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SUITABILITY OF THE BUFF AND RED SANDSTONE FROM TROIS-PISTOLES, P.Q. FOR USE AS A DIMENSION STONE

by

F.E. HANES AND J.A. SOLES

MINERAL PROCESSING DIVISION

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F. E. Hanes* and J. A. Soles**

SUMMARY OF RESULTS

Four distinct zones (A, B, C and D) of the Trois-Pistoles sandstone were tested for their suitability for use as building-stone material. The zones proved to be characteristically different, but a consistent variation in the physical properties of each zone was apparent from the different tests.

Physical acceptance tests, including resistance to abrasion, specific gravity, absorption and compression on wet, dry and freeze-thaw cycled samples indicated that material from any one of the four zones tested was satisfactory for building use.

Comparisons with tests on one of Canada's quality sandstones, the Wallace Sandstone from Wallace, Nova Scotia, showed that three zones ('D' 'C' and 'A') of the Trois-Pistoles sandstone had higher compressive strength, whereas the fourth zone ('B') had a slightly lower strength.

Petrographic study and X-ray determinations showed the interbedded buff and red zones 'C' and 'D' contained less intergranular material than the 'A' and 'B' zones, and quartz grains which were in contact had serrated interlocking boundaries as opposed to the smooth-bounded grains in zones 'A' and 'B'.

An interesting clay mineral found in this sandstone is being studied further.

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INTRODUCTION

Mr. Elzear Gagnon, Manager of Les Ciments Decoratifs, Enr., visited the Mineral Processing Division of the Mines Branch to request assistance for the development of a sandstone deposit near Trois-Pistoles, P.Q. Some quarrying has been done on this outcrop in the past. The quarry is located on lots 158, 359 and 360 in the parish of St. Mathieu, Nicolas Rioux Seigneury.

The quarry, which is situated near the St. Lawrence river and the Canadian National Railway main line, has access by both water and rail transportation to large Canadian markets. Trois-Pistoles is 28 miles northeast of Riviere du Loup, placing it within a few miles of No. 2 Trans-Canada Highway.

Samples of the sandstone submitted by Mr. Gagnon during his visit to Ottawa showed an aesthetic quality and physical characteristics which indicated that it was a sandstone rock of above-average quality. An investigation to determine the sandstone's suitability for use as a building stone was warranted.

SCOPE OF INVESTIGATION

The investigation of this sandstone was comprised of physical acceptance tests and a petrographic study to determine the suitability of the rock for use as dimension stone in outdoor locations. The following tests were made.

(a) Petrographic analysis
(b) Mineralogical analysis of sandstone matrix
(c) Specific gravity and absorption
(d) Compressive strength tests
(e) Freezing/thawing tests
(f) Resistance to abrasion (Kessler's H_a).

PREPARATION OF SAMPLES

Three large blocks measuring approximately 16 x 12 x 10 inches were submitted for testing. One block was composed of a buff sandstone; test samples of this rock were designated as 'A'. Samples from the second block, which was composed entirely of a red sandstone, were designated as 'B'. From the third block, a mixture of buff and red sandstone lenses interfingering in varying degree samples were taken from both top and bottom; those from the top, primarily buff stone with red sandstone lenses, were designated as 'C'; and those from the bottom, essentially red sandstone with buff lenses, were designated as 'D'.

The selection of these four zones for testing was considered necessary as each type of rock appeared (megascopically) to vary slightly from the others. After a few tests it was evident that marked differences existed between the selected groups. It was also evident that the trend established for any one set of test results held for all tests.

Samples were obtained by diamond sawing with occasional lapping where opposite surfaces were required to be smooth and/or parallel. Two-inch cubes were prepared for freeze-thaw cycling and compressive strength testing. Samples 2 inches square and 1 inch thick were prepared for abrasion resistance testing. Specific gravity and absorption values were determined on test pieces from each of the four selected zones.

Thin sections and powdered material from various rock fragments were used for petrographic and mineralogical analyses.

PROCEDURE AND TEST RESULTS

(a) Petrographic Analysis

The petrographic study of the Trois-Pistoles sandstone was made on four thin sections*, one from each zone; it was supported by X-ray diffraction analyses** of representative materials.

The sandstone is fine grained, having an average grain size of less than 0.3 mm and only rare fragments greater than 0.5 mm. The most distinctive feature of the rock is a strong banding, caused by an abrupt colour change from light buff to brownish red. The colour bands parallel subdued sedimentary bedding planes in which the clastics vary slightly in grain size and mineralogy.

The rock is a quartz sandstone consisting of at least 90 per cent quartz grains, rare grains of potassium feldspar, and intergranular hematite and clay minerals. The rock is porous, voids occupying up to 20 per cent of the volume. Compositionally the buff sandstone is little different from the red or the banded rock, and distinction in thin section is difficult (Figure 1). The red colouration apparently resulted from the oxidation of intergranular iron to the ferric state at some time in the rock's history; its distribution in bands presumably reflects either a changing depositional environment, when iron was either present or absent, or selective post-depositional introduction of iron.

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*TS-65 Series, Nos. 60, 61, 68, 69

**Debye-Scherrer photograph MP-5985 ; Diffractograms 2893/65-2904/65 incl. Guinier photograph G-192

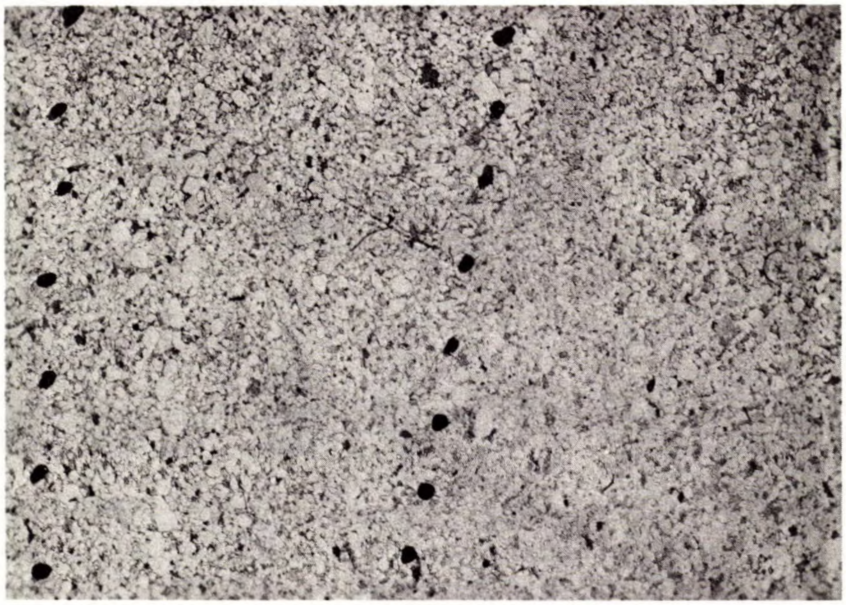
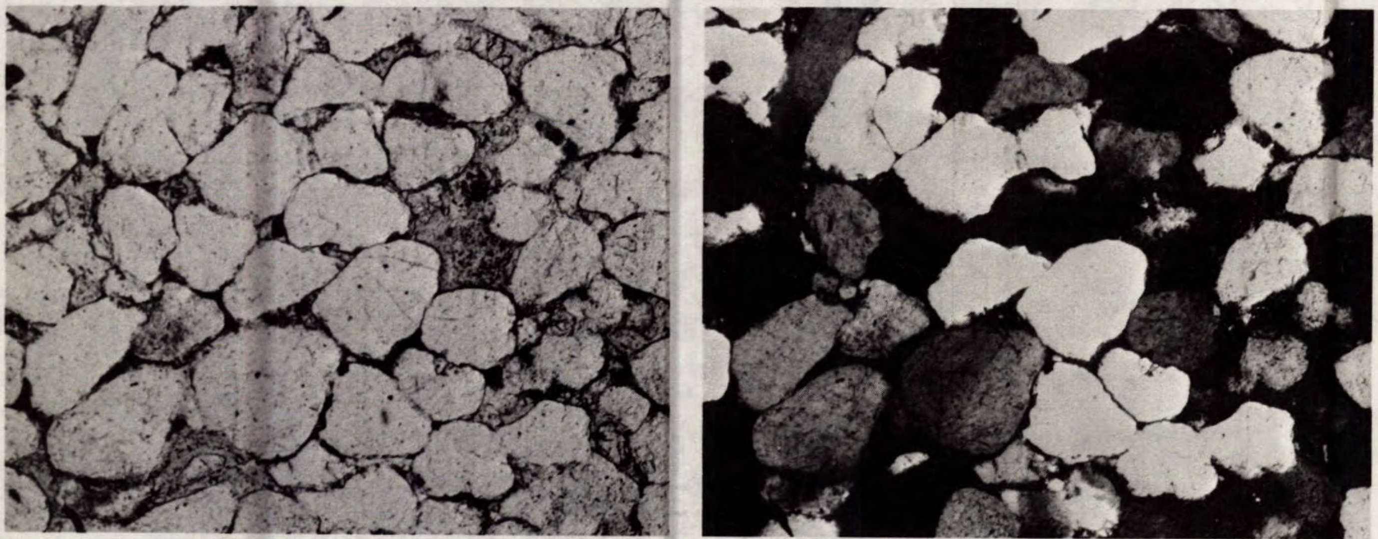


Figure 1. Photomicrograph of sandstone illustrating the textural similarity of buff and red bands, the latter between the dotted lines, Quartz grains are white, voids and intergranular material are grey. Magnification x6.

A distinctive textural feature, visible in thin section, is the serrated grain boundaries between adjacent quartz grains in some samples of the rock. Note in Figure 2, a section of darker red sandstone, that the quartz grains are rounded and mostly discrete, being separated by a clayey matrix or voids (both grey) or by a dark hematitic film. Grains which touch have smooth boundaries. On the other hand, a section of buff-and-red sandstone (Figure 3) having less intergranular material shows that quartz grains in contact have serrated, interlocking boundaries. This feature is significant petrogenically and important physically.

Quartz sandstones in different stages of lithification usually have a common feature, viz. the optically continuous overgrowth of secondary quartz on the abraded quartz grains. This feature is completely lacking in Trois Pistoles sandstones, as it is in many quartzites. Petrogenically, the indication is that this rock has suffered a dynamic type of metamorphism, with the result that the grain edges have been obliterated and a closely knit fabric developed except where soft intergranular materials (e.g. clays) inhibited recrystallization and intergrowth. The strength of the rock should be markedly affected by the amount of local intergrowth of quartz grains. X-ray diffraction studies of the intergranular material are given below.



Polarized light Crossed polaroids

Figure 2. Red sandstone, showing smooth, rounded, discrete grains of quartz separated by dark hematitic films, clayey material, and relatively large voids (grey). Magnification X70.

Polarized light Crossed polaroids

Figure 3. A section through pale red sandstone, revealing sub-rounded, compacted quartz grains serrated at points of contact and lacking overgrowths, Rounded or straight boundaries are maintained at contacts with voids and intergranular clayey or hematitic material (arrows). These textural features are similar on the adjacent buff band. Magnification X70.

(b) Mineralogical Analysis* of Sandstone Matrix

The following procedure was used to fractionate the sample for mineral identification by Guinier X-ray powder photographs and X-ray diffractograms.

Approximately 50 grams of sandstone was crushed to minus 8 plus 30 mesh. The resulting chips and grains were boiled for 24 hours. The suspension was decanted from the remaining chips, and fractions coarser and finer than five microns equivalent settling diameter were separated by centrifugation. Guinier X-ray powder photographs were made of each of the fractions. Following chemical treatment for removal of free iron oxides, oriented mounts of the minus 5-micron fraction were scanned with the X-ray diffractometer before and after glycol saturation and heat treatment at 580°C. HCl treated material was also examined. The following minerals were identified.

(1) Chlorite - (very abundant) - unusual type; very strong 003 reflection; resistant to HCl treatment, probably dioctahedral, from position of 060 reflection; normal reaction to heating.

(2) Quartz - (abundant)

(3) Illite - (fairly common)

(4) Hematite - (fairly common)

(5) Plagioclase - (trace)

(6) K-Feldspar - (trace)

Further studies are being made of the unusual dioctahedral chlorite. Its presence in this rock is of particular academic interest, as its structure is similar to that of chlorite commonly found in dynamically metamorphosed rocks.

(c) Bulk Specific Gravity and Absorption

The bulk specific gravity and absorption values for samples from all zones (A, B, C and D) were obtained in accordance with ASTM specification C 97-47, Absorption and Bulk Specific Gravity of Natural Building Stone. The Results of these tests are shown in Table I.

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*Dr. R. S. Dean, Research Scientist, Ore Mineralogy Section, Mineral Processing Division, Mines Branch.

TABLE I

Bulk Specific Gravity and Absorption Values

Sample No.	Bulk Specific Gravity	Absorption (%)
A (buff)	2.37	1.4851
B (red)	2.35	1.7587
C (buff with red)	2.43	0.9927
D (red with buff)	2.47	0.8970

(d) Compressive Strength Test

In accordance with ASTM Procedure C 170-50, Compressive Strength of Natural Building Stone, three 2-inch cube samples for each type of rock were crushed to obtain the compressive strength for both dry and wet conditions.

Table 2 shows the individual compressive strength results of the three samples tested for each type of rock. The average of each set of three samples is also shown.

TABLE 2

Compressive Strength Test on Standard Dry and Wet Cubes

Test Method	Cube No.	Compressive Strength (psi)			
		Type A	Type B	Type C	Type D
Dry	1	18,125	14,136	16,350	25,463
	2	12,791	11,750	22,350	31,293
	3	16,667	13,500	17,333	23,171
	Ave	15,861	13,129	18,678	26,642
Wet	1	14,476	15,500	18,256	22,805
	2	13,690	12,878	21,548	21,410
	3	17,683	16,683	19,619	23,051
	Ave	15,283	15,020	19,808	22,422

(e) Freeze-Thaw Cycling Tests

Three sets of 2-inch cubes for each test were subjected to 107, 230 and 518 F/T cycles through a two-hour, 51-minute cycle (approximately eight cycles per day) in accordance with modification of ASTM Specification C 291-61T, to determine their resistance to rapid freezing in air and thawing in water.

Only one set of samples (buff sandstone, Type A) was tested at 107 cycles of freezing-thawing because of limited sample material in the B, C and D types of rock. The complete results of the compressive strength tests at three levels of F/T cycling are shown in Table 3 with averages of each three shown for comparison with the results in Table 2.

TABLE 3

Compressive Strength Values of Samples in Freeze-Thaw

No. of Cycles	Cube No.	Compressive Strength (psi)			
		Type A	Type B	Type C	Type D
107	1	18,300	Not Tested	Not Tested	Not Tested
	2	15,750			
	3	12,550			
	Ave.	15,533			
230	1	14,625	15,800	24,150	14,100*
	2	18,275	16,750	23,350	21,750
	3	19,075	14,150	20,375	24,000
	Ave	17,325	15,567	22,625	19,950 (22,875)*
518	1	18,625	10,200	16,800	23,500
	2	13,925	13,700	22,000	28,200
	3	12,175	15,125	24,900	21,375
	Ave.	14,908	13,008	21,233	24,358

*The value 14,100 psi is probably due to an unsound sample; with it removed an average value based on two samples would be 22,875 psi.

(f) Resistance to Abrasion (Kessler's H_a)

The procedure used in this test conforms with ASTM Specification C241-51. This method is used to evaluate the resistance of a material to abrasion by foot wear. The value of resistance obtained by this method can be used for comparative assessment with other rocks. Average values required for application in Kessler's formula* to calculate the resistance to abrasion (H_a) are shown in Table 4. The value for (H_a) was obtained by using average values of the separate groups of tests.

TABLE 4

Resistance to Abrasion by Kessler's Method

Type Material	Average Wa(g)	Average Ws(g)	Bulk Specific Gravity	Resistance to Abrasion (H_a)
'A' (buff)	0.993	162.92	2.37	25.81
'B' (red)	1.667	161.65	2.35	15.24
'C' (buff with red)	0.873	177.82	2.43	30.31
'D' (red with buff)	0.60	176.97	2.47	44.81

*Kessler's Formula =

$$(H_a) = \frac{10G\ (2000 + Ws)}{2000\ Wa}$$

where (H_a) = resistance to abrasion
G = specific gravity
Ws = average weight of sample before and after test (grams)
Wa = loss in weight (grams)

DISCUSSION

Results varied widely between types and between samples in each separate type, thus making it difficult to arrive at definite conclusions. However, the results obtained were sufficient to establish a definite trend between the types tested. The caliber of the results indicated that all four types of sandstone were of good building-stone quality.

The 'D' zone rock proved to be of superior quality for use as building stone with 'C', 'A' and 'B' progressively less acceptable; compressive strength values within the four zones ranged between 26,000 and 13,100 psi. All zones compare favourably in all respects with the well-known Canadian sandstone quarried at Wallace, Nova Scotia. By comparison, the crushing strength of the Wallace sandstone reported by W.A. Parks* was 13,680 psi. Recent tests made in the Mines Branch laboratories in Ottawa on 2-inch cubes of newly quarried Wallace sandstone gave average compressive strength values of approximately 14,000 psi. Wallace sandstone is well known for its suitability for use as a building stone appearing in many structures in Ontario, Quebec and the Maritimes. It is also found in many structures in cities in the United States, particularly New York, Boston and Providence.

Compressive strength values in all groups increased during freeze-thaw testing. Compressive strength for the first three types ('A', 'B' and 'C') during freeze-thaw treatment reached values approximately 10 to 22 per cent higher than the values obtained in the standard ASTM test (C-170). The first three types apparently reached maximum strength values in the 200-250 cycle range. The 'D' type showed an increase in strength at 518 cycles compared with its value at 230 cycles, although neither set of average results reached the original dry strength. It is possible that maximum strength may have developed before 518 cycles of freezing-thawing testing, or, it may not have attained its maximum value during the interval tested. Several writers have described experiences with anomalous conditions in sandstone testing where increasing strength has been noted during freeze-thaw cycling. Dr. Parks** reports, "It is not to be inferred that the freezing and thawing has produced this result; the explanation more likely lies in the heating and drying". G. P. Merrill in his book 'Stones for Building and Decoration', reports values from compressive strength tests that are higher after cycles of freezing and thawing than the original strength value.

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*W. A. Parks, "Building and Ornamental Stones of Canada", Vol. 2, Canada Department of Mines, Ottawa (1914).

**W. A. Parks, "Building and Ornamental Stones of Canada", Vol. 1, Canada Department of Mines, Ottawa (1912), page 66.

Petrographically the stone in groups 'D' and 'C' differed markedly from the 'A' and 'B' types inthat they contained less intergranular material and, where quartz grains were in contact, the boundaries were often serrated and interlocking. The latter physical condition accounts for the greater strength of the 'C' and 'D' rock types.

Dr. O. Maurice* notes that '.....the churches of St. Mathieu and Ste. Francoise nearby were built with this stone.. that the colour was conserved remarkably well since time of construction which dates back to more than 50 years. Also, the pillars of the railway bridge over the Trois-Pistoles river were built with this stone and the rigorous winter conditions do not seem to have affected the stone adversely in all these years."

Intergranular material in the Trois-Pistoles sandstones is of unusual mineralogical interest and the study of the clay minerals is continuing.

CONCLUSIONS

Results of physical tests made on the Trois-Pistoles, P.Q., sandstone indicate that the sandstone is of good quality, particularly the red-buff, buff-red and buff varieties. The 'B' (red sandstone) type, which showed the lowest compressive values of the four groups tested, is sufficiently sound for building stone use.

Petrographically the rock types 'D' and 'C' have been described as containing grains with interlocking crystal boundaries, thus accounting for the added strength shown by physical tests.

Aesthetically, the rock is pleasing to the eye, particularly in the colourful interbanded zones. The grains of all four zones are bonded sufficiently to allow sharp-edge dressing and carving.

The Trois-Pistoles sandstone makes an outstanding, colourful building stone. Rough-face blocks have been used effectively on churches and railroad pier construction in the Trois-Pistoles area.

It has not been determined if the deposit is amenable to production of large-sized dimension stone.

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*Dr. O. Maurice of the Quebec Department of Natural Resources, Quebec, P.Q. (Personal Communication)