thorold (cement rock 8 feet, thickness of shale not determined). The following analyses indicate the chemical composition of the cement rock and the shale within the above area.

*Analyses of Cement Rock

	1.	2.	3.	4.
Silica	12.08	17.10	19.10	20.90
Ferric oxide	1.73	1.35	1.80	1.21
Alumina	2.85	4.06	5.60	2.94
Potash	not det.	0.94	not det.	not det.
Soda	not det.	0.18	not det.	not det.
Calcium oxide	26.34	25.01	24.47	26.90
Magnesium oxide	17.21	15.22	13.61	12.15
Volatile matter	38.38	36.34	34.15	34.91
	98.59	100.20	98.73	99.01
Sulphur	0.10	0.32	0.35	0.30

1. Niagara Falls. - Six feet of cement rock in gorge.

2. St.Davids. - Six feet of cement rock forming the floor in building-stone quarry operated by Queenston Quarries Ltd.

3. East of Thorold. - Nine feet of cement rock exposed in bottom of Walker Bros. quarry.

4. East of Thorold. - Eight feet of cement rock from the now abandoned Battle quarry.

*Unless otherwise stated all analyses in this report were made by C.L.O'Brian, Division of Chemistry, Mines Branch.

Analyses of Rochester Shale.

	5.	6.	7.	8.	9.	10.
Silica	26.00	27.38	22.88	24.46	39.44	24.44
Ferric oxide	2.92	2.71	2.45	3.07	3.41	3.85
Alumina	10.06	11.71	8.81	9.21	15.81	9.35
Potash	2.32	2.82	2.06	3.60	2.40	1.64
Soda	0.08	0.30	0.16	0.16	0.06	0.06
Calcium oxide	18.46	17.46	21.10	20.42	13.78	21.04
Magnesium oxide	12.15	11.34	12.60	10.77	5.61	10.70
Volatile matter	27.02	26.30	30.14	28.80	18.34	27.96
	99.01	100.02	100.20	100.49	98.85	99.04
Sulphur	0.50	0.24	0.05	0.04	0.06	0.30

5. Niagara Falls. - Twelve feet of shale immediately underlying the cement rock in the river gorge.

6. Niagara Falls. - Next 10-foot section of shale below the 12-foot section.

7. St.Davids. - Six feet of shale immediately beneath the cement rock as exposed in the banks of a small brook a short distance west of the building-stone quarries.

8. St.Davids. - Next 6-foot section of the outcrop beneath Sample No.7.

9. St.Davids. - Bottom 10 feet of the shale outcropping in brook.

10. East Thorold. - Ten feet of shale immediately underlying the cement rock as exposed in excavation for the weir on the new Welland Canal.

It will be noted that the sections of shale represented by samples 5, 6,8 and 10 came within the chemical composition required for wool rock (page 3). By simply mixing the shale represneted by analysis No. 9, which is too high in silica and alumina, in the correct proportions with the overlying cement rock, or with shale deficient in silica and high in content of calcium and magnesium carbonates, a rock mixture of suitable chemical composition can be obtained which in laboratory tests yielded results just as favourable as did the natural wool-rock.

Although chemical analyses are not yet available of all the shale samples taken, it appears that the Rochester shale in this area becomes increasingly siliceous and aluminous from the top downward, thus presenting a deposit from which by varying the depth of face worked and thoroughly mixing the material after it is

broken down, a product of the exact composition desired can be obtained. Close chemical control of the furnace mixture would be essential in order to produce a uniformly high-grade product.

Excellent opportunities of quarrying the wool rock without first having to remove a heavy overburden of Lockport dolomite and soil, exist on the properties of Queenston Quarries Ltd., and of Walker Bros. where the Lockport has already been removed for other purposes and the cement rock and shale are exposed over large areas. In the floors of several other abandoned quarries along the brow of the escarpment just east of Thorold these opportunities exist on a smaller scale. It is possible, provided the soil is not too deep, that the Rochester shale may be found in a quarriable location along that part of the escarpment between Walker Bros. quarry and St. Davids. In this locality the face of the escarpment has a very gradual slope and the probabilities are that the shale is the rock underlying the upper part of this slope.

Area Between Thorold and Hamilton.

West of Thorold, with the possible exception of the area between Thorold and De Cew Falls, which area has not yet been investigated, the rock available would seem to be all of the type which would require mixing with rock obtained from another deposit in order to yield the necessary combination of ingredients for the manufacture of rock wool. The Rochester shale as it is traced westward gradually decreases in thickness. At the same time it becomes much less siliceous and contains a correspondingly greater proportion of calcium and magnesium carbonates. With the possible exception of zones too thin to exploit, it ceases to be in itself a source of wool rock and requires the addition of material high in silica and alumina. Within the same area the cement rock is absent in the sections of rock exposed along the face of the escarpment between De Cew Falls and Beamsville — the Lockport dolomite resting directly on the Rochester formation. From Beamsville west to Hamilton the cement rock in general is much more siliceous than it is east of Thorold but not quite sufficiently so to yield rock wool itself. It was not observed west of Hamilton. Thus there is required a rock high in content of silica and alumina to mix with either the Rochester shaly dolomite or the cement rock. These requirements are met in a grey shale which is found near the foot of the escarpment only a short distance above the red Queenston shale. This shale formation, known as the Cabot Head shale, is about 45 feet thick at Stoney Creek, excluding the sandy beds which occur at top and bottom. Eastward this formation thins out to very small proportions.

Below the Cabot Head shale, and separated from it by a thickness of from 15 to 30 feet of dolomite and sandstone, is the

red Queenston shale which is available in quantity all along the base of the escarpment. An average of a number of analyses of this shale gives:

Silica	56.0
Ferric oxide	6.6
Alumina	18.0
Potash and soda	4.0
Calcium oxide	3.8
Magnesium oxide	2.7
Volatile matter	8.7
	99.8

It is problematical whether this shale could be utilized in rock wool manufacture for reasons mentioned later.

Outcrops of cement rock and the shaly-dolomite phase of the Rochester shale occur beneath the Lockport dolomite at numerous points along the upper part of the escarpment, notably at: Power Glen (cement rock 8 feet thick, shaly dolomite 50 feet plus); in the valley of Twenty Mile creek south of Jordan (no cement rock, shaly dolomite 14 feet thick underlain by sandstone); Beamsville in floor of old quarries (cement rock 6 feet, Rochester formation not visible but undoubtedly present); in the water course at the boundary between the townships of North Grimsby and Clinton, Lincoln county (cement rock 6 feet thick, exposed thickness of Rochester shaly dolomite and shale 15 feet); in the valleyof Forty-Mile creek at Grimsby (cement rock 6 feet, entire thickness of Rochester formation totaling 30 feet); in small quarry by the road down the escarpment on lot 16, con. II, North Grimsby tp.,Lincoln county (cement rock, 7 feet, Rochester formation,6 feet visible); on the first two roads west of Grimsby which descend the escarpment, both the cement rock and the underlying Rochester shaly dolomite are visible; from Winona to Stoney Creek no cement rock was observed; between Stoney Creek and Hamilton thin deposits of cement rock were seen in places. The Rochester formation between Winona and Hamilton is extremely variable in thickness and in physical characteristics and no satisfactory statement as to its suitability for rock wool can be made until further field work and analytical work are done.

The grey Cabot Head shale is well exposed in the banks of Stoney creek just above the level of the track of the Toronto Hamilton and Buffalo railway. A thickness of 45 feet of shale is visible with sandy beds at top and bottom. The shale portion seems quite uniform in chemical composition throughout. This shale is also visible at Hamilton in the face of the escarpment below the city quarries where it is over 40 feet thick. The top of this formation is to be seen in the gorge at Grimsby and also at Jordan. Beds of sandstone occur at intervals through this shale.

The following analyses show the composition of the cement rock, Rochester shale and Cabot Head shale within the Thorold-Hamilton area.

Analyses of Cement Rock

	11	12	13	14	15	16
Silica	27.20	24.70	26.20	25.36	21.54	14.48
Ferric oxide	1.41	1.28	1.25	1.41	1.24	2.00
Alumina	3.31	3.10	3.03	2.53	2.58	5.10
Potash	not det.	0.58	0.90	not det.	not det.	not det.
Soda	not det.	0.16	0.06	not det.	not det.	not det.
Calcium oxide	22.16	21.77	21.34	21.64	22.88	20.29
Magnesium oxide	13.04	15.00	14.51	14.64	15.64	15.96
Volatile matter	31.71	33.57	32.68	33.05	35.07	not det.
	98.83	100.16	99.97	98.63	98.95	
Sulphur	0.08	0.08	0.05	0.38	0.48	not det.

11. Power Glen. - Seven feet of cement rock just west of power house flumes.

12. Beamsville. - West quarry on top of escarpment. Six feet of cement rock in floor.

13. Lincoln County. - Six feet of cement rock in bed of brook at edge of escarpment just west of boundary between townships of Clinton and North Grimsby.

14. Grimsby. - Six feet of cement rock in bank of Forty-Mile creek.

15. West of Grimsby. - Six feet of cement rock exposed in small quarry on edge of escarpment on lot 16, con. II, North Grimsby.

16. Mount Albion.- Cement rock in Redhill creek, west of Mount Albion (Williams, M.Y.:Geol. Surv., Canada, Mem. III, p. 112 (1919)

Analyses of Rochester Shaly Dolomite

	17	18	19	20	21	22
Silica	19.22	19.72	18.18	23.06	22.52	22.00
Ferric oxide	1.46	1.36	2.07	1.41	2.43	2.37
Alumina	4.30	4.16	5.55	4.07	8.12	12.65
Potash	not det.	not det.	1.32	not det.	not det.	not det.
Soda	not det.	not det.	0.02	not det.	not det.	not det.
Calcium oxide	35.71	22.56	27.69	21.78	21.83	20.81
Magnesium oxide	4.39	15.78	11.43	14.76	10.14	7.77
Volatile matter	32.82	35.05	32.66	33.31	not det.	not det.
	97.90	98.63	98.92	98.39		
Sulphur	0.30	0.32	0.57	0.55	not det.	not det.

17. Power Glen. - Eight feet of shaly limestone beneath the cement rock.

18. Lincoln county. - Five feet of shaly dolomite beneath the cement rock of Sample No.13.

19. Grimsby. - Below falls on Forty-Mile creek. Entire thickness (30 feet) of Rochester shaly dolomite.

20. West of Grimsby. - Six feet of shaly dolomite below cement rock of Sample No.15.

21. Hamilton. - Top 4 feet of Rochester shale (Williams, M.Y., Geol. Surv., Canada, Mem.111, p. 111 (1919))

22. Hamilton. - Rochester shale, 3 feet above base (Williams, M.Y.; Geol.Surv., Canada, Mem.111, p.111 (1919))

Analyses of Cabot Head Shale.

	23	24
Silica	54.28	54.36
Ferric oxide	5.94	5.97
Alumina	22.12	23.29
Potash	5.71	4.82
Soda	0.49	0.38
Calcium oxide	1.34	1.26
Magnesium oxide	3.58	2.75
Volatile matter	7.07	5.70
	100.53	98.53
Sulphur	not det.	nil.

23. Stoney Creek. - Top 7 feet of Cabot Head shale formation exposed in valley of creek above track level of the Toronto Hamilton and Buffalo railway. (Keele, J.: Geol.Surv.,Canada, Mem. 152, p. 25 (1924))

24. Stoney Creek. - Next 20 feet of shale beneath that of Sample No. 23.

None of the rocks represented by samples 11 to 24 comes entirely within the range of composition found desirable in a material for rock wool manufacture, and in laboratory tests no satisfactory results were obtained by using these materials alone. However,by mixing Cabot Head shale with cement rock or with Rochester shaly dolomite in such proportions as required to bring about a nearly balanced ratio between the acidic and basic constituents of the mixture,good results were obtained in every case.

The Cabot Head shale can very likely be located underlying some terraces along the lower slopes of the escarpment between Hamilton and Grimsby in such a position that the relatively small tonnages required can be quarried. In any event it is available by underground mining methods at numerous points. The only analyses yet available are from the exposure at Stoney Creek. However, it should not be assumed to be of the same composition or character wherever found.

The cement rock and the shaly dolomite of the Rochester formation can be quarried at a few points within this area. Particularly favourable places are; from the floor of the Beamsville quarries; in the area at the edge of the escarpment at the boundary between the townships of Clinton and North Grimsby, Lincoln county; in the valley of Forty-Mile creek south of Grimsby; in the valley of Redhill creek at Mount Albion.

Laboratory Tests.

The process of making rock wool is based on producing a melt that on cooling exhibits a relatively long period of viscosity between the temperature at which it is entirely liquid and the temperature at which it resolidifies, and from which, during the viscous period, thin, pliable fibres can be obtained. A correct proportioning of the chemical constituents in the furnace charge ensures these characteristics in the melt. A mixture with a high initial fusing point is essential to give a product that can be used for high-temperature insulation.

In the manufacture of glass wool as practised in Europe[1] the fibres are drawn out by a rotating drum placed underneath the perforated base of the furnace. The tiny streams of molten glass

1. Saborksky,A.D.: Glass wool Heat Insulation in Europe. Journ. Am. Ceramic Soc., Vol. 6, pp.674-684, 1923.

which pass through the openings in the base of the furnace are drawn into extremely long, thin, tough fibres which are wound upon the rotating drum. The prolonged range of viscosity exhibited by melts of glass and the very tough fibres obtainable therefrom during the cooling period, render this method possible. It is not suitable for making the short-fibred rock wool and slag wool as these are obtained from melts with a much shorter range of viscosity than that of commercial glass. With melts of the latter class the fibres are not so tough and also they must be obtained quickly and thus the method of atomizing the melt and violently propelling the particles through the air, in order to obtain fibres, is preferable. The latter method is also to be preferred from the standpoint of output per unit of time.

After the initial experiments to determine the possibilities of the deposits which happened to be similar in chemical composition to those used for rock wool manufacture in the United States, other experiments using the samples obtained from Niagara peninsula, were conducted to find out the approximate proportions of the various constituents which must seemingly be present in the natural raw materials, in order that the resultant melts will exhibit a definite period of viscosity and at the same time yield fibres. It will be readily realized that on account of the number of chemical constituents involved and also on account of the possible variations in temperature, a very large number of experiments would be necessary before —if ever— definite limits could be set to the relative proportions of the various constituents which should be present in the furnace charge in order to yield the best results. However, in the belief that it would be a guide to any who might wish to pursue the matter further, the maximum and minimum amounts of the main chemical constituents which our experiments to date have shown desirable in a furnace charge of rock from the Niagara peninsula are given on page 3.

In the experimental work so far completed it was found impracticable to test the fibre-yielding possibilities of each melt by atomizing it with steam, largely because temperatures high enough to render these tests satisfactory could not be obtained in the furnaces available. Instead, the expedients described below were resorted to.

The preliminary tests made on the various samples in addition to chemical analyses, consisted in fusing them in graphite crucibles in an electric furnace. The maximum temperature obtained was 2480°F. Ash from Hamilton by-product coke was added to the crucible charge in the proportion in which it would be present in the melt if the coke were used as fuel in the ratio of 1 part coke to 4 of rock. (This ratio might be bettered in actual practice). The average ash content of Hamilton by-product coke is 8 per cent. Thus in fusing 400 grams of rock, 8 grams of coke ash was added. The temperatures at which incipient fusion took place and also at which complete liquefaction was obtained were determined. In pouring the molten rock the degree of viscosity was observed and the time taken to solidify was noted.

To determine whether the melt would yield pliable fibres, small quantities were poured from a height so that a fibre would have an opportunity to form between the lip of the crucible and the molten drop, as the latter passed through the air. Fibres were also obtained by dipping iron tongs into the molten material in the mould and then withdrawing them;with a melt of suitable composition long fibres could always be thus obtained whereas none would be obtained from melts of unsuitable composition. Repetition of these tests at different times gave remarkably concordant results. The solidified material was examined for color, lustre, texture and general characteristics.

It seems a justifiable assumption that if the melts yield fibres under the conditions of the tests that fibres will also be obtained in a blowing process provided that the melt is raised to the correct temperature and that the pressure of the steam blast is adequate.

Each of the samples 5,6,8 and10 of the Rochester formation at Niagara Falls,St.Davids and Thorold yielded quantities of fibres after fusion. They commenced to fuse between temperatures of 2175°F and 2200°F and were completely fluid at 2480°. Upon being poured in moulds they each solidified comparatively slowly in contrast to some of the basic fusions, there being a prolonged period of viscosity before complete solidification. This is an essential property in a material for rock wool manufacture. The resolidified material had a glassy lustre and texture. Samples 5, 6 and 10 have an almost black glass, but that from sample No.8 was a clear light green, similar to bottle glass.

Sample No. 7, containing as it does an excess of basic constituents over the proportion desired, yielded no fibres. It solidified quickly to a finely granular mass, sub-glassy in texture and light-green in colour. When, however, the deficiency in silica and alumina was remedied by the mixing of 1 part sample No. 9 (from the base of the Rochester formation) with 3 parts of No.7, the results from the fusion of the mixture were entirely satisfactory. The glass, though, was much darker in colour than that given by sample No. 8, this being due to the admixture of sample No.9 which of itself yields a black glass.

Similarly the cement rock at St.Davids has too high a content of calcium and magnesium carbonates to be used alone, but, when mixed with an equal portion of the strata from the base of the Rochester in the same locality, fibres of good quality were obtained. The glass in this instance was very dark green.

None of the samples of cement rock gave any results when used alone. They fused only to a paste at 2480°.

Mixtures of the bottom strata of the Rochester formation at St.Davids in equal proportion with cement rock obtained from

Walker Bros. quarry, from the Battle quarry, and from Power Glen gave good results.

Fusions in which proper proportions of the Cabot Head shale from Stoney Creek (Sample No.24) were used with cement rock from various localities also gave favourable results. Combinations tested included 1 part Cabot Head shale and 3 parts of Rochester shaly dolomite of Sample No. 18, and 1 part shale and 3 parts of Sample No. 19 (Rochester shaly dolomite at Grimsby) also yielded fibres.

The simple proportions in which the various rocks were mixed in the above instances was for initial experimental work only. These proportions yielded a product but not necessarily the best product. Undoubtedly more refinements in mixing would be found advisable in actual practice.

The Queenston shale, so abundant and easily obtained in the Niagara peninsula will probably cause trouble if used in rock wool manufacture on account of the way in which it swells and foams on being rapidly heated. In the laboratory tests the foaming was lessened but not entirely overcome by adding oxidizing compounds to the charge. Very pliable fibres of good colour were obtainable from a mix of 1 part Queenston shale and 2 parts cement rock from St.Davids.

From the results of more than 50 fusions the limits of the constituents in a suitable raw material as given on page 3 were drawn up, and also the lowest ratio to which the weighted sum of acidic constituents should bear to the weighted sum of basic constituents in the furnace charge in order to yield fibres, was provisionally determined as being 0.80. (See below) The upper ratio was not fixed as it is apparently to be determined more by the economics of the furnace operation than by composition of charge, for the acid melts all gave fibres even though some were very pasty; to render them liquid would require higher temperatures thus necessitating an excessively high fuel consumption.

In the calculation of the ratio of weighted acidic to weighted basic constituents, the method outlined in Richards'[1] "Metallurgical Calculations", page 250 et seq. was followed. This method involves the calculating of the fluxing power of acid constituents in terms of silica and adding them to obtain "summated silica", and calculating the fluxing power to the various basic constituents in terms of lime and adding them to obtain "summated

[1]Richards, J.W.: Metallurgical Calculations. McGraw-Hill Book Co., Inc., New York (1918)

lime". The ratio of the summated silica to the summated lime is then obtained. Based on atomic weights the equivalent fluxing power of the bases in terms of CaO is as follows:

CaO equivalent of	any	amount	of	MgO	=	1.4 x	amount	MgO
"	"	"	"	"	"	FeO	=	0.78 x	"	FeO
"	"	"	"	"	"	Fe_2O_3	=	0.7 x	"	Fe_2O_3
"	"	"	"	"	"	K_2O	=	0.6 x	"	K_2O
"	"	"	"	"	"	Na_2O	=	0.9 x	"	Na_2O

In discussing the fusibility of low silica slags, below 45 per cent, which in some instances are very similar in composition to the fused materials with which we are concerned, Richards (p.257) holds that "alumina acts like silica when considerable is present, and like lime when less is present". On this assumption in all cases where alumina exceeded 8 per cent in the furnace charge it was calculated as an acid constituent in determining the ratio of the weighted sum of the acidic constituents.

SiO_2 equivalent of any amount of Al_2O_3 = 0.88 x amount of Al_2O_3

An example of this method of calculating follows:

Analysis of furnace charge:

Silica	28.27
Ferric oxide	2.38
Alumina	9.94
Potash	1.67
Soda	0.12
Calcium oxide	19.39
Magnesium oxide	10.42
Volatile matter	27.60
	99.79

Acids in terms of silica.

SiO_2		= 28.27
Al_2O_3	= 9.94 x 0.88	= 8.77
		37.04

Bases in terms of lime.

CaO		= 19.39
MgO	=10.42 x 1.4	= 14.59
Fe_2O_3	= 2.38 x 0.7	= 1.67
K_2O	= 1.67 x 0.6	= 1.00
Na_2O	= 0.12 x 0.9	= 0.11
		36.76

$$\text{Ratio } \frac{\text{Weighted acids}}{\text{Weighted bases}} = \frac{37.04}{36.76} = 1.01$$

This method of calculating the ratio between the weighted acidic and basic constituents in order to obtain a practical basis for classification of the various composition experimented upon was

found much more satisfactory than merely obtaining a ratio between the percentages of the acid and basic constituents as shown in the chemical analysis.

Mention has been made of the colour of the glasses resulting from the various fusions. Upon the colour of the glass depends the colour of the wool which can be produced. The mixes which give greenish glass will yield light-coloured fibres; the very dark green and black glasses will yield grey fibres. In the manufacture of acoustic tiles which are tinted in various shades, a light-coloured rock wool is necessary, but for insulating purposes where it is to be placed out of sight, the colour is immaterial. But the light-coloured wools are preferred to some extent over the dark wools and this must be taken into account when considering the raw material available.

The cause of the dark colour has not yet been ascertained. In general the cement rock along the escarpment when fused is of varying shades of green. The same is true of the Cabot Head shale at Stoney Creek, and mixtures of these two will yield light-coloured fibres. The Rochester formation generally makes a black glass and consequently a grey fibre, but at St.Davids the upper part of the formation yields a very light-green glass from which an almost white fibre can be produced.

Conclusions.

The experimental work to date indicates that there are substantial quantities of rock available in the Niagara peninsula for the manufacture of rock wool. It has been demonstrated on a laboratory scale that, if the natural rock, or mixture of rocks, has a chemical composition within the limits given on page 3, and, in addition if the acidic and basic constituents in the furnace charge be present in such proportion that the ratio of weighted acids to weighted bases be above 0.80, the material will yield rock wool fibres. In this report it has been pointed out how simply these requirements can be met either by using the rock from a single deposit or by mixing the materials obtainable from two adjacent deposits. The gradation in composition from top to bottom of the deposits which may be classed as natural wool-rock, and the proximity of deposits which yield material suitable for mixing, afford excellent opportunities to obtain a composition in the furnace best suited to yield a high-grade rock wool at the lowest fuel cost. If research should indicate that a better product can be obtained by altering the proportions of the principal constituents at present recommended for the furnace charge, it will be an easy matter to make these alterations in view of the variety of raw material available.

Although the work undertaken so far is entirely on a laboratory scale it is not anticipated that great difficulties would

be encountered by skilled operators in making rock wool on a commercial scale, provided close chemical control is maintained over the furnace charge. The utilizing of rock from single deposits of generally uniform composition probably will prove more satisfactory from the standpoint of economical furnace operation than will the utilizing of a mixture of rocks from two deposits of diverse composition. The Rochester and Cabot Head shales when freshly quarried are obtainable in large lumps and only after prolonged weathering do the lumps break down into fragments too small to be used in a cupola furnace. These shales do not swell and foam during the melting process as does the Queenston shale.

The samples of the various rocks obtained for the laboratory tests were taken with care and are virtually channel samples. The rock composing the samples appeared to be unaltered, but in all cases except at the excavation for the weir on the Welland canal east of Thorold, the samples were obtained from within one foot of the faces of the outcrops which had been subject to the action of the weather for many years. Blasting would have been necessary in every case to obtain rock which was undoubtedly fresh, but this was not practicable in the preliminary work covering such a large area. But for further tests, either on a large or small scale, material at least 5 feet back from any exposed face should be obtained in order to ascertain if the characteristics of the fresh rock, and of the rock which has been subject to weathering agencies, are materially different.

In view of the possibility of local variations in the composition of the deposits, core drilling is to be recommended where feasible, in order to obtain representative sections of deposits for chemical analyses and for fusion tests.

NOTES ON THE ROCK WOOL INDUSTRY.

History.

The early history of rock wool manufacture is obscure. The first definitely known date of production is stated by Thoenen[1] to be 1897, when it was made at Alexandria, Indiana, which place is still the chief centre of rock-wool manufacture in the United States. Herbert Lang[2] in 1923 stated that slag wool had then been made and sold as a non-conductor of heat and sound for at least 50 years.

1. Thoenen, J.R.: Mineral Wool, Information Circular No.6142, U.S.Bureau of Mines, Washington, D.C.
2. Lang, Herbert: Some Problems Encountered in Designing and Operating a Slag Wool Plant., Chem. and Met. Eng. Aug.27, 1923, pp. 365-367.

Prior to 1915 the growth of the rock wool industry in the United States was slow. Its products were not well known, and in addition the matter of insulation received but scant attention. With the awakening to the economic advantages of high-grade insulation by industry in general and by the building industry in particular, the rate of growth of the rock wool industry became greatly accelerated. Unfortunately no production figures are available but the present capacity of rock wool plants in the United States is, according to reliable information, about 65,000 tons of raw wool per year. This does not include the output of slag wool which is also steadily increasing in quantity.

Slag wool and glass wool are manufactured for insulating purposes in several countries in Europe where the industry became firmly established during the war.

Plant and Process.

The usual type of cupola furnace used in the making of rock wool in the United States is the vertical, water-jacketed, cylindrical variety constructed of steel. It is unlined and has a removable base. Inside diameters vary from 4 to 6 feet, and the height from 8 to 15 feet. A bustle pipe with 8 small tuyeres, which enter the furnace about 18 inches above the base, supplies the air for combustion. Rock and coke are charged through a trap door near the top of the furnace. A fuel ratio as low as 1 part coke to 6 of rock is reported in one instance where pre-heated air is used for combustion, but the average is 1 to 3.5. The molten rock comes from the base of the furnace in a stream about the thickness of a lead pencil and falls just in front of a nozzle of special shape from which steam or air issues at a pressure of about 90 pounds. The blast of steam, inclined upwards at an angle of 50 degrees from the horizontal, blows the molten rock stream into myriads of tiny globules which are directed into a chamber known as the wool room, the bottom of which is usually a wide belt conveyor. The fibres form behind the molten globules as they are propelled through the air. The fibres fall on the moving floor in a fluffy mass and are transported from the wool room. The capacity of the average size cupola is 900 pounds of wool per hour. A certain proportion of glassy globules (shot) is always present in the raw wool. In order to make a dustless product a tiny stream of high-flash paraffin oil is run onto the stream of molten rock globules just after they begin their flight from the steam jet. This gives what is known as oiled wool.

Products.

This material as it comes from the wool room may be sold in that condition without further treatment or it may be processed

in various ways.

Granulated wool is the name applied to raw wool after it has passed through a machine termed a "granulator", in which the wool is pulled into tufts and the shot removed. The tufts pass to a rotary screen where they are rounded into pellet shapes. In this form it is used for insulating houses already built, it being blown by air into the wall and floor spaces. Granulated wool is also used as the basis of a number of moulded products made from rock wool.

Rock wool blankets are made by compressing loose wool between wire netting or metal lath. The blankets or pads can be made in any desired shape and are used extensively for insulating buildings in course of construction. The industrial uses include the insulation of electric stoves, tank cars, ovens and boilers.

Rock cork is the name applied to the product made by mixing granulated wool with vegetable fibre and asphalt, and lightly compressing the mixture in a mould after which it is dried in hot-air ovens. This product is used only for low-temperature insulation, chiefly for refrigerator equipment.

Moulded shapes for covering pipes are made by mixing a suitable binder with wool and compressing the mixture.

Acoustic tiles are moulded products made from rock wool by using starch gel as a binder along with the addition of mineral filler and water-proofing material. It is possible to obtain a wide variety of tints by the use of suitable colouring matter.

Canadian Consumption.

No separate record is kept of the imports of raw and processed rock wool into Canada. In any case the import statistics would not be a reliable indicator of the extent of the market which could be developed for rock wool produced within the Dominion. Statistical data and a picture of the market possibilities in Canada for building and low temperature insulation materials in general, are given in a report[1] issued by the National Development Bureau, Ottawa.

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[1] Building Insulation Industry in Canada, 1930, and Low Temperature Heat Insulation Industry in Canada, 1929.