GM 36008

A COMPARATIVE STUDY IN REGARD TO OTHER COMMERCIAL SILICA/SANDS OF NORTHEASTERN AMERICA

THE VAL BRILLANT SANDSTONE

MATANE CTY, P.Q.

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Dorval, Quebec
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1.0 GEOLOGY OF SILICA DEPOSITS:- Great Lakes - St.Lawrence Lowlands - Appalachian Uplands

1.1 General: Quartz is the most common mineralogical form of silica (SiO_2). A quartz deposit may be found in nature as:

a) hydrothermal deposit . . . . quartz vein

b) highly metamorphosed (recrystallized) detrital sediments . . . . quartzite

c) slightly metamorphosed (recemented) detrital sediments . . . . sandstone

d) loose detrital sediment . . . . sand & gravel

Large tonnage of quartz occur as quartzite in which the quartz grains recrystallise and develop an interlocked mosaic texture. Impurities in the quartzite are converted to equivalent metamorphic minerals such as sillimanite, wollastonite, talc. Quartzite is exploited commercially for use in the production of silicon, ferrosilicon, refractories, etc. Quartz veins are exploited for about the same purposes and according to their chemical composition.

Sandstones, the recemented product of detrital quartz grains, are classified according to their quartz content - for exemple, proto-quartzite (75-95% quartz) and orthoquartzite (over 95% quartz) - the remaining material being impurities and cement. A particular variety of orthoquartzite is "ganister" which is an arenaceous earth found below coal seams.

A silica sand is an assemblage of individual quartz grains in the size (diameter) range of 0.06 mm (230 mesh) to 2 mm (10 mesh) that is mid-way between silt ($^{-}$0.06 mm) and gravel ($^{+}$2 mm to 4 mm) - the granulometric requirement of a glass sand is $^{-}$30 mesh + 120 mesh, that is with a coefficient of uniformity between 1.3 to 1.8. The perfect glass sand would have a coefficient of uniformity of 1. The size range for a foundry sand is about the same but the grain shape has to be rounded.

Most of the silica sands consumed in N.E. America derive from the St. Lawrence Lowlands sandstones (2%) of Cambrian age (Potsdam Ss), the Great Lakes sandstones of Ordovician age (56%) (St.Peter or Ottawa Ss.) and the Appalachian Uplands sandstones (40%) of Devonian age (Oriskany Qtze).

1.2 The Potsdam Sandstone - These arenaceous rocks rest on the precambrian granitic shelf and underly the Ordovician flat lying beds that extend from Montréal to Georgian Bay. The Potsdam Sandstones, however, are only exposed north and south of Montréal, at Potsdam (USA) and sporadically south-west of Ottawa. The beds are horizontal to slightly dipping at 35° and make up a maximum thickness of 280 feet. Only the top 40 feet is exploited at St. Canut by careful mining and blending; the problem comes from their pyriteferous nature and the discontinuous high alumina content. These sandstones could not be mined and beneficiated satisfactorily at Potsdam in the State of New York.

The pyrite occurs not only as loose grains but also as a tight coating on the individual quartz grains. Beneficiation at St.Canut has only permitted to produce a second quality sand for the manufacture of colored containers. South of Montréal, the Potsdam is used to make a low quality ferro-silicon or is used as a fluxing agent. The remaining exposed or sub-exposed Potsdam of the Montréal region has, with all other available lands, been zoned for agricultural purposes.

A few months ago, the Ontario Department of Mines has released a report on the Silica Sand Potential of the Potsdam exposed between Ottawa and Kingston. Considering the past and actual beneficiation problems of the Potsdam, the new environmental restrictions, the size and thickness of the outcropped sandstones, the past investigations by reliable companies, it is doubtful that the Potsdam, in that region, will now prove to be a competitive acceptable product. The Medina (Whirlpool) sandstones of lower Siluvian age crop out at a few localities west of Niagara Falls in Ontario but are not marketable as good quality silica sand. The Oriskany formation is exposed at one locality, has a maximum thickness of about 20 feet and its potential is very limited to non-existant.

1.3 The St.Peter Sandstone (Ottawa Sand) - The most successfully exploited silica sand sources on the basis of quality, tonnage and profit in northeastern U.S. are the St.Peter sandstone and the Oriskany sandstone, according to T.D. Murphy (1975).

The St.Peter sandstone is largely exposed in northern Illinois. It is a sandstone of Ordovician age and a sedimentary orthoquartzite sandstone. It lies on the erosional surface of Shakopie Dolomite and attains a thickness upward of 400 feet. Locally, the formation itself has been subjected to post depositional erosion, resulting in thicknesses upward to 200 feet. Exposed outcrops in river banks within the Ottawa area are most common; elsewhere, it is covered with formations of Silurian, Mississipian and Pennsylvanian ages. Lithologically, the formation is a white to buff, medium to fine grained orthoquartzite; rounded quartz grains with minor secondary silica and clay cement. The St.Peter grain size ranges from medium to coarse grained in the upper part of the formation and medium to fine grained in the lower sections. As a rule, the lower 100 feet of the formation is fine grained, with iron, alumina and carbonate contaminations. For this reason, the upper 100 feet of the formation is actually exploited. This upper section is massively bedded material of weak to moderate consolidation and is being extracted by open pit or by underground mining. Hydraulic techniques are used from the mine face to a light beneficiation and sizing. Reserves are large and nearly completely controlled by current producers. Even deeply covered areas have been explored and acquired by operating companies for future use. What remains under private ownership will soon be zoned out of the market by urbanization pressures.

Because of its exceptional physical and chemical properties, the St.Peter sands is in good demand. However, it presents difficulties of exploitation during the winter months and its delivery for distant markets in Ontario and Québec is subjected to delays because of a lack of railroad cars and of an increasing high cost of transportation.

~~3~~1.4 The Oriskany Sandstone - The Oriskany sandstone (Ridgeley sandstone) also corresponds to an orthoquartzite, is part of the Appalachian Uplands and constitutes a ridge marker because of its greater induration. For the most part, the Oriskany is found in strongly dipping beds ranging from 45° to the vertical. Its economic occurrences are pretty well limited to the tri-state area of Virginia, West Virginia and Pennsylvania.

The texture, purity, and degree of induration are all subject to extreme variability relative to the St.Peter sandstone. However, it shares the same perfection of grain that the St.Peter enjoys and most of the defects are secondarily induced and can be nearly eliminated by suitable plant beneficiation. Here again, all known reserves and potential resource acreage are owned by, or under long-term lease to local operating companies. Because of the ever increasing zonal restrictions due to urbanization, a substantial portion of this potential will never be exploited.

1.5 The Cohansey Sand - This sand, of probable Miocene age, is a strong local factor in the foundry and ceramic supply businesses of southern New Jersey. This is a very weakly consolidated sand of extremely erratic quality, both physical and mineralogical, but selected deposits can be and are up-graded by suitable processing into salable products. Exploitable reserves are strictly limited and those that are known are jealously held by mining companies who operate in the outcropping areas.

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1.6 Scotland Sand (Ind. Min. , June 1976) - One of the purest sands produced in the U.K. is extracted from the cretaceous sandstone deposit at Loch Aline, a sea loch in Argyllshire, Scotland. The deposit is an 18 to 20 feet thick seam at the top of the sandstone sequence which is overlain in turn by tertiary basalt. A feature of the deposit is its naturally low iron content - the grade has the following analysis: 99.75% SiO_2, 0.03% Fe_2O_3 and 0.15% Al_2O_3.

The sandstone is extracted by the room and pillar method which necessitates about 40% of the sandstone being left behind as support pillar. About 3 million tons of sandstone have been extracted up to now and workings stretch for over 20 miles. A new pier has been completed recently which can handle vessels of up to 2,500 tons with a loading rate of about 400 tph. Work has now began on the installation of a new working and classification plant which will include attrition scrubbers. About 40% of the yearly production of 300,000 tons is exported to Sweden, Norway and Eire, and to a lesser extent Iran and the USSR. Supplies to the U.K. are maintained by shipping the sand to stores at strategic points.

2.0 THE VAL BRILLANT SANDSTONE OF THE QUEBEC APPALACHIAN UPLANDS

2.1 Introduction - Although the rock has been quarried intermittently and used locally as a decorative stone since several decades, it has never been investigated as a source of silica sand mainly because little geological data concerning this formation were published prior to 1967; also, there was no water transportation infrastructure facilities until 1975 and finally, because the problem of silica sand availability in Eastern Canada emerged as an acute malaise only a few years ago. Nonetheless, there is a lot of geological information available as the Val Brillant formation has been the object of a McGill University thesis by J.R. Lajoie (1961) and, at about the same time, was also part of N.C. Ollerenshaw's PhD thesis at the University of Toronto.

2.2 <u>Stratigraphy and Lithology</u> - The Val Brillant formation was first described by G.W. Crickmay in 1932. The type section is on the shore of Lake Matapedia, 1¼ mile northwest of Val Brillant. At this locality, the sequence is composed of a series of thin and thick-bedded, white and buff sandstones. The outliers of this formation, namely the Langis-Tamagodi and the Turtle Hill located 20 miles south of Matane, are said, according to Ollerenshaw (1967), to expose better sections than the type locality. Wherever exposed, the Val Brillant sandstone forms a ridge due to differential erosion and can easily be detected on air photographs. Previous reports have confused Kamouraska and Val Brillant stratas in two or three instances.

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Extent and thickness of the formation - The Val Brillant sandstone outcrops sporadically at the base of the Silurian sequence from Rimouski to Gaspé on a distance of over 100 miles; the thickness of the Val Brillant changes irregularly along strike from 100 to 400 feet, yet its best development is only observed in the 3 outliers behind Matane as shown on the accompanying geological map. Beds are from 3 feet thick up to 12 feet thick.

Lithology - According to Lajoie and Ollerenshaw, the Val Brilland sandstone belongs to the orthoquartzite category. The typical sandstone is composed almost entirely of quartz grains more or less silica-cemented. The rock is white to buff and, in places, pink. The pink colouration may increase in intensity to red due to a greater concentration of hematite as pigment within the cement.

2.3 Physical Properties of the Val Brillant Sandstone - Grain Size Distribution - Ollerenshaw (1967) described the main outliers of sandstone as being mainly fine to medium grained, changing locally to medium or coarse grained. The coarser-grained sandstone locally has a sugary appearance. The sandstones are moderately to well sorted. The coarse-grained layers are intercalated with well-sorted, finer-grained sandstone. Grains are typically rounded to well rounded.

2.3.1 - Grains size distribution and coefficient of uniformity - Lajoie (1961) studied the Val Brillant occurrences from Lake Matapedia westward to Rimouski; he computed these data mathematically and indicated that:

- the median for grain size ranges from 0.1 mm to 0.4 mm,
- the arithmetic mean for grain size ranges from 0.1 mm to 0.4 mm,
- the mode for grain size ranges from 0.09 mm to 0.37 mm.

Lajoie concluded that the Val Brillant sands fall in the upper limit of the fine sand size. Four samples were on the lower limit of medium sand size.

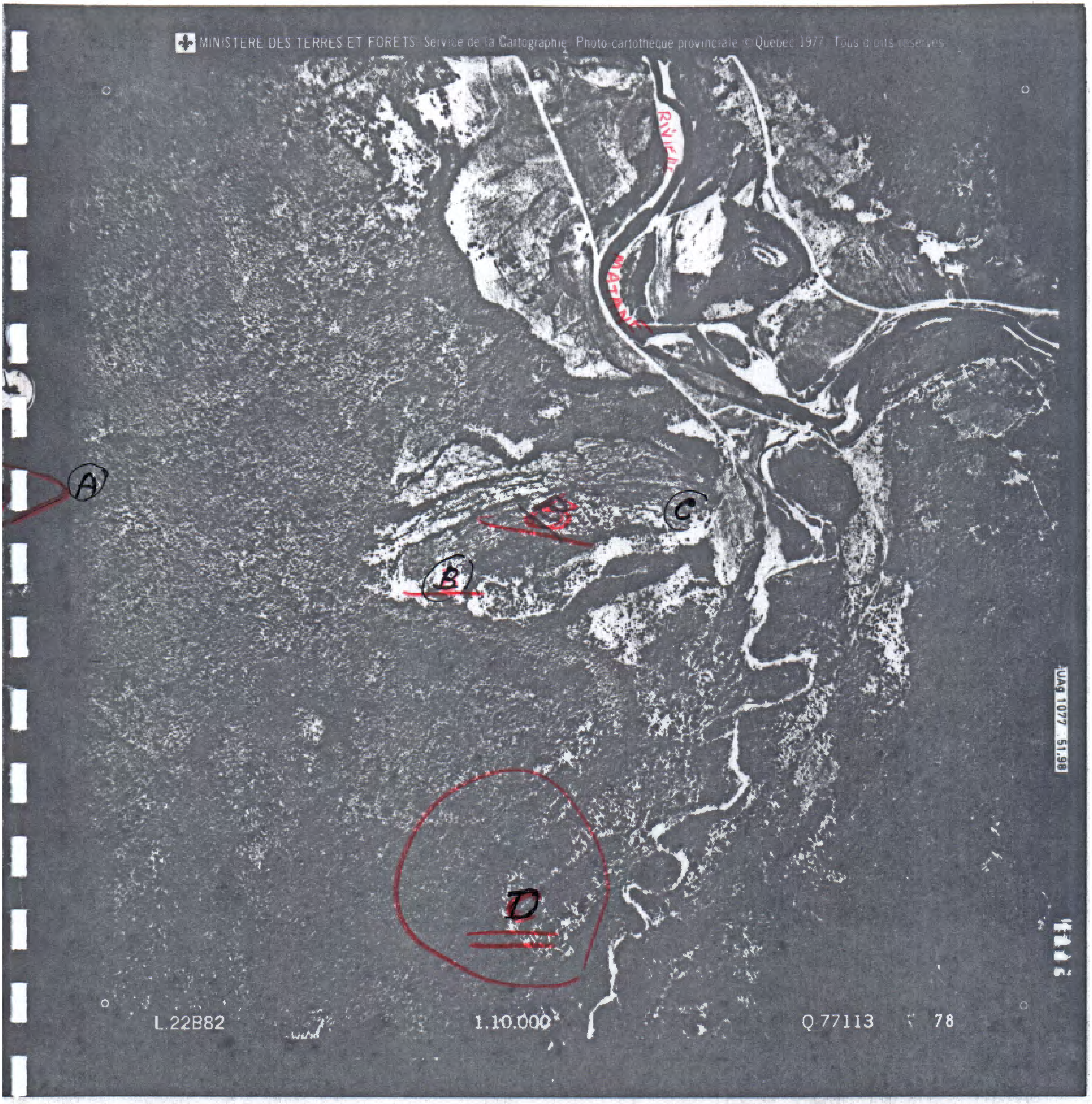
Recent granulometric tests on the Val Brillant sandstone outcropping behind Matane indicate a grain fineness (AFS) varying from 55 to 64 (see report by CRM, March 1979 annex). As to grain size distribution, the latter report indicates that 95% of the sand grains are between 20 mesh and 150 mesh. (See enclosed photo micro-graphs).

2.3.2 - The sorting coefficient (coefficient of uniformity) - measured by Lajoie ranges from 0.18 to 1.41. Similar measurement in 1979 on samples from the Matane occurrences indicate a coefficient of uniformity between 1.5 to 1.7 (see enclosed curve p. 13).

Lajoie concluded that the Val Brillant sandstone is very well sorted.

2.3.3 - Particle shape - sphericity and roundness - Lajoie (1961) carried out such measurements and concluded that the sphericity of quartz grains in the Val Brillant ranges from 0.67 to 0.8. Since

Areal photograph showing Eastermost tip of the Langis outlier near Matane & Tamagodi rivers. Scale: 1000' = 1".



SCALE 1000' 1"

Sphericity and roundness decrease with decreasing grain size

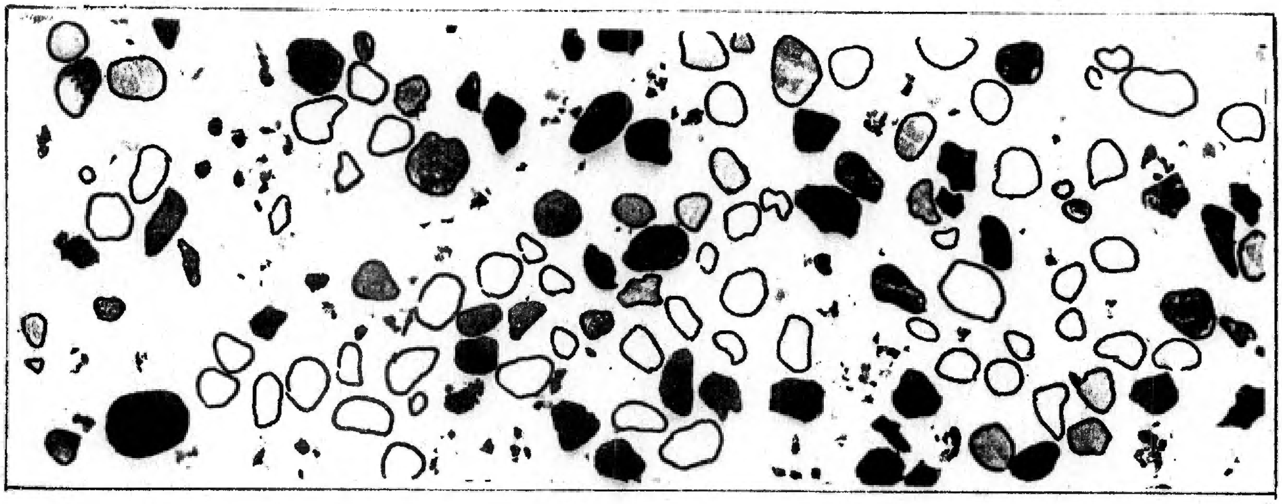


Photo micro-graph 12X (-28M + 35M) (.7 to .5 mm)

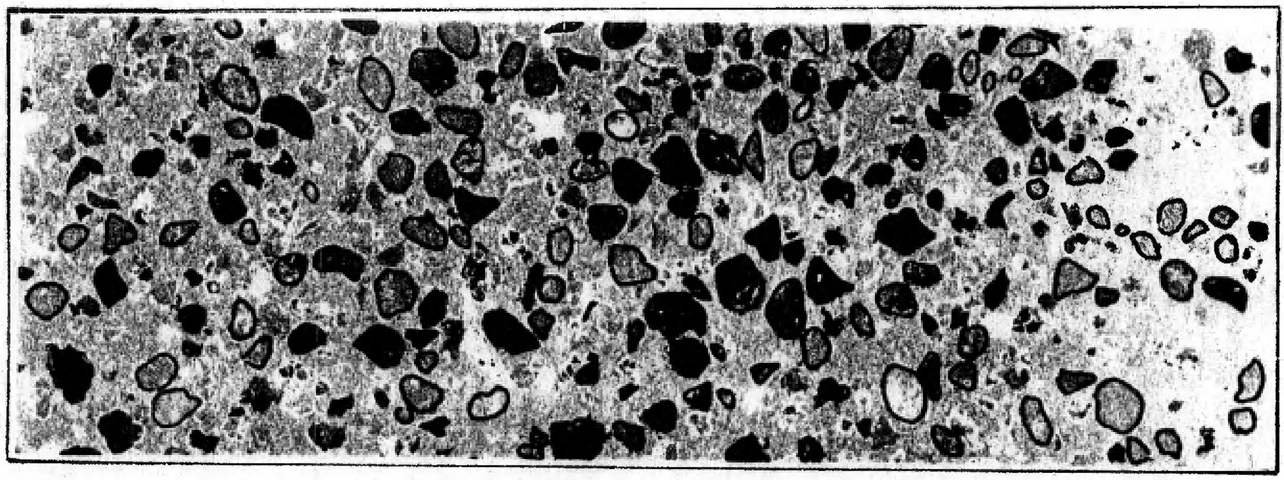


Photo micro-graph 12X (-35M + 60M) (.5 to .25 mm)

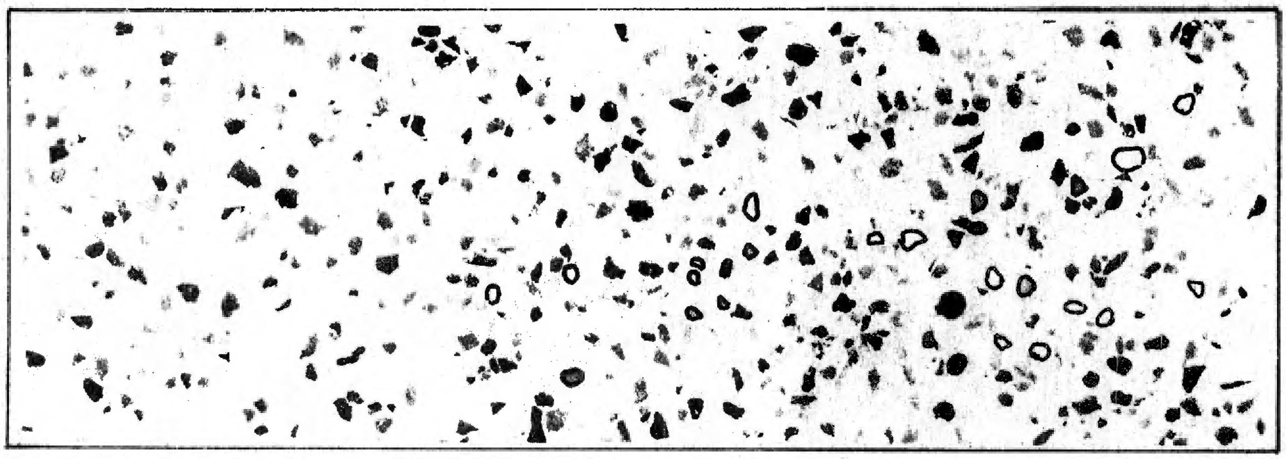
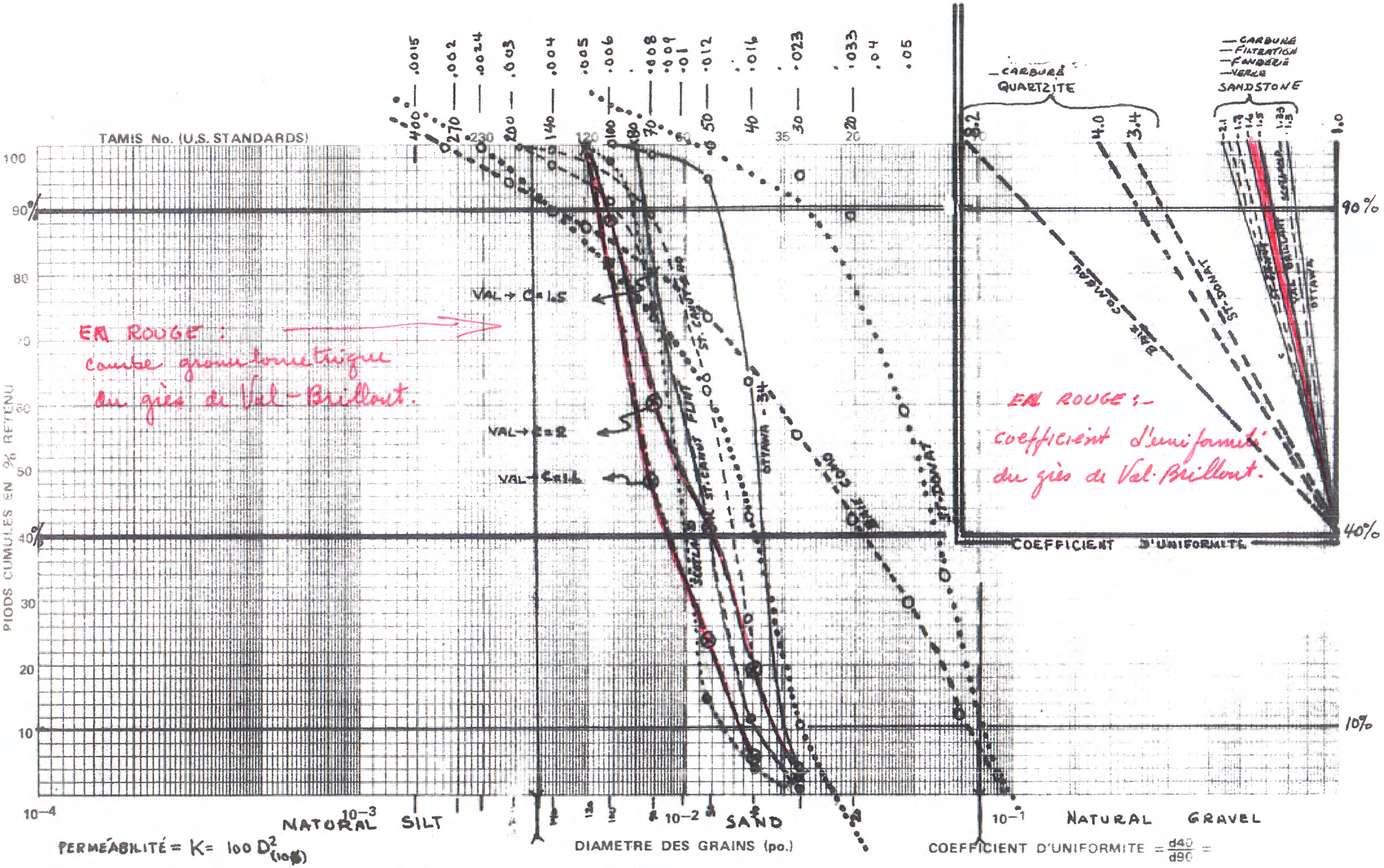


Photo micro-graph 12X (-60 M + 120 M) (.25 to .125 mm)



LOCALISATION

FORAGE No.

PROFONDEUR

DATE

Val Brillant - Grain size distribution on 10 samples 50 miles apart

HISTOGRAMS

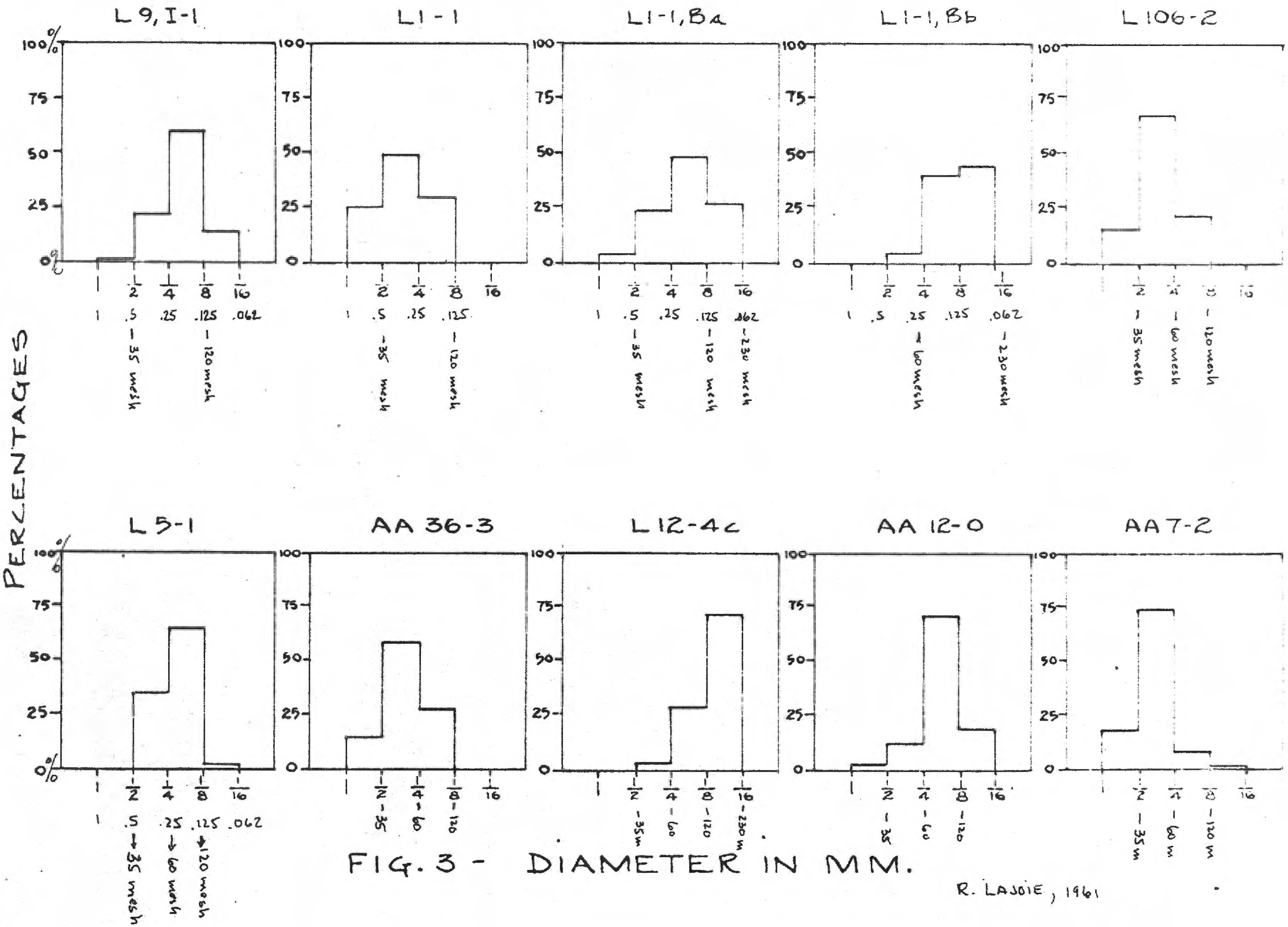


FIG. 3 - DIAMETER IN MM.

R. LAJOIE, 1961

Val Brillant - Coefficient of Uniformity

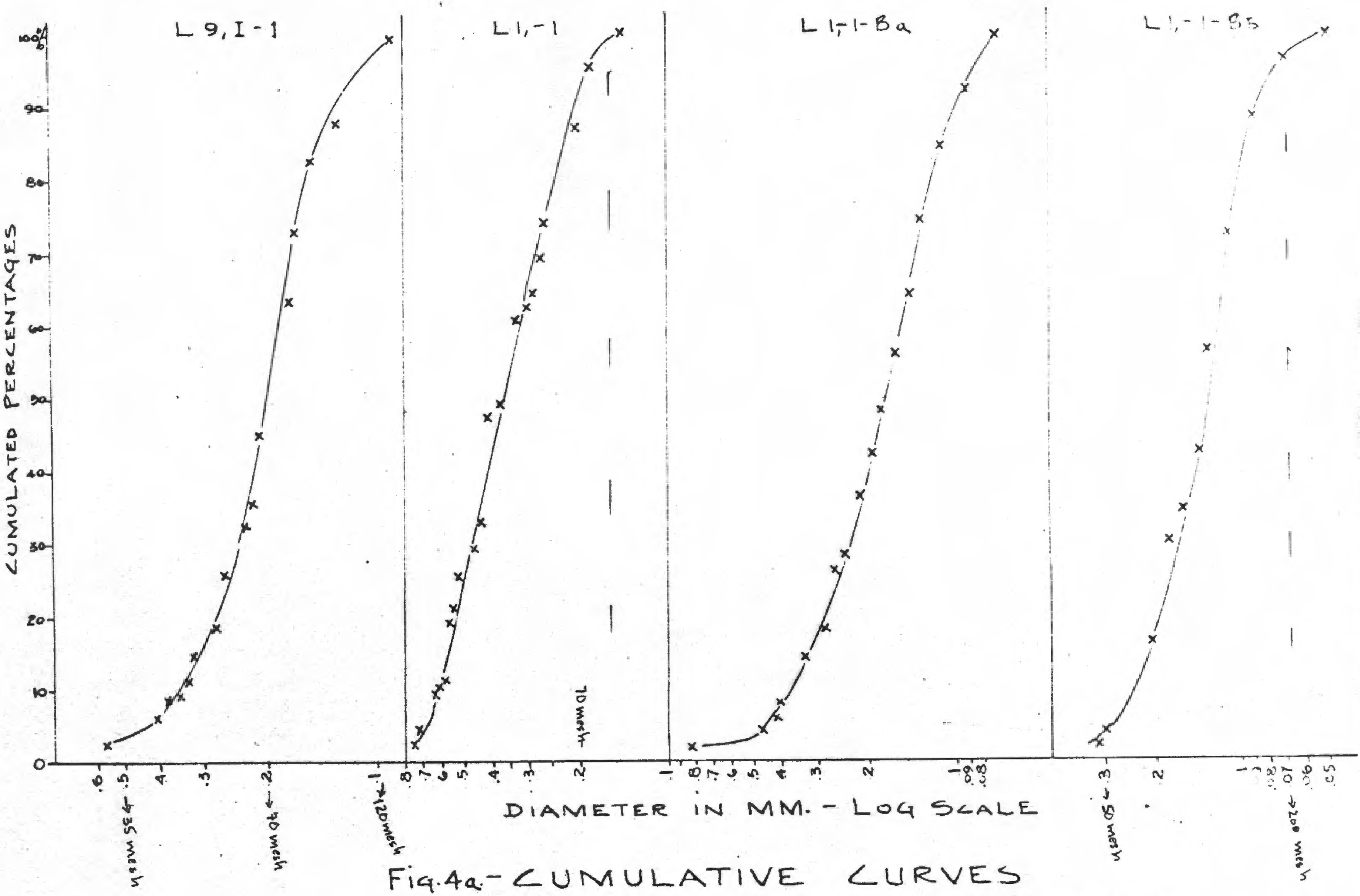


Fig. 4a - CUMULATIVE CURVES

R. LAJOIE, 1961

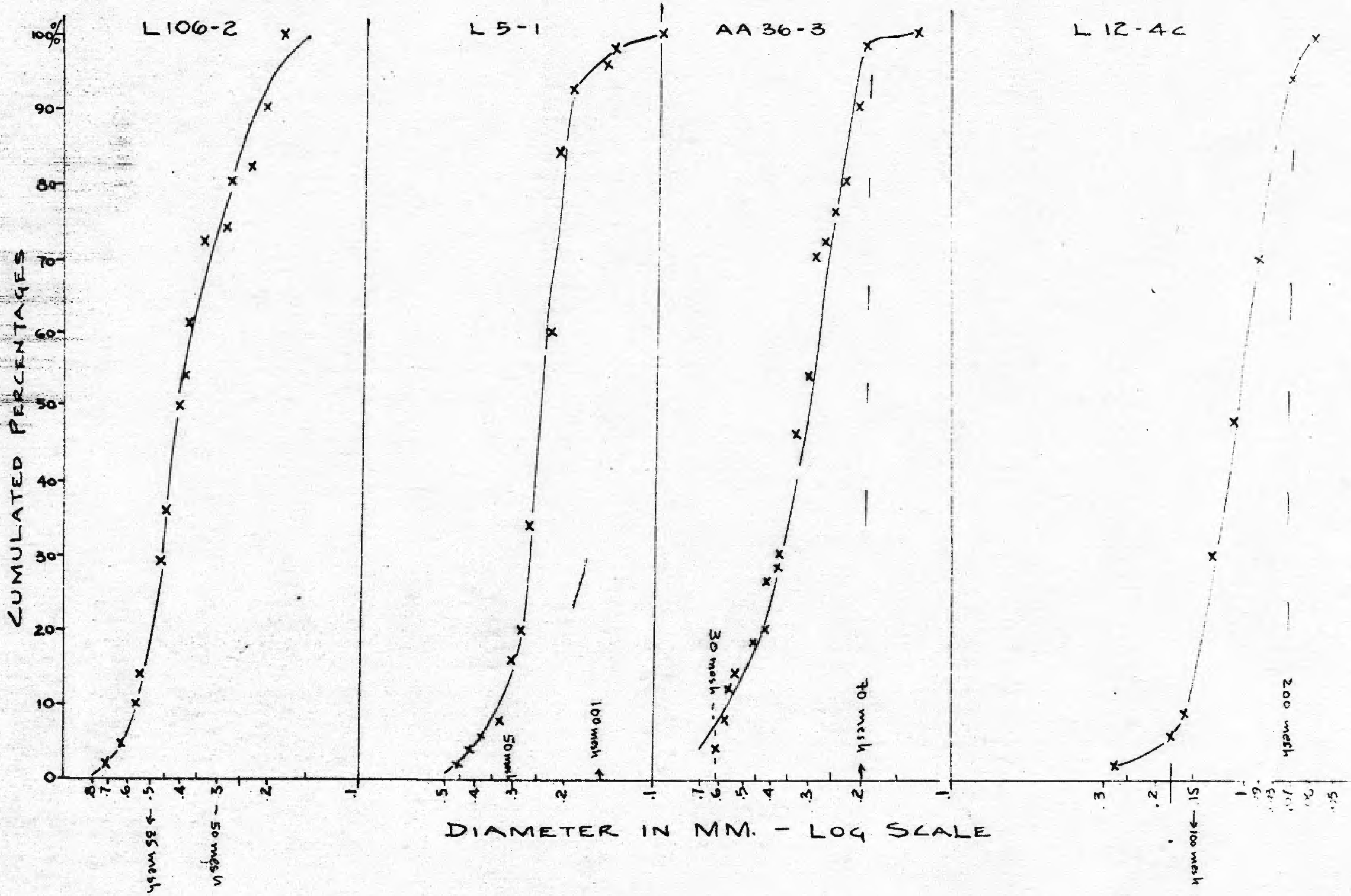


Fig. 4B CUMULATIVE CURVES

By: R. LAJOIE, 1961

Val Brillant - Coefficient of Uniformity

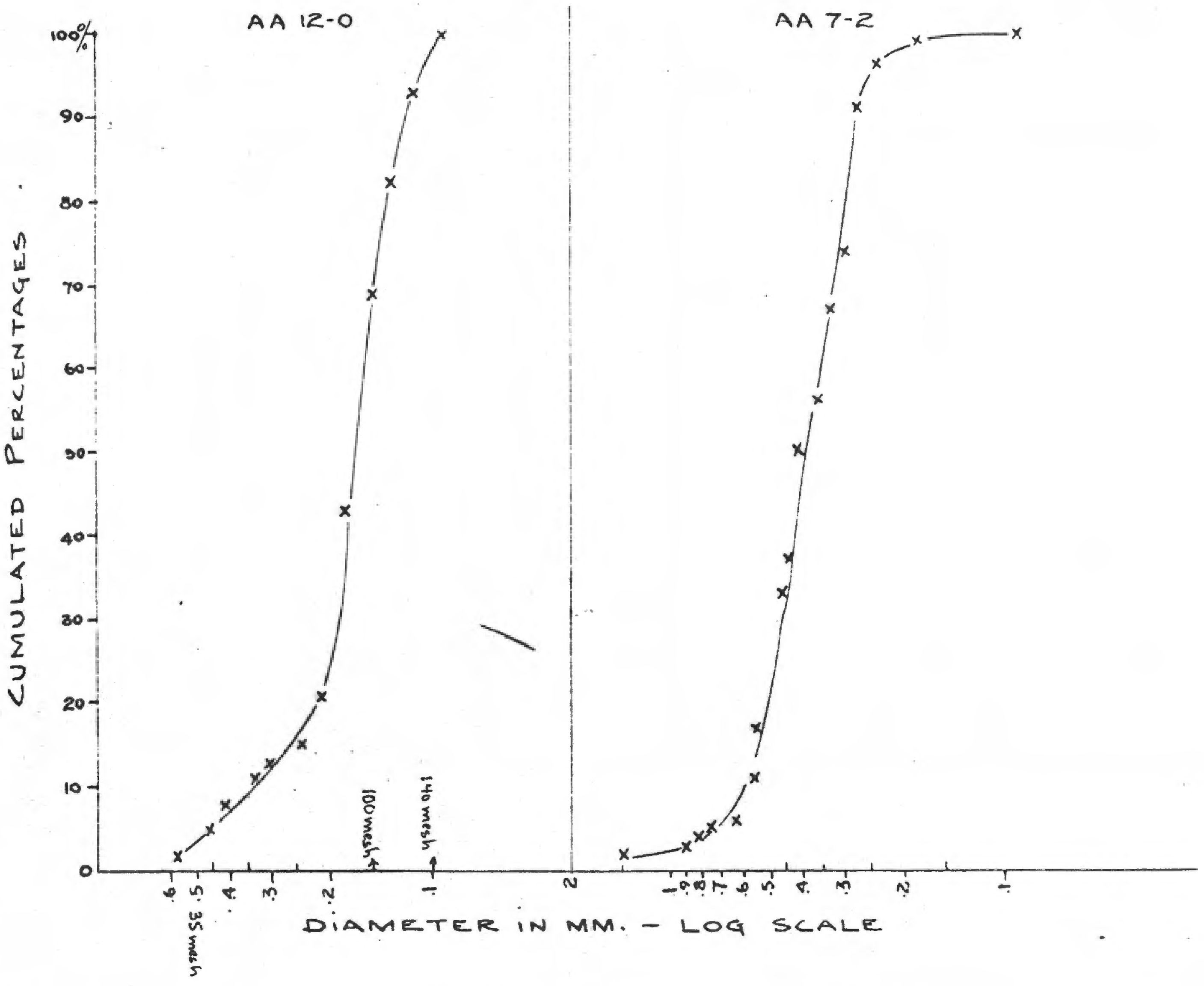


FIG. 4c CUMULATIVE CURVES

R. Lagore, 1961

the samples he studied were representative of the formation, he opined that the sand grains have a "high sphericity". Krumbein (1943, p.83) conducted measurements on selected samples from the St. Peter sandstone (Lasalle county, Illinois) and indicated that the average sphericity of the sand grains was 0.83.

As to roundness, Lajoie's mean values obtained in his analyses range from 0.37 and 0.9 and permit to conclude that the sand grains are "well rounded" to "very well rounded". Krumbein (1953, p. 83) indicated that the average roundness of the St. Peter sands is 0.77.

Lajoie's diagram shows that both sphericity and roundness decrease with decreasing grain size. (See enclosed photo micro-graphs).

2,3.4 - <u>Thermal breakdown test or decrepitation test</u> - Such a test is applied to quartzite or sandstone to determine whether or not the rock sample (4" x 4" x 4") will crack in several small pieces under severe thermal shocks. For metallurgical use and in the process of manufacturing ferro-silicon in a furnace, the sandstone, in lumps, must not decrepitate into small fragments before it melts. Such laboratory tests on the Val Brillant sandstone were conducted into three different laboratories (Geolab Inc., Québec Government Lab., and the Airco Alloys Lab. in Niagara Falls, U.S.A.) along with witness samples of Potsdam sandstone already recognized as a metallurgical sandstone. The three tests performed at a temperature between 1000°C to 1200°C turned out to be positive indicating that the Val Brillant sandstone is acceptable as a metallurgical sandstone.

The loss on ignition on the lump sandstone is, according to Airco Alloys, 0.15% (L.O.I.) whereas the L.O.I on the sand grains after treatment is 0.19% from a result obtained in the Québec Government Lab.

2.3.5 - Practical considerations - The overall physical properties of the Val Brillant sandstone suggest that the rock can be used in metallurgy, that it can be used as a source of foundry sand and as a source of glass sand.

Murphy (1975) stated: "To generalize, a naturally light-coloured quartzite, sandstone, or quartz sand or one which readily breaks down and washes to a light colour, having at least 95% of its grain between 20 mesh and 140 mesh, and with a fairly uniform size frequency distribution, is, from a textural standpoint, a potential multi-purpose industrial silica material, per se."

2.4 Chemical Composition of the Val Brillant Ss.

- Until 1974, studies of the Val Brillant sandstone were directed mostly to the lithology, the stratigraphy and the texture of the rock. A brief investigation by M. Tiphane (1974-75) on behalf of the government of Québec led to the publication of three chemical analyses followed in

1978-79 by further sampling and assaying of the Langis outlier.

The assay results may be tabulated as follows:

	Tiphane (1975)	Tiphane (1975)	Tiphane (1975)	Béland (1960)	Ollerenshaw (1967)
SiO_2	99.00+	98.45+	98.50+	98.70+	97.58+
Al_2O_3	0.12	0.20	0.29	0.26	0.16
Fe_2O_3	0.01	0.03	0.02	0.31	1.72
MgO	--	0.02	0.03	0.00	0.04
CaO	0.01	0.01	0.01	0.00	0.02
Na_2O	0.01	0.03	0.02	--	--
K_2O	0.03	0.06	0.07	--	--
TiO_2	0.00	0.01	0.03	--	--
P_2O_5	0.002	0.001	0.001	--	--
L.O.I.	0.12	0.16	0.09	--	--
TOTAL:	99.302	98.971	99.060	99.270	99.600

1978-79 - Sampling & Assaying by Geolab Inc. of the Langis Outlier

A - Southwesternmost Part of Outlier

	A-1	A-2	A-3	A-4	A-5
Al_2O_3	0.3	0.3	0.3	0.34	0.49
Fe_2O_3	0.1	--	0.08	--	--
MgO	0.04	--	0.03	--	--
CaO	0.01	--	0.01	--	--
TiO_2	0.04	--	0.04	--	--

B - Central Part of Outlier

	B-1	B-2	B-3
Al_2O_3	0.13	0.14	0.21
Fe_2O_3	0.12	0.13	0.11
MgO	0.02	0.03	--
CaO	0.01	0.01	--
TiO_2	0.03	0.03	--

B - Northeasternmost Part of the Outlier (near Matane River) (each is a composite sample of at least 4 samples on sections 200' apart)

	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	C-9	C-10
Al_2O_3	0.3	0.22	0.18	0.16	0.15	0.09	0.27	0.15	0.35	0.09
Fe_2O_3	--	0.11	0.11	0.12	0.06	0.08	0.08	0.11	--	0.09
MgO	--	--	0.03	0.04	0.03	.027	--	0.02	--	--
CaO	--	--	0.01	0.01	.003	0.01	--	0.01	--	--
TiO_2	--	--	0.03	0.03	0.01	0.04	--	0.04	--	--

Québec Gov. Analysis on a 30-pound Composite Sample

	Raw Sample	→ After Scrubbing & Mag. Separation
SiO_2	99. %$^+$(by difference)	99. %$^+$(by difference)
Fe_2O_3	0.11	0.03
Al_2O_3	0.29	0.13
CaO	0.02	0.01
MgO	0.07	0.03
Na_2O	0.01	0.01
K_2O	0.04	0.02
TiO_2	0.03	0.02

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	Raw Sample	→	After Scrubbing & Mag. Separation
P_2O_5	0.01		0.01
Cr	18 ppm		3 ppm
Ni			1 ppm
Co			1 ppm
V			1 ppm
Mn			10 ppm
L.O.I.			0.19

The examination of the above chemical analyses representing about 80 grab samples shows that the Val Brillant sandstone has an average alumina content of 0.22% and (not including the red sandstone of the top) an iron oxide content of 0.1%. Yet, the results given by M. Tiphane (1974-75) indicate that it would be possible to select 2 sections (50' thick) by the Val Brillant sandstone to produce without treatment silica sands suitable for the glass and foundry industries. However, for the purpose of quality control, it would be wise to apply a mild beneficiation such as scrubbing followed up by a wet magnetic separation. A bench test of beneficiation has been conducted at the pilot plant of the Québec Government and has easily yielded satisfactory results. The comparaison of the chemical compositions of the Val Brillant sand with other sands on the northeastern American market is illustrated on the following table.

TABLE - REPRESENTATIVE SILICA SANDS FROM UNITED STATES, CANADA, AND WESTERN EUROPE

OXYDES (%)	1	2	3	4	5	6	7	8	9	10	11	12	13
SiO_2	99.07	99.76	99.16	99.45	96.71	98.61	99.27	99.00^{+}	99.67	99.55	98.77	99.75	88.65
Al_2O_3	0.56	0.22	0.43	0.053	1.71	0.47	0.26	0.13	0.19	0.17	0.73	0.15	5.22
Fe_2O_3	0.03	0.03	0.03	0.023	0.17	0.25	0.05	0.03	0.002	0.02	0.01	0.03	0.94
TiO_2	ND	0.02	0.03	0.015	ND	ND	0.04	0.02	-	-	-	0.02	0.21
CaO	0.03	0.01	0.08	0.04	TR	0.13	0.02	0.01	0.14	0.20	0.14	0.01	0.23
MgO	0.09	0.001	0 TR	0.02	0.05	0.05	0.02	0.03	TR	TR	TR	0.01	0.39
Na_2O-K_2O	ND	ND	ND	ND	0.34	ND	0.54	0.03	ND	ND	ND	0.015	3.60
FUSION LOSS	ND	0.12	0.18	0.07	ND	0.35	ND	0.17	0.18	0.16	0.43	0.10	0.95
% TOTAL	99.78	100.15	99.91	99.69	98.98	99.86	100.20	99.42					

NO.	FORMATION	GEOLOGIC AGE	LOCATION	TYPE OF SAMPLE	REFERENCE
1	BOVIL CLAY-SAND	HOLOCENE	LATAH, IDAHO, USA	LABORATORY PROCESSED	CARTER, 1962
2	COHANSEY SAND	TERTIARY-MIOCENE	CUMBERLAND, N.J.	LABORATORY PROCESSED	LEFONF-MURPHY, 1975
3	ORISKANY SAND	LOWER DEVONIAN	FREDERICK, VA. USA	COMMERCIAL PRODUCT	LOWERY, 1954
4	ST.PETER SAND	LOWER ORDOVICIAN	LASALLE, ILL. USA	COMMERCIAL PRODUCT	LAMAR, 1927
5	CHICKIES QTZE	LOWER CAMBRIAN	LANCASTER, PA. USA	COMMERCIAL PRODUCT	HARRIS, 1965
6	POTSDAM SAND	UPPER CAMBRIAN	ST.CANUT LEEDS, CAN.	LABORATORY PROCESSED	IND. MIN. 1975
7	LORRAIN QTZE	PRECAMBRIAN	BADGELY IS.ONT. CAN.	COMMERCIAL PRODUCT	IND. MIN. 1975
8	VAL BRILLANT SAND	LOWER SILURIAN	MATAPEDIA, QUE. CAN.	LABORATORY PROCESSED	D.N.R.Q. 1978
9	FONTAINEBLEAU SAND	-----	PARIS, FRANCE	COMMERCIAL PRODUCT	IND. MIN. 1975
10	MURKISH MT. SAND	-----	DONEGAL CO. IRELAND	COMMERCIAL PRODUCT	IND. MIN. 1975
11	TURNBRIDGE WELLS SAND	-----	KENT CO. ENGLAND	COMMERCIAL PRODUCT	IND. MIN. 1975
12	LOCH ALINE SAND	CRETACEOUS	ARGYLLSHIRE, SCOTLAND	COMMERCIAL PRODUCT	IND. MIN. 1975
13	FELDSPATHIC SAND	HOLOCENE	NORTHERN ITALY	COMMERCIAL PRODUCT	N.I.G. 1975

3.0 SPECIFICATIONS & USES

3.1 General Specifications - With the higher melting rates, the demand on quality of raw material increases. One trend has been toward decreasing the amount of coarse material in those raw material most difficult to melt such as sand. Such products with 100% passing 30 mesh screen are desirable for higher melting rates. The glass technologist is also concerned about refractory impurities (chromite, sillimanite, etc.). These are refractory particules (also coarse quartz) which can survive the glass melting process and come out in the finished glass as a solid inclusion or "stone" defect. The larger the particle, the more chance it has to come through the finished glass. Specifications on refractory heavy minerals (RHM) are normally based on size and quantity.

WEIGHT BASIS	PARTICLE COUNT BASIS
+60 mesh RHM 0.0003% max.	+40 mesh RHM = 2 particles max. -40+60 mesh RHM = 20 particles max.

While it is difficult to generalize on tolerances and specifications of a glass sand or of a chemical sand, the maximum limits for chemical composition and moisture content are, in most cases, to be agreed to between buyer and vendor. Although explicit ranges and tolerances of unwanted contaminants are agreed upon, shipments, year in and year out, of unfailing uniform quality is the most important requirement.

General specifications for silica sand and quartz lump by end use

	End use	min SiO_2	max Al_2O_3	max Fe_2O_3	max CaO/MgO	Grain size	Remarks
I	Glass sand						
	a) optical	99.5	0.1	0.008		0.1–0.5 mm 30–100 mesh	Must be less than 6 ppm chromium and 2 ppm cobalt. 0.01 . 0–05% TiO_2. Grain size and purity constant.
	b) colourless	99.5	0.15	0.013			
	c) container /flat glass	98.5	0.20	0.030			
	d) coloured glass	98.5	0.5	0.07			
	Fibre glass	any silica sand				20–200 mesh	No alkali for electrical F.G. uses
	Silica flour	97–98	0.5	0.2		micron sizing	
	Sodium silicate	99.3	0.25	0.03	0.05	20–100 mesh	Broadly the same specifications as glass-grade sand.
	Fibre optics	grade "A" of glass sand & same physical properties					
	Silica brick (refactory)	96–98	0.1		low	–8 mesh	Angular grain.
	Foundry sand	98–99	Extremely variable			20–200 mesh	Chemical composition variable; 98–99% SiO_2 now preferred. Sub angular to rounded grains.
	Silicon carbide	99.5	0.06–0.25	0.1	absent	+100 mesh	No phosphorus allowed. 0.25% Al_2O_3 sand for black SiC, 0.1% for green SiC.
II	Lump silica						
	Silicon	99.5	0.2	0.3	0.2 each	>1inch diameter	No phosphorus or arsenic allowed.
	Ferrosilicon	98.5	0.4	0.2		>1inch diameter	0.1%phosphorus maximum.
	Silica flux	90	1.5	1.5	0.2	<5%–1/4 inch	

3.2 The Glass Industry - Because of the very high melting point of silica (about 1700°C) it is difficult to work and therefore it is modified, for example, to a soda/lime/silica glass by incorporating fluxes such as soda ash and lime. The exact specifications of the sand vary according to the type of glass being produced. For optical and colourless domestic glass a 99.5% SiO_2 product is required and the iron content needs to be less than 0.008% and 0.013%

respectively (at low concentrations, iron imparts the glass with a green colour and at higher concentrations a brown colour). Container and flat glass, on the other hand, can be produced with a 98.5% SiO_2 sand and up to 0.03% Fe_2O_2 can be tolerated. In all cases six parts per million (ppm) of chromium, and 2ppm cobalt is the maximum allowed. Both the chemical purity and the grain size should be uniform - fines in a sand batch encourage seeding in the glass whilst coarse fractions may survive in the melt forming resistant nodules.

Alumina tends to decrease transparency and to make the batch more difficult to melt; the maximum quantity permissible in sand for the best flint glass is about 0.1 per cent, but up to 0.6 per cent may be present for plate or window glass.

As regards chemical composition, the sand shall correspond to one of the following grades based on the class of glassware to be manufactured from the sand:

a) fine grade optical glassware,
b) high grade decorative glassware,
c) general colourless glassware, including containers.

The limits for chemical composition of the sand, after drying at 110°C are as indicated in the previous table.

Maximum limits, if required, to be agreed between buyer and vendor.

Since titanium dioxide does not produce in glasses a colour comparable to the colours produced by oxides of iron and chromium, no maximum limits are specified for the grades B and C, but the determination of titanium oxide content is a useful guide to the presence of heavy minerals.

For grade C sand having a chromic oxide content of less than 0.0002 per cent, the ferric oxide content may be greater than 0.030 per cent, but not greater than 0.035 per cent.

3.3 The ceramic industry - In the manufacture of ceramics, not only plastic components such as china clay and/or ball clay, but also sources of silica or non-plastic components are required. Since the early eighteenth century flint, calcined to 900°C to convert it from black to white, has been used to avoid distortion during firing and to increase the whiteness of the ceramic body. Very pure silica sand, usually ground down to a flour, is also used in the production of glazes and whiteware.

3.4 Silica-based chemicals industry - "Sodium silicate" is produced by fusing a 20 to 100 mesh silica sand (with 99% SiO_2, and less than 0.25% Al_2O_3, 0.03% FeO_3, and a combined CaO/MgO content of 0.05%) with either sodium carbonate at 1,200°C or at a lower temperature. The ratio of Na_2O to SiO_2 can be varied thus giving a wide range of products. Sodium silicate is used in soap to impart

Na & K SILICATES AND HYDRATED SILICATE

Name of Product	Description	Raw materials required	Uses
Sodium Silicate	Clear transparent liquid in several grades	Quartz fines (40 to 100 mesh) Soda ash, caustic soda	Soap, adhesives and for mfgr. or chemical end prods. such as silica gel, silicates of Ca. Al., etc.
Potassium Silicate	Ditto	Quartz fines (40 to 100 mesh) Caustic potash	Acid proof flooring, welding electrodes
Precipitated Silica	White voluminous powder	Sodium silicate, Sulphuric & Hydrochloric acid, organic additives	Reinforcing filler in rubber (tires, shoe soles, coloured rubber products), finishing agent in paper industry, extender for TiO_2 in paints imparting matte finishes, polishing agent, thickening agent in printing inks, textile and cosmetic industries, etc.
Hyd. Aluminium Silicate	Dense white powder	Sodium Silicate, Aluminium sulphate, sod. aluminate, red mud by-products from Bayer process in mfgr. of aluminium	Reinforcing filler in rubber, finishing agent in paper, mfg. of non-ionic detergents, carrier for insecticides acts as a molecular sieve.
Hyd. Calcium Silicate	White voluminous powder	Sodium Silicate, limestone, burnt lime calcium chloride, gypsum, lime available as by-products from other industries, HCL. $H2SO4$, etc.	Essentially as a carrier in the insecticide industry on account of its high oil absorbing capacity of 400%.

hardness and durability, as a fixing agent in textile printing and finishing, and as a cleaner,ed.

Most other silicate chemicals are manufactured from intermediate silicate compounds. "Silicon tetrachloride" is prepared by the chlorination of silicon, ferrosilicon, or silicon carbide. As well as its role as a modifying agent in plastics and a drying oil in paints, silicon tetrachloride is used as a starting point in the production of organosilicon compounds, particularly "silicones", whereby it is mixed with methyl magnesium chloride under certain set conditions to form methyl-trichlorosilane. Silicones are used to make fabrics highly water-repellent and stain-resistant; in the manufacture of polishes, cosmetics, and high temperature lubricants; as adhesion promoters, in non-stick mould release coatings; and to increase electrical insulation.

"Activated silica", made by agitating a very dilute solution of neutral sodium silicate with a precipitant such as sulphuric acid, chlorine, or carbon dioxide, is used to aid coagulation in water treatment processes. "Silica gel" is utilized as a moisture absorbent or desiccant, particularly in gas drying plants. The water absorption is a purely physical process and H_2O can be driven off by heating the gel to 300°C. If the gel is impregnated with cobalt chloride, it changes colour when saturated.

3.5 Metallurgical uses - Refractories - Silica Brick - Silica exhibits good refractoriness when heated to 1500°C, and in fact at this temperature quartz is converted to the cristobalite and tridymite forms which lift the fusion point still further to around 1700°C. Angular quartz grain is preferred to permit interlocking of the grain mass and only small amounts of interstitial minerals. Quartzite is the oldest known refractory and was used in the first refractory brick plant in the early nineteenth century. Silica refractories are classified as acid (which refers to the operating atmosphere rather than the material itself). Other examples are alumino-silicates such as clays. For metallurgical uses acid refractories (including silica) have largely been replaced by basic refractories (such as magnesite).

However, despite the decline in the overall tonnage of silica-based refractories consumed, certain forms are becoming more popular, for example high-quality silica bricks for by-product coke ovens and blast furnace hot stoves, and silica monoliths.

Foundry sands - Silica sand for use in the foundry industry is required to have a minimum SiO_2 content of 95-96% although 98-99% is increasingly becoming the standard specification. The loss on ignition should be less than 0.4%.

Sub-angular to rounded sand grain is usually preferred to have maximum permeability to permit the flow of gases through the mould. Only small amounts of fluxes, such as alkalis or lime can be tolerated, but no organic matter.

The main advantages of silica sand as a foundry or moulding sand is that it has strength to resist the pressure from the molten metal being poured, it is permeable enough to allow the vapours and gases to escape, and its texture and composition allow the mould to be smooth. It also has the advantages of widespread availability and relatively low cost.

Silicon and ferrosilicon production - Quartz suitable for silicon production is required to have more than 99.5% SiO_2, no phosphorus or arsenic, less than 0.2% each of lime and magnesia, and a very low alumina content (alumina is difficult to reduce in an electric furnace and promotes a sticky slag which tends to contaminate the product). Much of the contamination comes from the surface of the quartz and therefore lumps of greater than one inch diameter have to be used in order to reduce the surface area. In addition, the quartz used should not decrepitate below 950°C and should have a minimum softening point of 1700°C. Quartz for ferrosilicon production required 96% SiO_2, and less than 0.4% Al_2O_3 and 0.1% P_2O_5. The process is similar to that for silicon except that scrap iron is added to the furnace.

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The production of one ton of 75% FeSi requires two tons of quartz, 1.1 tons of coke, 0.25 tons of iron (in addition to 55kg. of carbon electrode consumed). During the process 15 to 20% of the silicon is lost in various ways. The production of these materials is very high on energy consumption, for example, silicon requires between 13,000 and 15,000 kWh per ton and 75% FeSi requires 8,000 to 10,000 kWh.

Silica as a flux - Sandstone, silica sand, and quartzite are often used as fluxes in base metal smelting where iron and basic oxides are slagged as silicates. The free silica content - the active slagging agent - should be high, although minor amounts of iron and alumina can be tolerated. Silica fluxes are also used in the production of elemental phosphorus in electric furnaces.

3.6 The abrasive industry - Sand paper: Silica's moderate hardness of 7 on the Mohs scale is utilised extensively in the abrasive industry (the hardness is only moderate when it is compared with diamond at 10, silicon carbide at 9.5 to 9.6, emery at 7 to 9, and garnet at 6.5 to 8.5). Silica is used in preference to these harder materials because of its low cost and widespread availability. It is used extensively as a coated abrasive (sandpaper) which in turn is used in general repair and maintenance, in finishing leather, felt hats, and electrical equipment.

Sand blasting: Another abrasive use of silica sand is in sand blasting whereby sand is fired under pressure, usually in the presence of water to suppress the dust, against the material to be cleaned or polished. Although angular sand grains promote better cutting action, this advantage is invalidated by an increase in the loss of fines (the sand is always recovered for re-use). Although the chemical composition of the sand is relatively unimportant, size frequency distribution and the absence of clay or any other clogging materials are of the utmost importance.

Silicon carbide - Artificial abrasive: Silicon carbide is produced by heating a mixture of silica sand and petroleum coke up to 2400°C in an electrical resistance furnace. The silica sand needs to contain more than 99% SiO_2; less than 0.1% each of Fe_2O_3 and Al_2O_3; no lime, magnesia, or phosphorus; and to be plus 100 mesh with the bulk being plus 35 mesh. When silicon carbide is used in abrasives it has to adhere to very tight specifications, in particular it must have a uniform grain size. Silicon carbide is sold in two commercial grades - green (a very pure product containing over 99.5% SiC) and black (over 99% SiC). Silicon carbide is also used as a refractory, for example in kiln furniture and special shapes, and is often bonded with clay, silicon nitride, or silicon oxynitride. It is also used in metallurgy as a deoxidant. At very high temperatures SiC dissociates into Si and C - both reducing agents - in an exothermic reaction which superheats the molten metal at the time of casting. SiC's exothermic action is also utilised in LD steelmaking since it allows a greater proportion of cold scrap to be used.

3.7 Construction industry and other uses of silica - A recent innovation is the production of silica flour which is sand, quartzite, or sandstone ground to micron sizes usually in an air-swept ball mill. The flour is mainly used as a filler in plastics, rubber, etc. Graded silica sand is used as a filtration medium in the treatment of water, for example in swimming pools and sewage works. Silica sand is used in horticulture as an ingredient in potting composts, in lawn dressing, and on golf courses and bowling greens. It is also used as bird sand - usually mixed with crushed oyster shells and sold loose or bonded to paper. Large tonnages of sand are consumed by the construction industry in the manufacture of concrete, asphalt and road fill. As a filler for acid-proof cements, putty, epoxy and polyester resin, paints, and varnishes (a minimum SiO_2 content of 99.5% is required). As an ornamental sand which may be dyed various colours and resin-coated rendering it resistant to chemical and physical attack.

3.8 Fibreglass - In recent years considerable developments have taken place in the production and use of glass in the form of very fine fibres which are flexible and continuous.

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Three basic processes are in use, either singly or in combination, for producing the fibres from a carefully controlled glass melt, i.e.: (1) mechanical drawing in which the fibres are drawn, at the rate of 6,000 to 10,000 ft. per minute, to a diameter of about 0.00023 in or about the thickness of natural silk. The basic filaments are later twisted and doubled into finished yarn; (2) a centrifugal process in which molten glass is dropped on to a rotating refractory disc from which it flies off in fibre form; (3) a blast drawing process in which the molten glass, in droplets, is subjected to a powerful blast of steam or air.

Fibreglass is marketed in many forms suitable for sound, heat, cold, or electrical insulation, air or chemical filtration and as a fireproofing fabric.

The use of glass fibres for reinforcing plastics has made great strides in recent years. Fibreglass reinforced plastics are used in vehicle panels, crash helmets, battery boxes, aircraft components, yacht hulls, furniture, petrol tanks and suitcases. When used with electrical grade phenolic, silicone, polyester, epoxide, or melamine resins, the alkali-free grade is claimed to give increased mechanical strength, temperature resistance and dimensional stability.

Fibres consisting of 96% silica are manufactured under the name of "Refrasil". The filament produced much resembles the glass fibre and ranges in size between 5µ and 10 µ. It can be used at temperatures up to 1000°C and is supplied either in the form of bulk fibre, yarn, cloth, tape, sleeving, cordage or batt. It has many industrial applications, particularly for high temperature electrical and thermal insulation and in chemical engineering.

Fibreglass for electrical application is relatively alkali-free and the raw sand has also to be low in alkali. Otherwise, any sand may be used to make fibreglass.

The fibreglass industry in the U.S. has experienced lately a growth rate of 19%. The latter is to reach within the mean term a flat, while the fibre optics industry for communication purposes will pick up momentum indicated in the following chapter.

3.9 Fibre optics cable - The science of fibre optics is a new technology based on devices which transmit light pulses along a glass fibre. Electrical signals are converted by a light emitting diode or laser into light pulses. At the other end of the fibre the light signals are converted back to electrical signals by a detector. The principal advantage is that the information may be transmitted over long distances without interference from outside electrical sources. The fibre optic cable weighs 1% of the equivalent copper cable.

There are several existing communication systems using fibre optics.

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Optical fibres are made from glass rods containing two kinds of materials. These are arranged to form an inner core (to carry the light rays) and an outer cladding to keep the light rays from leaking. One 18-inch glass rod, by the way, can be stretched to produce one mile of the hair-thin filament, which is then coated with plastic.

Optical fibres do have some disadvantages. They are more fragile than conventional cable and there may be some difficulties in repairing broken fibre cables until personnel are fully trained. These are not considered major problems. For example, optical fibres can be mechanically spliced together or fused by heat.

Use for armed forces - The army, navy and air force are involved with applications for fibre optics. They are interested in the small size, light weight and freedom from interference which make fibre optics ideal aboard aircraft or ships, as well as secure for tactical and strategic links under water and on land.

The replacement of copper wire by optical fibre could increase the useful load of the aircraft by nearly 1,000 pounds, or reduce its total weight. Each pound saved is valued at about $1,000. over the life of the aircraft.

Worldwide uses - In England, Japan, West Berlin and

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Australia operational fibre optics links have been installed. The British application carries communications over a 1.5-km stretch of cable servicing 34,000 subscribers.

Fibres are manufactured by Corning, ITT, Galileo, Valtec Fibre Communications Inc., Dupont, Polyoptics, Fibre Optic Cable Corp. and others.

Corning Glass Works is acknowledged as having made the first fibre to carry light signals over long distances in 1970.

Fibre optics require less repeater (signal booster) stations than conventional co-axial cable systems.

Fujitsu Ltd. of Japan is intensively developing component sub-systems necessary for optical fibre communications.

A substitute to copper - At present about 15% of the market for copper is used by the communications industry. According to one fibre optic expert the technical characteristics make it possible to replace all copper used in this area. However, in practice rather than replacement of existing systems, one would most likely see fibre optics used for additions to existing systems and for new systems. A conservative estimate is that 25% of the present requirement for communications use of copper could be replaced.

Noranda Mines (N.M. Feb.24, 1977) bought a 13% interest in Valtec Corp. which has plants in the U.S. manufacturing optical fibres, cables and ancillary products in the U.S., Japan and Europe. Major companies from other industries including glass, communications and computers are investing heavily in fibre optics.

Raw material -Most raw material (sand) to make glass suitable for fibre optics needs high beneficiation before use. The silica sand is believed to be of the colourless glass grade "A" and relatively alkali-free.

4.0 MARKET

4.1 Introduction - Despite the abundance and relative low cost of the materials, the uneven distribution of good quality commercial deposits of silica sand and quartz in the world has given rise to a lively trade. The bulk of this trade is usually confined to countries within a single continent, and generally only involves high-quality sands. Canada has imported this year more than 1.1 MT of silica sands of all types and because of the devaluation of the Canadian dollar an additional cost was then absorbed by the manufacturers. A market survey made this year by the Québec Department of Industry and Commerce over a cross section of users indicates that:

a) there will be an increasing demand for silica sand,
b) a new source of supply is needed to stabilize price via competition,

c) customers would purchase from new source provided equal prices and equal (or better) quality are offered.

A recent study published by the Ontario Department of Mines led to the same conclusions.

4.2 The glass industry in Eastern Canada - The glass industry in Canada has experienced an average growth rate of 6.5% through the 1960's (in 1970 the consumption was 800,000 TPY for Québec and Ontario) and a growth rate of 7.5% had been forecasted for the period 1970-1978. The real consumption in Eastern Canada for 1978 is 1,132,000 tons - indicating that the growth rate was actually higher than the forecast. Actually, the study by Québec Industry & Commerce predicts an overall additional demand of about 20% for the period 1979-1985 (i.e.: a growth rate of about 3% per year) such as expressed in the following tables (see next page).

Considering that the growth rate of the glass industry in the U.S. is 5% to 6%, the figures in table 6.2.5 by the Industry and Commerce Department are conservatives and may well apply for 1983 assuming a growth rate of 4%. Thus, the global available silica sands market for 1983 could be as expressed in chapter 4.3 (see page 42).

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4.2.1 1978 Consumption (expressed in thousand S.T.) (Ind. & Comm. Dpt. Québec)

	Ontario	Québec	Maritimes	Total
Glass container	332	230	40	602
Flat glass	275	-	-	275
Fiber glass	50	40	10	100
Na-K silicates	23	12	-	35
Silicium carbide	-	120	-	120
	680	402	50	1132

4.2.2 1978 Canada supply

Glass container	115	230	20	365
Flat glass	110	-	-	110
Fiber glass	30	28	10	68
Na-K silicates	-	-	-	-
Silicium carbide	-	80	-	80
	255	338	30	623

4.2.3 1978 USA Import

Glass container	217	-	20*	237
Flat glass	165	-	-	165
Fiber glass	20	12	-	32
Na-K silicates	23	12	-	35
Silicium carbide	-	40	-	40
* from Belgium	425	64	20	509

4.2.4 1985 Market

Glass container	415	274	80	769
Flat glass	300	-	-	300
Fiber glass	66	53	13	132
Na-K silicates	23	12	-	35
Silicium carbide	-	120	-	120
	804	459	93	1356

4.2.5 Available market to replace importation and to satisfy the growth rate until 1985

Glass container	300	44	60	404
Flat glass	190	-	-	190
Fiber glass	36	25	3	64
Na-K silicates	23	12	-	35
Silicium carbide	-	40	-	40
	549	121	63	733

4.3 Available market for "all" silica sands - 1983 (for Eastern Canada)

I --- Silica sands

a)	container/flat/fiberglass/ Si-Na/SiC (as per table 6.2.5)	733,000
b)	foundry sand, blasting sand and filtration sand 40% of the actual import in Canada . . .	240,000
c)	export of glass sand to Mexico (40% of their importation)	120,000
d)	export to Italy (20% of their importation)	200,000

II --- Silica lump for ferro-silicon

a)	Eastern Canadian additional market for 1983	100,000
b)	export to U.S; to Iceland and Venezuela (15% of these markets)	110,000
		1,503,000

The projected market of 1.5 MT for silica sand and lump for 1983 seems to be a realistic estimation considering that Eastern Canada is already importing 1.1 MT per year of silica sands. It is, therefore, reasonable to assume that a new Canadian producer will easily acquire 1/3 or more of this available market within the next three to four years.

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5.0 1978 PRICE (as per market survey by Québec Dept. of Industry & Commerce)

5.1 Toronto:

U.S. glass sand 1st quality	$ 23.40 + X
Canadian glass sand 2nd quality	18.35

5.2 Montréal:

U.S. glass 1st quality	$ 24.40 + X
Canadian glass sand 2nd quality	18.15

5.3 Trois-Rivières:

U.S. Carbide sand	$ 25.20 + X
Canadian Carbide sand	23.20

Bécancour:

Metallurgical quartz 1st quality	$ 22.00
Metallurgical quartz 2nd quality	13.50

5.4 Moncton, New Brunswick

Belgium glass sand	$ 23.00 + X
Canadian glass sand	22.00

5.5 Europe:

Italy - arriving by railroad from France or Belgium	$ 23.00
Metallurgical quartz-lump	38.00

N.B. X is the exchange on currency

The average price for first quality silica sand F.O.B. Toronto, Montréal and Trois-Rivières is $24.33 and with the exchange on currency, the overall price may well be in the neighbourhood of $26.00 per ton.

6.0 MINING & POTENTIAL RESERVES

6.1 General

- The review of the mining of silica sand in northeast America and in western Europe indicates that:

- both open cast and underground (room & pillar) mining methods are utilised in the U.S. and in Scotland;
- the thicknesses of the pay zones (which are rather flat) are respectively 100' maximum in the U.S; 40' in Canada and 20' in Scotland;
- proven ore reserves are enormous in the U.S; in Canada, the two deposits actually mined for silica sand have limited proven commercial reserves;
- selective mining and blending is practised in Canada and in a few other countries.

6.2 Ore reserve potential of the Val Brillant -

6.2.1 - Size of the exposed sandstone bodies:

Matane area	Langis twp:	: 125' high cliff x 900' wide x 7500' long
	Cuoq twp: (Turtle outlier)	: 135' high cliff x6000' wide x 7500' long

6.2.2 - Mineable reserves - The Val Brillant sandstones reach an aggregate thickness of about 400 feet. The beds are dipping at 13^{o} to 15^{o} behind Matane and at about 15^{o} to 20^{o} behind Rimouski. Although the sandstones are well exposed, it would be premature to make ore reserves calculations without minimum drilling and without a few complete sequences of assays. But considering that the Langis E & W and the Turtle Hill outliers are not intercalated within other sedimentary formations and because of faulting and erosion are just resting on the Ordovician platform, it can be said that they are mineable almost entirely by open pit method. There is but a thin erratic capping of patchy dolomite (20' thick) and overburden of 2 to 5 feet on the Langis outlier. So the quantity of mineable material by open pit at the Langis and the Turtle outliers is in the range of 400 MT.

6.2.3 - Commercial sandstone - Yet, these sandstones are not all of commercial grade since reddish sandstones layers (1' to 2' thick) are seen to carry a higher content of hematite which may be selectively put aside with the hydraulic shovel after blasting and before crushing. For this reason, it can be added that the bottom part of the sandstone sequence shall not be mined at some of the deposits mentionned above. Tiphane (1975) and others stated that there are a few 50-foot high-grade thicknesses of sandstone that are very low in alumina and iron oxide; such bands may be very attractive for direct selective mining.

Taking into account all of the above discussed factors, it can be said with a good degree of certainty that the potential of open pit mineable sandstones of glass sand (grade "C"), of foundry sand, of filtration sand, of blasting sand and metallurgical lump for ferro-silicon are in the range of 25 to 50 MT enough to sustain mining and processing operations during 50 to 100 years. Nonetheless, a minimum drilling is compulsory to prove up reserves for the first 10 years.

6.2.4 - Selective mining - The optimization of a selective mining operation is likely toward mining by open pit the whole sequence in having 4, 5 or 6 working faces on 2 or 3 levels about 30' high. The low iron sandstone of the best 3 or 4 faces would be processed first to make glass sand of B or C grade; then the higher iron sandstone from the other 2 faces would be treated, in turn, to make other brands of sands, such as foundry sand, filtration sand and blasting sand.

7.0 BENEFICATION OF SILICA SAND

7.1 The problem - Silica sand low in iron is much in demand for glass, ceramic and pottery use, and for many of these applications clean, white sand is desired. Impurities such as clay, lime, iron stain and heavy minerals including iron oxides, chromite, zircon and other accessory minerals must be removed. Chromium, for example, must not be present in the coarse fraction and in extremely small amounts in the -60 fraction in order for the sand to be acceptable to certain markets. Feldspars and mica are also objectionable. Generally, iron content must be reduced to 0.030% Fe_2O_3 or less. By removing the iron down to 0.015%, the glass-maker may save ($1.50/t.) on the use of decolorizer (selenium).

7.2 Grinding - The lump ore is crused to ¼" with impact crusher and is reduced to natural sand grain size by Rod Milling. Generally, one pass treatment through the Rod Mill is sufficient (the grinding time for Val Brillant sand is 40 seconds). Grinding is done wet at dilutions in excess of normal grinding practice.

7.3 Primary classification - The sand and water slurry is classified or dewatered. This may be conveniently done by cyclones or by mechanical dewatering classifiers such as the drag, screw or rake classifiers.

7.4 Attrition scrubbing - From classification the sand, at 70% to 75% solids, is introduced into an Attrition Scrubber for removal of surface stain from the sand grains. This is done by actual rubbing of the wet sand grains, one against another, in an intensely agitated high density pulp. Most of the work is done among the sand grains - not against the rotating propellers.

From this service rubber covered turbine type propellers of special design and pitch are used. Peripheral speed is relatively low, but it is necessary to introduce sufficient power to keep the entire mass in violent movement without any lost motion or splash. The degree of surface filming and iron oxide stain will determine the retention time required in the scrubber.

7.5 Secondary classification - The scrubbed sand from the attrition machine is diluted with water to 25-30% solids and pumped to a second set of cyclones for further desliming and removal of slimes released in the scrubber. In some cases the sand at this point is down to the required iron oxide specifications by scrubbing only. In this case, the cyclone or classifier sand product becomes the final product.

Some of the more difficult sand to treat may require two stage-attrition scrubbings with classification and slime removal between stages.

7.6 Conditioning - Deslimed sands still containing alumina and iron bearing heavy minerals can be successfully cleaned to specifications by flotation. Generally this is done in an acid pulp circuit. Conditioning with H_2SO_4 and iron promoting re-agents is most effective at high density, 70-75% solids. To minimize conditioning and assure proper re-agentizing a two-stage Heavy Duty Open Conditioner with rubber covered turbine propellers is used. This unit has two tanks and mechanisms driven from one motor.

7.7 Flotation - The conditioned pulp is diluted with water to 25-30% solids and fed to a flotation machine especially designed for handling the abrasive, slime free sand. Acid proof construction, in most cases, is necessary as the pulps may be corrosive from the presence of sulfuric acid.

A pH of 2.5-3.0 is common. Wood construction with molded rubber and 316 stainless steel are the usual materials of construction. In the flotation step, the impurity minerals are floated off in a froth product which is diverted to waste. The clean, contaminent-free silica sand discharges from the end of the machine to vibrating screen that removes the -120m. particles.

7.8 Final Desliming - The flotation tailing product at 25% to 30% solids contains the clean silica sand. A SRL pump delivers it to a dewatering classifier for final dewatering. A mechanical classifier is generally preferable for this step as the sand can be dewatered down to 15% to 20% moisture content for belt conveying to stock pile or drainage bins. In some cases, the sand is pumped directly to drainage bins but in such cases, it would be preferable to place a cyclone in the circuit to eliminate the bulk of the water. Sand filters of top feed or horizontal pan design may also be used for more complete water removal on a continuous basis.

7.9 Magnetic separation - In some cases, it may be necessary to place high intensity magnetic separators in the circuit ahead of the grinding mill to remove last traces of iron which may escape removal in the wet treatment scrubbing and flotation steps. Iron scale and foreign iron particles are also removed by the standard magnetic separator (for the test done on the Val Brillant sand, a Jones wet magnetic separator was utilized).

7.10 Drying - Drying is done in rotary, oil or gas fired dryers.

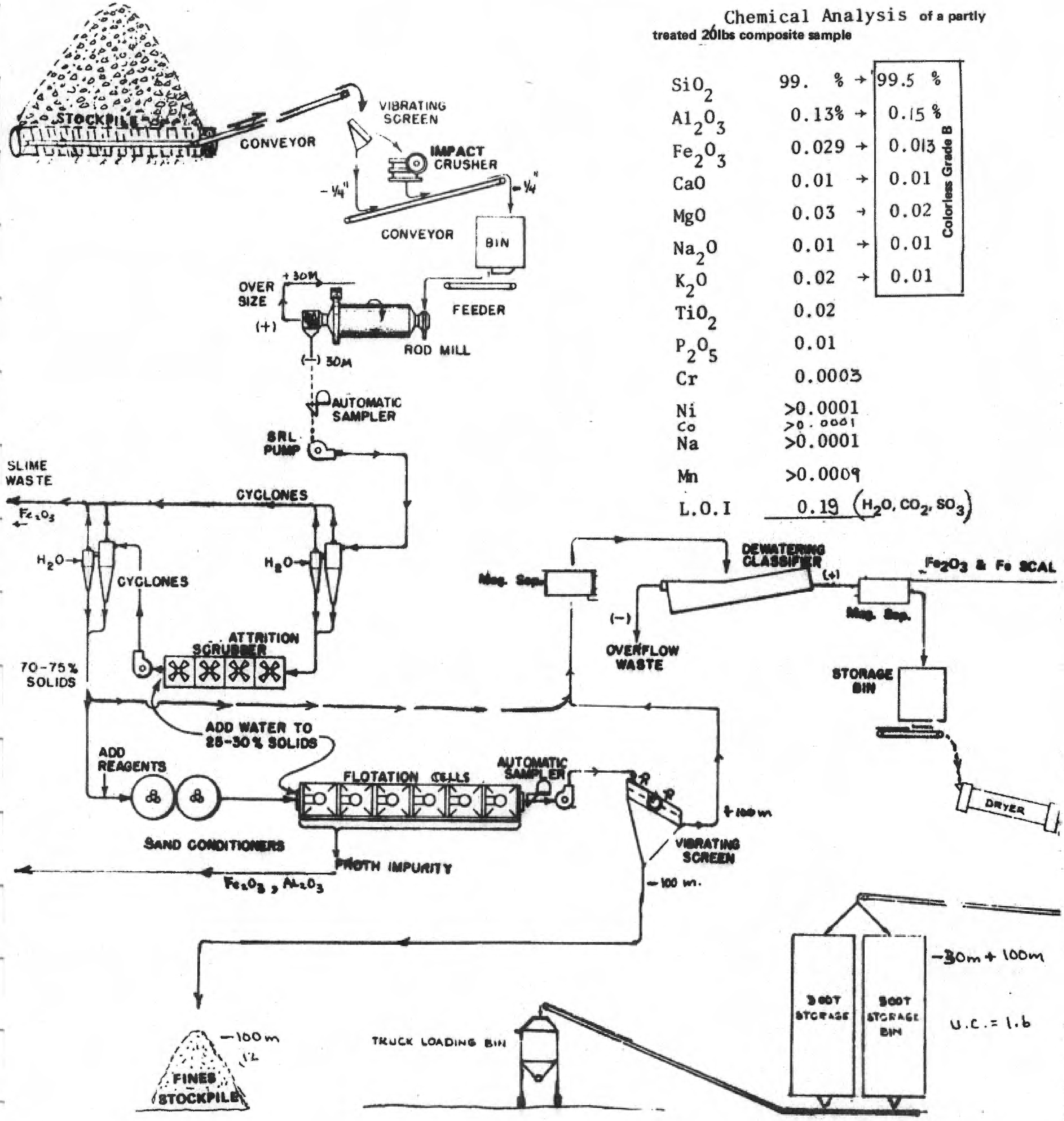
7.11 Practical considerations - In general, most silica sands can be beneficiated to acceptable specifications by the flowsheet illustrated on p.47.The latter shows that iron oxide impurities may be taken out at four points in the circuit. The beneficiation bench test conducted on the Val Brillant sandstone by the Québec Department of Natural Resources was restricted to (1) grinding, (2) attrition scrubbing and (3) cycloning. The assay results of this test is shown at the upper right of the flowsheet; other results are in the appendix.

The bench test has shown that the Val Brillant sandstone can be beneficiated satisfactorily without flotation. Nonetheless, a 5-ton representative of the Val Brillant sandstone is scheduled for the Québec pilot plant in order to prepare samples for the eventual consumers. This will be an opportunity to carry on a

FLOWSHEET

Chemical Analysis of a partly treated 20lbs composite sample

			Colorless Grade B
SiO_2	99. %	→	99.5 %
Al_2O_3	0.13%	→	0.15 %
Fe_2O_3	0.029	→	0.013
CaO	0.01	→	0.01
MgO	0.03	→	0.02
Na_2O	0.01	→	0.01
K_2O	0.02	→	0.01
TiO_2	0.02		
P_2O_5	0.01		
Cr	0.0003		
Ni	>0.0001		
Co	>0.0001		
Na	>0.0001		
Mn	>0.0009		
L.O.I	0.19 (H_2O, CO_2, SO_3)		



flotation test to check if greater amounts of impurities can be removed without difficulties and at a low cost.

In practice and once the project reaches the production and the processing stage, the basic idea is to have a first but simple treatment at the mine site only to obtain a glass sand of "grade C" and to ship on barge or vessel this material with a moisture content of about 5%. The point is that this first treatment leads to a loss of about 25% of the fines with the impurities which can cheaply be disposed of into a settling pond. Indusmin has this major problem at Midland, Ontario.

At distribution centers in Montréal and Toronto, the glass grade material could be stocked into open stockpiles and, if necessary, all or parts of the material could be subjected to a lesser treatment such as flotation, magnetic separation, classification and ultimate drying. The loss (2% to 4%) incurred during the ultimate treatment would be minimum and will be sold locally to the cement industry or the cement block manufacturing, etc. Any contaminations picked up on barge or vessel would then be eliminated before distribution in order to maintain quality. For that reason, prices have to be quoted F.O.B. Montréal, Toronto or Trois-Rivières. The other types of sands present no problem.

8.0 TRANSPORTATION

8.1 Historic - Prior to 1930, the greatest volume of sand (foundry and 2nd quality glass) in northeastern U.S., was moved on barges via a complex system of canals, lakes and rivers, then washed silica sand was introduced in the market and railways transportation took over. The trend to-day is swinging toward truck delivery for shipment up to a 150-mile radius of the sand plants. The truck driver can, within 30 minutes, discharge 20 tons or more of sand, blowing it into a silo. The other alternative is to use covered hopper rail cars, but this method requires mechanical unloading equipment which is justified only for the large user. For the last few years, rail transportation is not as reliable and efficient to handle the increasing demand for silica sand. The service is very erratic as evidenced by unavailability and poor conditons of cars. In Canada, most available decent hopper cars are now utilized in western Canada to haul potash and sulfur which are higher value commodities. Another problem is related to the union-labourer who, because of silocosis hazard, are reluctant to enter and to clean hopper cars.

Water transportation of silica sand is well used, for the intercontinental market, Japan - Australia - South Korea - China, U.S.A. - Mexico - Latin America - Belgium - Eastern Canada, Scotland - Spain - Norway, etc. Several million tons of glass sand is moved this way every year.

8.2 Local transport via roads - All of the Val Brillant mineable sandstone bodies are easily accessible by paved roads and are within 15 to 25 miles from the St. Lawrence River.

A quarrying operation was started and abandoned a few years ago at the Langis outlier; the purpose of the quarrying was to provide blocks to repair the road along the Matane river. The deposit is thus easily reached.

8.3 Regional transport - The railway crosses the sandstone formation at Val Brillant - open pit mineable sandstone at that locality is limited and environment regulations are too restrictive. Other deposits are within 12 miles of railroad sidings. The 40,000-ton market of New Brunswick may be served by rail or truck since it is within 150 miles. The Montréal and Toronto markets may be supported by unit-train during one or two months of the winter season.

8.4 Continental and intercontinental markets - Indusmin hauls all of its crushed silica on vessels from Badgely Is. to its processing plant at Midland, Ontario. The lump metallurgical silica is all delivered by self-unloading boat to the U.S. and particularly at Trois-Rivières (at about $4.50/ton).

Tilcon at Loch Aline, Scotland utilizes 2500-ton boats to haul the highest quality of silica sand. The vessels are loaded at a rate of 400 tph by the use of a belt conveyor incorporating an automatic weigher. The supplies (240,000 tons) to the U.K. are maintained by shipping the sand to stores at four to five strategic distribution points.

The glass-maker of Moncton, N.B., received from Belgium 50% of its sand consumption on 10,000-ton boats. The glass grade sand is stockpiled outside near-by the factory and is utilized without problems after drying.

The main Val Brillant sandstones outliers are about 25 road-miles from the harbour of Matane, opened to navigation 12 months per year and berth a ferry-boat which links Matane to Baie Comeau .Besides the ferry operation, the traffic at the opposite dock is negligeable. The available loading dock is 575 feet long by 135 feet wide. The water depth at low tide within the harbour is 32 feet. The tide is 9 feet minimum and 15 feet maximum. This dock has berthed the "Liberia Ocean Advance" having 29 feet of draft and 15,000 tons of cargo, the "Saguenay" (735' long) with a cargo of 20,000 tons of salt, the "Halifax" with a cargo of 12,000 tons of salt.

Inland water transportation to distribution centers, such as Trois-Rivières, Montréal and Toronto may be set up with barges of 2,500 to 4,000 tons or with vessels having 5,000 to 17,000 tons capacities. The latter would also be appropriate for the intercontinental market. The silica sand, in all cases, has to be beneficiated first at the plant site to avoid Indusmin's problem: i.e. to get rid of fines losses at Midland, Ontario.

9.0 ESTIMATE OF PRODUCTION COST

9.1 Mining cost - The capacity of the crushing and screening is conceived for 275 tons/hour (32" x 36" Cedar Rapid). Such new plant is valued at $350,000. Considering 9 hours/day shift, the hourly crushing comes to 250 t/h which is about 90% of the true capacity of the crusher. Assuming a mining operation of one or two shifts per day, the daily production will range from 2,250 tons to 4,500 tons per day which, on 22 operating days per month, yields from 50,000 to 100,000 tons of crushed material. The following production costs are adjusted to a true yield of 40,000 tons per month per shift, considering a loss of 25% during treatment at the mill.

9.1.1 - Crushing - Screening - Conveyors - Gen. Set.

				1st shift	2nd shift
a)	Equipment cost on a rental-purchase contrast $16,200/month (insurance included)			$ 0.405	0
b)	Labour cost:				
	- 1 crusher operator	$7.25/hr x9x22:	$1,435.50		
	- 1 crusher helper	$6.50/hr x9x22:	1,287.00		
	- 1 helper	$6.00/hr x9x22:	1,200.00		
	- fringe benefits 20%	:	784.50		
			$4,707.00	$ 0.117	$ 0.117

SILICA SANDS

	1st shift	2nd shift
c) Supplies cost:		
- liners and jaw, fuel, oil and grease - automobile & pick up truck $17,500/month	$ 0.350	$ 0.300
9.1.2 - Stripping - Settling pond, road		
Sub-contract: $7,500/month	$ 0.187	0
9.1.3 - Drilling - blasting - supplies (dynamite, amm. nitr. & bits		
Sub-contract for 200,000 tons minimum	$ 1.250	$ 1.250
No secondary blasting but secondary breaking with a Drop Ball		
9.1.4 - Hauling to crusher		
Sub-contract: one 5-cu yard loader & operator or one H-shovel & one truck plus 2 operators	$ 0.415	$ 0.415
9.1.5 - Shipping - Loading on truck		
Conveyor system	$ 0.150	$ 0.150
9.1.6 - Supervision and planning		
Field manager and/or general manager		
Salary, fringe benefits, etc. $3,000/month	$ 0.075	0
9.1.7 - Contingencies - 10%	$ 0.29	0
9.1.8 - Administration charges - 15%	$ 0.485	0
TOTAL:	$ 3.72	$ 2.32

$3.72 x 40,000 Tons: $148,800.00

$2.32 x 40,000 Tons: $ 92,800.00

Monthly cost : $241,600.00 ÷ 80,000 t. = $ 3.02

SILICA SANDS

9.2 Milling cost:

		$ 3.02	(mining cost)
- Interest on loan	$ 0.50		
- Equipment depreciation and amort. 15 years	0.44		
- Labour cost and fringe benefits	0.55		
- Supplies: elect., chemical	0.25		
- Contingencies - 10%	0.15		
- Administration - 15%	0.23		
- Loss on fines (already in mining cost)	0.09		
- Drying	0.68	$ 2.89	

9.3 Trucking from mine to harbour (25 m)

- $1.15/mile x 50: $57.50 ÷ 36 tons load		1.32	

9.4 Ship loading - 15,000-ton boat x 20 (300,000 T/Y)

- Conveyor system cost	$ 0.60		
- Warfage and piling up	0.25		
- Operating cost - $1 20, x 38 h ÷ 15,000	0.32		
- Contingencies - 25%	0.25	1.42	

9.5 Water transportation: Matane - Montréal

- 15,000-ton self-unloading boat: $10,000/day x 4.5 ÷ 15,000	3.00		
- Contingencies - 25%	0.75	3.75	
Matane - Toronto (6 days)			($1.00)

9.6 Handling from harbour to stockpile

- Loading & trucking within 5 miles incl. return		1.00	

9.7 Truck delivery within 25 miles of plant (return)

Truck delivery within 25 miles of plant (return)		1.50	
		$14.90	($15.90) Toronto

SILICA SANDS

On a 300,000 T.Y. production basis, the unit cost per ton delivered to end user is $14.90 in the Montréal area and $15.90 in the Toronto area.

10.0 FEASIBILITY

a) Projected selling price - 1st quality: $24.00
2nd quality: 18.00

b) Total cost per ton: 14.90 $15.90 Toronto)

c) Operating profit per ton- Mtl: $3.10 to 9.10
Operating profit per ton- Tor: 2.10 to 8.10

On a 300,000-ton production/year, the gross profits are **$1.5 M/year**

Soumis par:

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conseiller en économie
minérale

Dorval, Qué
le 20 janvier 1980.

Ministère des Richesses naturelles
CENTRE DE RECHERCHES MINERALES
Complexe scientifique
2700, rue Einstein
Sainte-Foy, Québec

Projet # 914

SGS Incorporée

TRAITEMENT D'UN GRES DE MATANE AFIN DE PRODUIRE UNE SILICE DE HAUTE QUALITE

Rapport final / Mars 1979

NOTE: Le présent rapport réfère seulement aux échantillons tels que soumis. Il ne devra pas être utilisé en tout ou en partie, pour des fins publicitaires ou de sollicitation financière, sans la permission écrite du Directeur du Centre de Recherches minérales.

Rapport préparé pour: PLACEMENTS APPALACHE LIMITÉE

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Résumé

Ce grès de Matane, qui est un sable de silice, contient, comme impuretés, de la poudre d'hématite et un peu de carbonate de calcium. Après broyage, nettoyage des surfaces et tamisage humide, nous réussissons à réduire la teneur des oxydes de fer présents de 0,12% Fe_2O_3 à 0,05% Fe_2O_3.

Par la suite, une séparation magnétique à haute intensité abaisse le fer, dans le sable, à 0,03% Fe_2O_3, et ainsi permet de rencontrer les exigences de plusieurs marchés du sable de verrerie.

La teneur des autres éléments considérés comme impuretés indésirables ne dépasse pas les valeurs maximales tolérées dans la plupart des catégories de sable de verrerie.

TABLE DES MATIERES

1. Introduction

Un sable de silice à basse teneur en fer est généralement intéressant pour les marchés du sable de verrerie. Ce grès de Matane est essentiellement composé de grains de silice qui sont agglomérés avec un ciment formé de poudre de silice, d'un peu de carbonate de calcium et de poudre d'hématite. Une fois nettoyé de ses impuretés, il pourrait être utilisé comme sable de verrerie.

Suite à une demande du client, la Société Placements Appalaches Inc., représentée par M. R.A. Marleau, conseiller en économie minérale de la firme SGS Inc., nous avons proposé un programme de travail qui a été accepté à la mi-décembre 1978. Les travaux ont été effectués au début du mois de janvier 1979.

Le plan de travail proposait deux phases: la première ne comportant qu'un traitement préliminaire et simple (auto-nettoyage, lavage, tamisage et séparation magnétique), et la seconde nécessitant une étape de flottation pour enlever les impuretés.

2. Sommaire

Dans un premier temps, on étudie la possibilité de libérer la silice par un léger concassage, d'en nettoyer la surface par un auto-frottage et d'enlever les fines et les impuretés par un tamisage humide.

Cette première opération donne de bons résultats puisqu'on abaisse déjà le fer de 0,12% Fe_2O_3 à 0,05% Fe_2O_3.

Cependant, pour atteindre les exigences du marché du sable de verrerie, on complète le traitement par une séparation magnétique à haute intensité afin d'abaisser la teneur en fer. On réussit ainsi finalement à produire un sable qui ne contient que 0,03% Fe_2O_3 et dont la teneur en silice se situe à 99,0% SiO_2.

3. Conclusions et recommandations

Avec une séparation magnétique à haute intensité (18 000 gauss), on abaisse suffisamment la teneur en fer dans le sable purifié pour rencontrer les exigences du marché du sable de verrerie qui se situent à 0,03% Fe_2O_3 dans la plupart des catégories sauf dans celui du sable pour le verre optique qui exige des valeurs inférieures à 0,01% Fe_2O_3.

Il est difficile d'indiquer les tolérances d'impuretés pour le marché du sable de verrerie puisque les variations sont fortes d'une compagnie à l'autre. Par exemple, les Industries Pittsburg du Canada Limitée exigent un sable de silice avec un contenu de Fe_2O_3 inférieur à 0,03% et une silice analysant 99,75% SiO_2, tandis que Dominion Glass demande un produit dont la teneur en fer soit inférieure à 0,04% et que l'alumine ne dépasse pas 2%.

Puisqu'il y a intérêt à élaborer un schéma de traitement le plus simple possible, et que le sable purifié est de qualité suffisante pour de nombreux marchés, nous recommandons de traiter, à l'échelle semi-industrielle, suffisamment de matériel pour fournir des échantillons aux clients éventuels.

Egalement, les conditions de traitement pourraient être améliorées afin d'obtenir un sable de verrerie encore plus pur.

4. Discussion

L'analyse des différents éléments dans les échantillons de sable a été effectuée par la méthode de l'absorption atomique sauf celle du P_2O_5 qui a été déterminée par la chimie conventionnelle. La teneur de la silice a été estimée par différence. Les résultats d'analyse figurent au tableau # 1 pour ceux de la souche et au tableau # 4 pour ceux du sable purifié.

On récupère, comme sable de verrerie, entre 68% et 75% de l'échantillon traité, ce qui indique que les grains de quartz se libèrent facilement du ciment et affichent une répartition granulométrique intéressante.

Une étude minéralogique sommaire montre que l'oxyde de fer présent recouvre les grains de sable sous forme de pellicules très minces. Il n'est peut-être pas nécessaire de songer à d'autres méthodes de traitement, telles que la flottation ou la lixiviation à l'acide, puisqu'un broyage, suivi d'un auto-frottage et d'une séparation magnétique, permet d'abaisser suffisamment la teneur des impuretés pour satisfaire aux exigences de la majorité des marchés du sable de verrerie.

Ce grès, prétend-on, pourrait être utilisé en métallurgie (ferro-silicium) et, de par sa granulométrie, présente un fort potentiel pour les sables de fonderie, sables d'abrasion, sablesde filtration et surtout comme sable de verrerie.

Dans ce dernier cas, les exigences du marché varient selon la qualité du produit visé. Par exemple, les composantes silice et fer sont d'une importance capitale. On sait que la présence du fer amènera une coloration verte à brune selon que le fer est en faible ($<0,3\%$ Fe_2O_3)

ou plus forte quantité (Fe_2O_3 <1,0%). Le verre optique demande la silice la plus pure, soit 99,5% SiO_2, et un maximum de 0,008% Fe_2O_3; le verre domestique incolore demande aussi 99,5% SiO_2 mais avec un maximum de 0,013% Fe_2O_3; la limite inférieure pour un verre incolore (bouteilles) est de 98,5% SiO_2 avec moins de 0,030% Fe_2O_3. Selon le produit du manufacturier, il peut être désirable qu'un peu d'alumine remplace la silice.

De même, un producteur établit normalement des normes sur quelques autres éléments tels que le calcium, le magnésium, le chrome et les alcalis.

Le Bureau des standards américains (U.S. Bureau of Standards) donne les spécifications pour neuf catégories différentes de sables de verrerie. Les teneurs exigées, pour la silice, varient de 99,8% SiO_2 pour le verre optique à 95,0% SiO_2 pour le verre coloré.

On note également que le chrome est indésirable puisqu'il a un effet colorant encore plus prononcé que le fer.

Quant à la granulométrie du sable de verrerie, les Industries Pittsburgh du Canada Ltée mentionnent qu'elle doit se situer idéalement entre 28 et 80 mailles Tyler.

4.1 Buts

Le but du projet, tel qu'énoncé dans la demande écrite du 13 décembre 1978, consiste à traiter ce grès pour en extraire, par un procédé de concentration relativement simple, un sable de verrerie. Les procédés de traitement utilisés sont indiqués aux schémas 2 et 3.

4.2 Traitement préliminaire et échantillonnage

L'échantillon de trente (30) livres a été mélangé et séparé sur un diviseur à riffles. Vingt-trois (23) livres ont été utilisées pour la première série d'essais et cinq (5) livres pour la seconde. Deux (2) livres ont été conservées comme échantillon témoin. Une analyse chimique a été effectuée sur le grès après l'opération de concassage (tableau # 1).

L'échantillon a subi trois passes consécutives dans un concasseur à rouleaux, modèle de laboratoire, pour être réduit à -10 mailles.

Le produit concassé a été mélangé et divisé en lots individuels de 1000 grammes (schéma 1).

4.3 Auto-frottage et tamisage humide

Dans la première série d'essais, chaque lot de 1000 g est broyé pendant 45 secondes au broyeur à tiges, modèle de laboratoire, sous forme de pulpe à 33% solides afin d'être réduit à -30 mailles.

Les tamisages humides sont effectués sur des tamis Tyler, 12 pouces, d'ouverture 30 et 140 mailles, et un échantillon est prélevé après le premier tamisage pour la détermination des principaux éléments.

On utilise un conditionneur Denver, d'une capacité de 1,17 pi. cu. et tournant à 860 r.p.m. pour le nettoyage des surfaces (auto-frottage). Le sable est agité pendant 15 minutes à haute densité (75% solides), suivi d'un 15 minutes additionnelles à 50% solides (voir schéma 2).

Dans la seconde série d'essais, on augmente le temps de broyage à 90 secondes pour chaque lot de 1000 g dans le broyeur à tiges.

De plus, afin d'avoir un nettoyage plus efficace, on utilise, pour l'auto-frottage, une cellule Denver Sub A, équipée d'une tige d'agitation, tournant à 2000 r.p.m., pendant 30 minutes, avec une pulpe à 75% solides (schéma 3).

4.4 Essais de purification

Nous avons traité la fraction du sable comprise entre 30 et 140 mailles au séparateur magnétique Jones pour abaisser la teneur en fer. L'intensité était de 30 ampères (18 000 gauss), le taux d'alimentation de 75 g/cycle et la densité de pulpe de 10% solides. La granulométrie du produit purifié (sable de verrerie) ainsi que l'indice de finesse apparaissent aux tableaux 2 et 3 pour les deux séries d'essais, tandis que l'analyse chimique complète du sable purifié produit lors de chaque série d'essais figure au tableau 4.

Dans la première série d'essais, le sable n'a subi qu'une seule passe au séparateur magnétique Jones, tandis que dans la seconde série, le sable nettoyé a été retraité une seconde fois aux mêmes conditions.

Le bilan métallurgique des deux séries d'essais donne la teneur du Fe_2O_3 tout au long du traitement de purification. Ces résultats sont compilés aux tableaux 5 et 6.

4.5 Commentaires

L'objectif d'abaisser la teneur de l'oxyde de fer pour pouvoir rencontrer les exigences du marché a été atteint. Nous obtenons, avec un vigoureux nettoyage des surfaces, une teneur inférieure à 0,03% Fe_2O_3 dans le sable purifié au moyen du séparateur magnétique Jones.

On constate également, entre les séries d'essais 1 et 2, l'importance du broyage préliminaire et de l'auto-frottage. Par exemple, la quantité de sable purifié dans la première série représente 74,6% de l'échantillon original (tableau 5), tandis que dans la seconde série le pourcentage baisse à 68,4 (tableau 6). Dans ce dernier cas, le sable de verrerie ne contient plus que 12,5% du fer original avec une teneur de 0,03% Fe_2O_3.

Dans le cas de l'alumine, le sable de verrerie produit lors de la deuxième série d'essais ne contient que 0,13% Al_2O_3 (tableau 4), ce qui prouve l'efficacité d'un bon nettoyage des surfaces et d'un broyage préliminaire un peu plus poussé.

Normalement, la teneur maximale d'éléments métalliques (Cr, Ni, Co, V, Mn) dans le sable de verrerie ne doit pas dépasser 10 ppm. Nous croyons rencontrer cette valeur (tableau 4). Toutefois, il faut vérifier, auprès des clients éventuels, l'exactitude et l'importance de ces teneurs.

L'indice de finesse AFS est un peu plus élevé (69) dans la deuxième série que dans la première (64) (tableaux 2 et 3). Un temps de broyage un peu plus long libère mieux l'argile qui recouvre le sable et donne une distribution granulométrique qui se répartit sur six tamis au lieu de sept.

La teneur en silice dans le sable de verrerie a été estimée, par différence, à environ 99% SiO_2.

Avec un sable purifié qui offre déjà de nombreuses possibilités sur le marché du verre, nous recommandons que le client fasse traiter à l'échelle pilote suffisamment de ce grès pour en évaluer la qualité en fonction des différents produits du marché. Egalement, ce traitement permettrait d'optimiser le circuit et d'obtenir un sable de verrerie encore plus pur.

A moins de vouloir toucher des marchés vraiment sélectifs où la pureté du sable doit être encore plus élevée, nous ne voyons pas la nécessité d'entreprendre des essais de flottation ou de lixiviation des impuretés par l'acide.

5. Remerciements

L'auteur remercie M. Patrice Bélanger, ingénieur au CRM, pour sa contribution à cette étude. M. Magella Bédard, technicien en technique minière, a effectué la partie expérimentale et le personnel de la Direction d'Analyse et Contrôle, les différentes déterminations analytiques.

6. Références

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2 - Minerals for the Chemicals and Allied Industries, M. Johnstone, New York, pp. 506-509.

3 - DECO Trefoil, vol. 23, no 5, nov. déc. 1959.

4 - Rapport préliminaire sur la silice au Québec, M. Tiphane, oct. 1974, MRN.

7. Appendices

Schéma 1

Traitement préliminaire en laboratoire

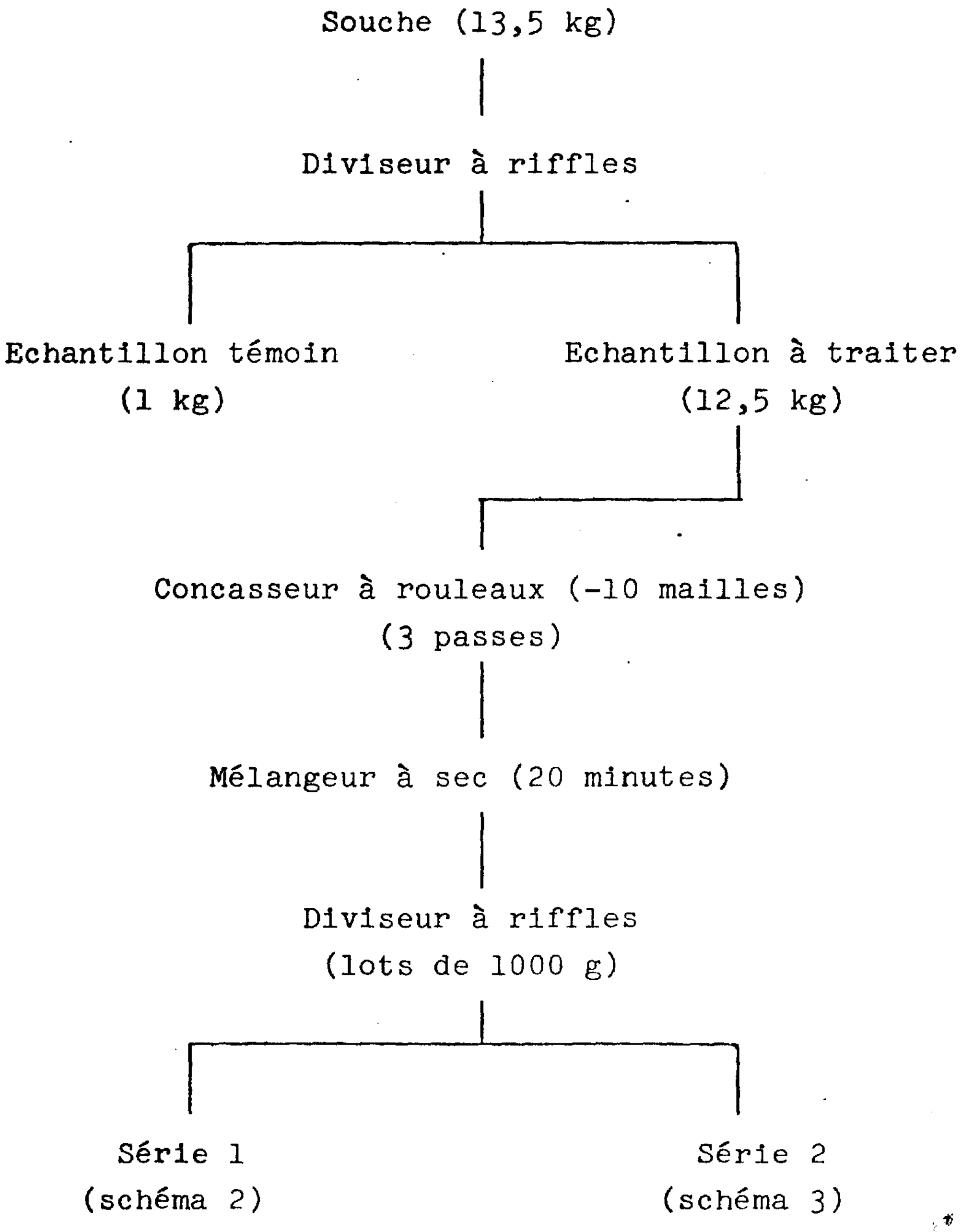

Schéma 2

Traitement en laboratoire (première série d'essais)

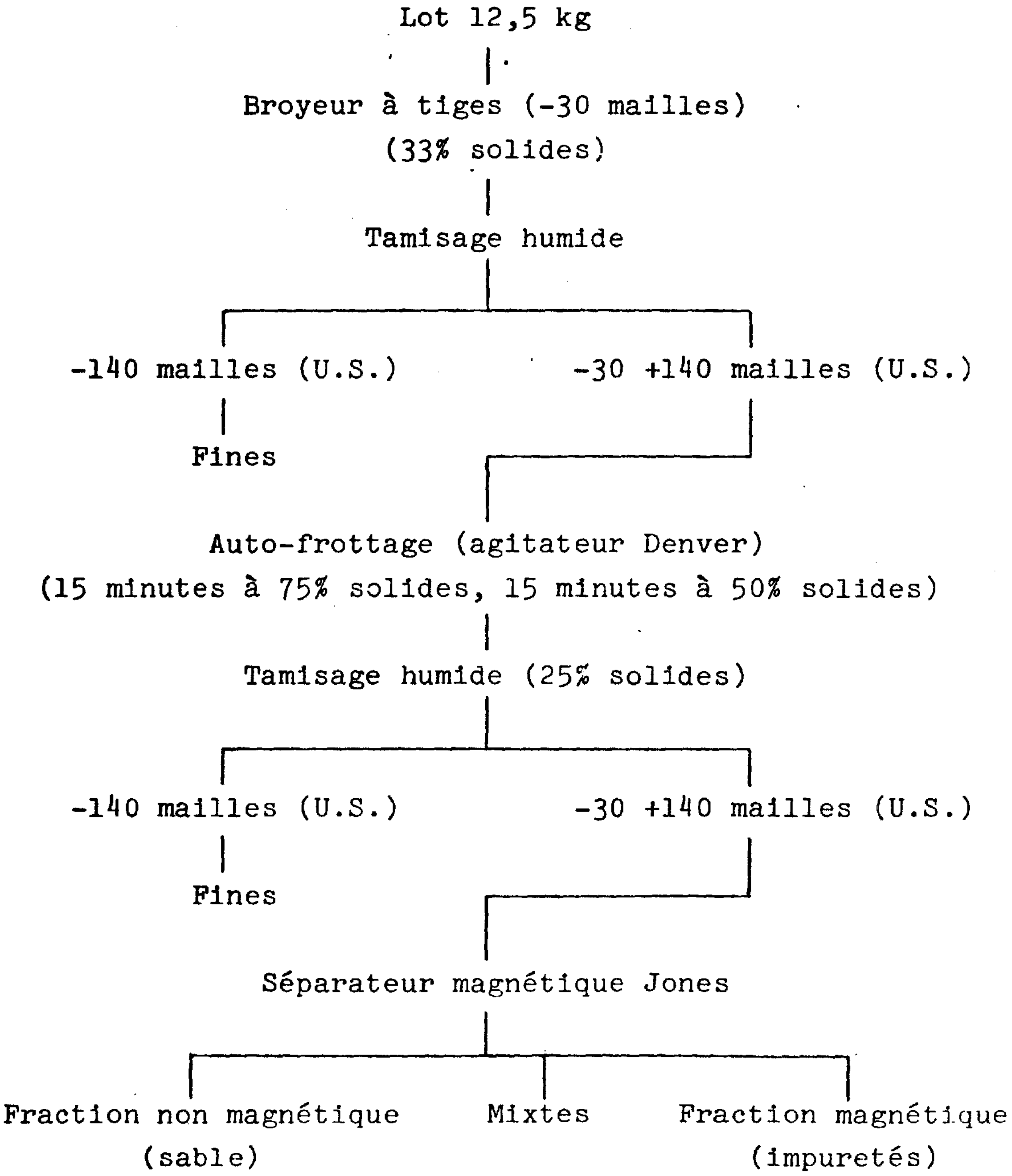

Schéma 3

Traitement en laboratoire
(deuxième série d'essais)

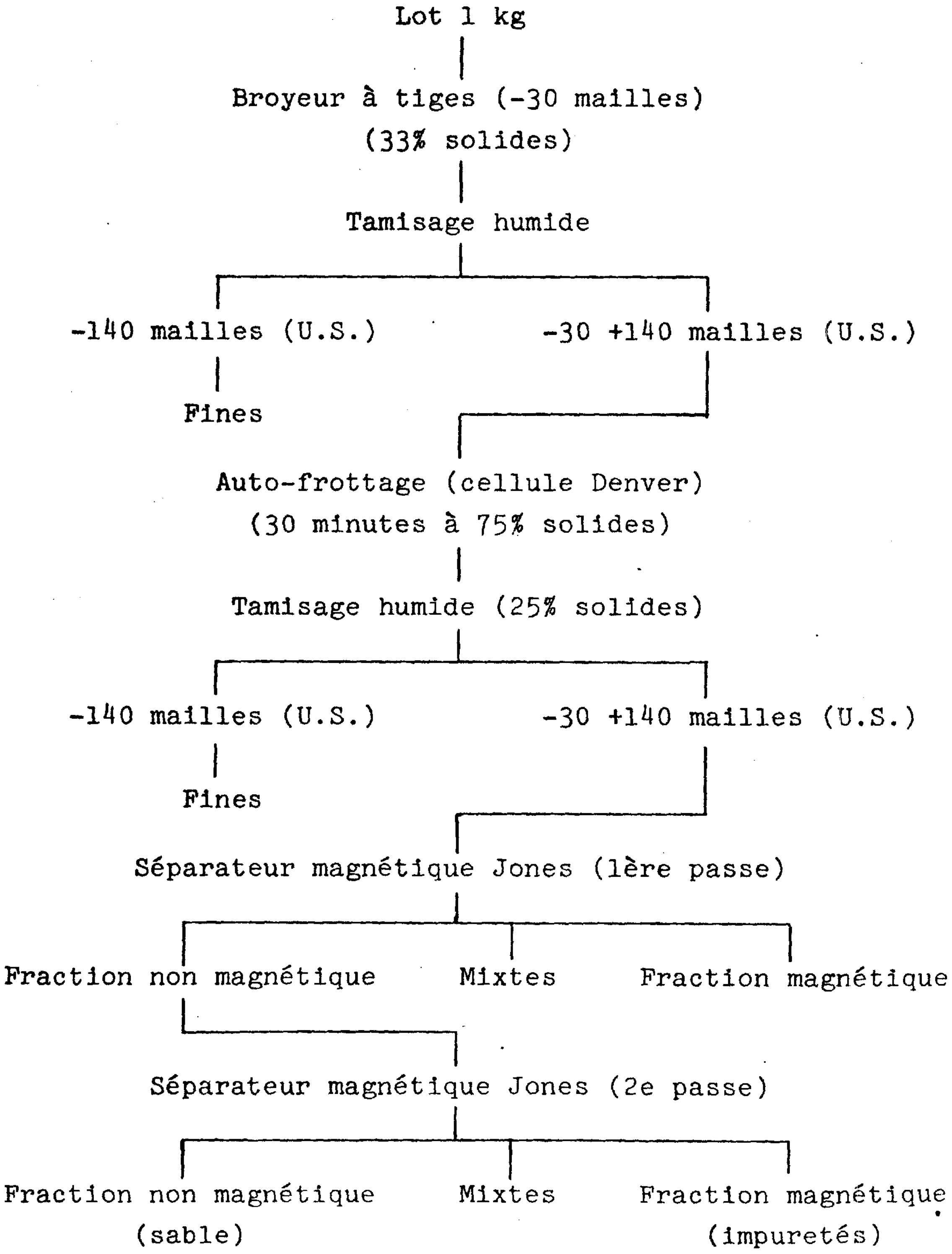

Tableau # 1

Analyse chimique de la souche

Elément	%
Fe_2O_3	0,11
Al_2O_3	0,29
MgO	0,07
CaO	0,02
Na_2O	0,01
K_2O	0,04
TiO_2	0,03
P_2O_5	0,01
Cr	18 ppm

Tableau # 2

Analyse granulométrique et indice de finesse

Fraction non magnétique - Séparateur Jones (1ère série)

(sable de verrerie)

Mailles (Tyler)	Mailles (U.S.)	Poids (%)	Poids (% Cum.)	Finesse (facteur)		Finesse (produit)
+ 28	+ 30	2,25	2,25	x 20	=	45
- 28 + 35	- 30 + 40	14,03	16,28	x 30	=	420,9
- 35 + 48	- 40 + 50	18,71	34,99	x 40	=	748,4
- 48 + 65	- 50 + 70	16,97	51,96	x 50	=	848,5
- 65 +100	- 70 +100	24,08	76,04	x 70	=	1685,6
-100 +150	-100 +140	17,58	93,62	x 100	=	1758,0
-150	-140 +200	6,38	100,00	x 140	=	893,2
						6399,6

Finesse AFS: $\frac{6399,6}{100} = 64$

Tableau # 3

Analyse granulométrique et indice de finesse

Fraction non magnétique - Séparateur Jones (2e série)

(sable de verrerie)

Mailles (Tyler)	Mailles (U.S.)	Poids (%)	Poids (% Cum.)	Finesse (facteur)	Finesse (produit)
+ 28	+ 30				
- 28 + 35	- 30 + 40	4,72	4,72	x 30	141,6
- 35 + 48	- 40 + 50	16,95	21,67	x 40	678,0
- 48 + 65	- 50 + 70	21,43	43,10	x 50	1071,5
- 65 +100	- 70 +100	29,78	72,88	x 70	2084,6
-100 +150	-100 +140	22,29	95,17	x 100	2229,0
-150	-140	4,83	100,00	x 140	676,2
					6880,9

Finesse AFS: $\frac{6880,9}{100} = 69$

Tableau # 4

Analyse chimique complète du sable purifié

Elément	1ère série	2e série
SiO_2	≈99%	≈99%
Fe_2O_3	0,03%	0,03%
Al_2O_3	0,16%	0,13%
CaO	0,01%	0,01%
MgO	0,03%	0,03%
Na_2O	0,01%	0,01%
K_2O	0,02%	0,02%
TiO_2	0,02%	0,02%
P_2O_5	0,02%	0,01%
Cr	2 ppm	3 ppm
Ni		1 ppm
Co		<1 ppm
V		<1 ppm
Mn		<10 ppm
P.A.F. (*)		0,19

(*) Perte au feu

Tableau # 5

Bilan métallurgique du fer (première série d'essais)

Produit	Poids		Fe_2O_3		
	(%)	(% Cum.)	(%)	(% Réc.)	(% Réc. cum.)
Souche	100,0	100,0	0,12	100,0	100,0
(1er tamisage)					
Fraction -30 +140 m	81,0	81,0	0,077(*)	44,6	44,6
Fraction -140 m	19,0	19,0	0,41	55,4	55,4
(2e tamisage)					
Fraction -30 +140 m	95,4	77,3	0,057(*)	70,2	31,3
Fraction -140 m	4,6	3,7	0,50	29,8	13,3
(Séparation magnétique)					
Fraction non mag. (sable)	96,4	74,6	0,03	56,7	17,7
Fraction mag. (impuretés)	1,5	1,2	0,86	22,6	7,1
Fractions mixtes (")	2,1	1,5	0,56	20,6	6,5

(*) Valeurs calculées

Tableau # 6

Bilan métallurgique du fer (deuxième série d'essais)

Produit	Poids		Fe_2O_3		
	(%)	(% Cum.)	(%)	(% Réc.)	(% Réc. cum.
Souche	100,0	100,0	0,12	100,0	100,0
(1er tamisage)					
Fraction -30 +140 m	78,8	78,8	0,06(*)	37,1	37,1
Fraction -140 m	21,2	21,2	0,40	62,9	62,9
(2e tamisage)					
Fraction -30 +140 m	94,8	74,7	0,05	74,6	27,7
Fraction -140 m	5,2	4,1	0,31	25,4	9,4
(Séparation magnétique)					
Fraction non mag. (sable)	91,6	68,4	0,03	45,1	12,5
Fraction mag. (impuretés)	2,3	1,7	0,53	20,3	5,6
Fractions mixtes (")	6,1	4,6	0,34	34,6	9,6

* Valeur calculée

B - Central Part of Outlier

	B-1	B-2	B-3
Al_2O_3	0.13	0.14	0.21
Fe_2O_3	0.12	0.13	0.11
MgO	0.02	0.03	--
CaO	0.01	0.01	--
TiO_2	0.03	0.03	--

B - Northeasternmost Part of the Outlier (near Matane River) (each is a composite sample of at least 4 samples on sections 200' apart)

	C-1	C-2	C-3	C-4	C-5	C-6	C-7	C-8	C-9	C-10
Al_2O_3	0.3	0.22	0.18	0.16	0.15	0.09	0.27	0.15	0.35	0.09
Fe_2O_3	--	0.11	0.11	0.12	0.06	0.08	0.08	0.11	--	0.09
MgO	--	--	0.03	0.04	0.03	.027	--	0.02	--	--
CaO	--	--	0.01	0.01	.003	0.01	--	0.01	--	--
TiO_2	--	--	0.03	0.03	0.01	0.04	--	0.04	--	--

1978-79 - Sampling & Assaying by Geolab Inc. of the Langis Outlier

A - Southwesternmost Part of Outlier

	A-1 (2)	A-2 (3)	A-3 (1)	A-4 (1)	A-5 (1)
Al_2O_3	0.3	0.3	0.3	0.34	0.49
Fe_2O_3	0.1	--	0.08	--	--
MgO	0.04	--	0.03	--	--
CaO	0.01	--	0.01	--	--
TiO_2	0.04	--	0.04	--	--