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CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

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MINES BRANCH INVESTIGATION REPORT IR 64-37

EVALUATION OF POZZOLANIC PROPERTIES OF A PUMICITE FROM QUESNEL, B. C.

by

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MINERAL PROCESSING DIVISION

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SUMMARY OF RESULTS

The results of petrographic examination show that the rock is a scoriaceous vesicular lava of andesitic composition.

Chemical analysis of the finely ground rock indicates that the material may have pozzolanic properties.

Tests carried out to determine the pozzolanic activity index of the finely ground material showed that with portland cement the index was about 100%, whereas with lime the compressive strength was 840 psi.

The drying shrinkage of mortar bars at 28 days was 0.004%, whereas autoclave expansion was 0.09%.

These results show that the sample under investigation, when finely ground, meets the chemical and physical requirements of ASTM Specifications C402-62T for natural pozzolans for use as an admixture in portland-cement concrete.

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INTRODUCTION

Four different rock samples were submitted by Mr. D.J. St. Louis, Quesnel, B.C. in June, 1963, for examination and evaluation by the Mineral Processing Division.

Samples 1 and 2 were identified and reported by Mr. J.S. Ross, of the Non-Metallic Minerals Section in a letter of October 3, 1963.

Samples 3 and 4 were identified and have been evaluated in the Construction Materials Section. The results of examination of sample 4 (Lab. No. CM-176) have been reported in Test Report MPT 63-76 by Messrs. H.S. Wilson and J.A. Soles.

This report presents the results of petrographic analysis, and chemical and physical tests on sample No. 3 (Lab. No. CM-175) to determine the pozzolanic properties of the material and evaluate its suitability for use as an admixture in portland-cement concrete.

The rock sample is reported to have been taken from a cliff, 300 feet high and a mile long, at Narosli Creek mineral claims, on vacant crown land, lot Nos. 3905 and 3906, where large deposits of this rock are available.

GENERAL INFORMATION ON POZZOLANS

Definition

Pozzolans may be defined as siliceous materials, which in themselves possess little or no cementitious value but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form stable, insoluble compounds possessing cementitious properties.

Classification

Pozzolans may be natural or artificial products and have to be ground before use. Natural pozzolans are chiefly of volcanic origin. The clayey pozzolanic materials, including altered volcanic ashes and tuffs as well as shales, may be calcined to activite their properties.

Artificial pozzolans are principally fly-ashes, burned clays and shales, spent oil shales and certain products resulting from industrial processes.

Use of Pozzolans

Pozzolans are used principally to supplement or partially replace portland cement to obtain specific properties such as: reduction in the heat of hydration of mass concrete, reduction in bleeding, permeability and improved concrete workability.

SCOPE OF INVESTIGATION

The purpose of this work was to determine whether the rock under investigation, when finely ground, possesses sufficient pozzolanic properties for use as a cementitious admixture in portland-cement concrete.

Petrographic examination and mineralogical analysis of the rock were made for identification and classification purposes.

Chemical analysis and physical tests were carried out on the finely ground material in order to compare its pozzolanic properties with the requirements stipulated in "ASTM Specifications for Raw or Calcined Natural Pozzolans for Use as Admixtures in Portland Cement Concrete"*.

TEST PROCEDURES

The rock sample was examined petrographically and thin sections were prepared from representative pieces for mineralogical analysis.

The chemical analysis and physical tests were made in accordance with the test methods specified in ASTM Designation C402-62T.

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*ASTM Designation C402-62T, 1961 Book of American Society for Testing and Materials Standards, Part 4, p. 678.

The fineness of the ground material was determined by percentage retained on a ASTM No. 325 sieve using the Alpine Air Jet Sieve(1), instead of the wet-sieving procedure recommended in the above specifications. The Alpine Air Jet Sieve is a new type of apparatus for dry-sieving of cement and other fine materials. The principle of this equipment consists in the use of an air current to disperse the material on the sieve and to carry the finer fractions through it.

A normal Type 1 portland cement was used to investigate the physical properties of the finely ground pumicite. The chemical analysis of the cement is given in Table 1.

TABLE 1

Chemical Analysis of Portland Cement*

Cement Constituents		Per cent
Insoluble residue		0.38
Silicon dioxide	(SiO_2)	21.06
Aluminum oxide	(Al_2O_3)	5.34
Ferric oxide	(Fe_2O_3)	2.54
Calcium oxide	(CaO)	63.46
Magnesium oxide	(MgO)	2.97
Sulphur trioxide	(SO_3)	2.33
Loss on Ignition		1.19
Undetermined		0.73
Total		100.0

*Supplied by the manufacturer.

A commercial brand of hydrated lime, ground to a fineness of 7.8 per cent retained on a No. 200 sieve, as determined by the Alpine Air Jet Sieve method, was used for pozzolanic activity tests.

TEST RESULTS

Petrographic Description*

The rock is porous, blue-grey, consists of dark vesicular fragments in a light-coloured matrix. Microscope study of the thin sections revealed that most fragments are distinctly vesicular, and consist of micro-crystals of zoned, corroded plagioclase feldspar and pyroxene in a glass matrix.

The approximate mineralogical composition of the rock sample is shown in Table 2.

TABLE 2

Mineralogical Composition of the Rock

Mineralogical Constituents	Approximate Proportions, %	Grain Size Length, mm	Remarks
Plagioclase	10 to 35	0.1 to 2	An_{20-50}
Augite	5 to 15	0.1 to 2	
Glass	60 to 40	nil	Contains some potassium
Vesicles	30 to 15	0.2 to 2	

The rock is a scoriaceous vesicular lava of andesitic composition; it would most likely be found near the surface of a flow, or with volcanic debris of the nueis ardentes type. It could be classified as pumicite.

Photomicrographs of a thin section of two fragments of the rock are shown in Figure 1.

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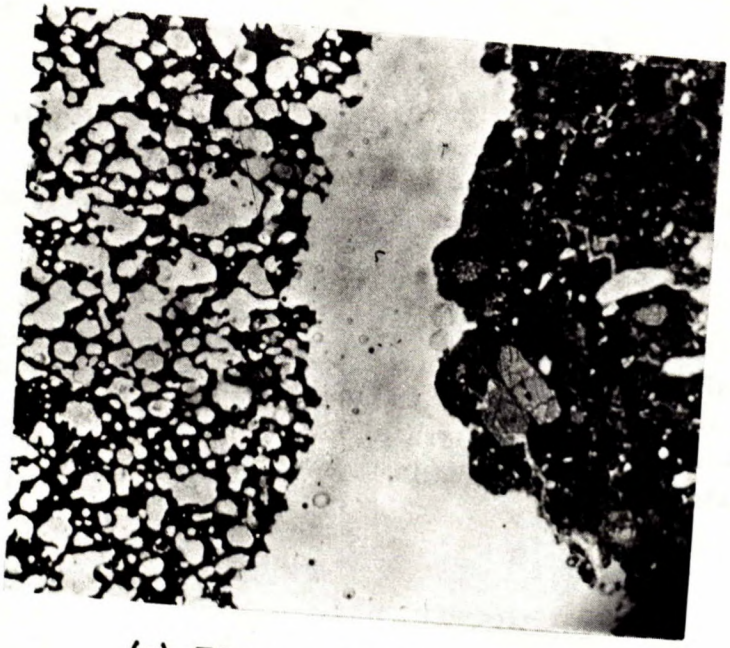
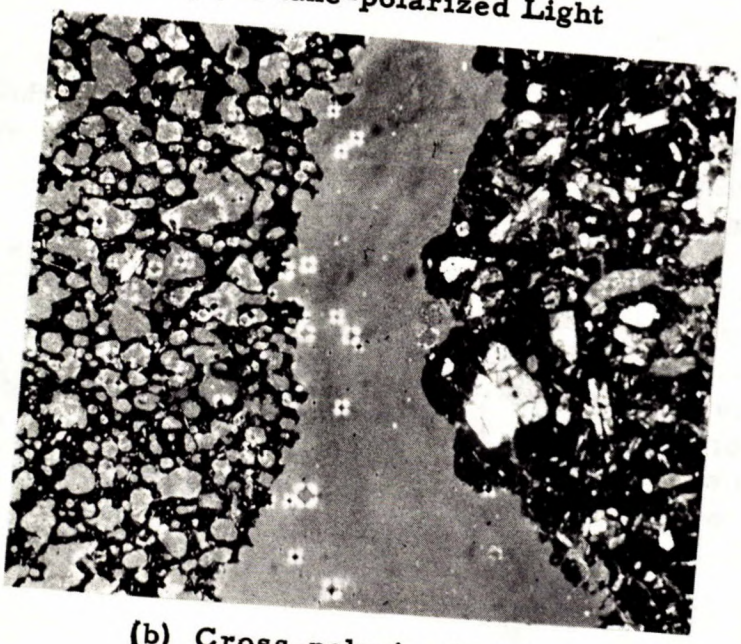
*by James A. Soles, petrologist, Ore Mineralogy Section.



(a) Plane-polarized Light



(b) Cross-polarized Light

Figure 1. Photomicrographs of two fragments of volcanic rock CM-175. Magnification X12.

Left: Vesicular glassy phase containing minute prisms of feldspar.

Right: General matrix of rock, showing vesicles and crystals of pyroxene and feldspar.

Chemical Analysis

The chemical analysis of the pumicite is given in Table 3. Also included in the table are the ASTM specification C402-62T and USBR* specification requirements for pozzolans.

Physical Tests

The results of physical tests, i.e., percentage retained on No. 325 sieve, pozzolanic activity index, drying shrinkage and autoclave expansion test are shown in Table 4. Both ASTM and USBR specification limits for the above tests are also shown in the table.

DISCUSSION

Chemical analysis and physical tests made with the finely ground sample of pumicite (CM-175) show that the material meets the ASTM specification requirements for raw or natural pozzolans for use as admixtures in portland cement concrete.

USBR specifications have been included in Tables 3 and 4, for comparison purposes, because this agency is one of the largest users of pozzolans in North America. Large amounts of different pozzolans are being incorporated in concrete mixes for its dam projects. Further, this specification is more rigid than that of ASTM for the pozzolanic activity index test with portland cement and lime. It must be noted that the test sample failed to meet the latter requirement of the USBR specification.

*United States Bureau of Reclamation.

TABLE 3

Chemical Analysis and Specification Requirements

Chemical Constituents	Test Sample CM-175*, per cent	ASTM Specification (C 402-62T), per cent	USBR Specification, per cent
Silicon dioxide (SiO_2) plus aluminum oxide (Al_2O_3) plus iron oxide (Fe_2O_3)	80.49	min. 70.0	min. 75.0
Magnesium oxide (MgO)	3.18	max. 5.0	max. 5.0
Sulphur trioxide (SO_3)	0.07	max. 3.0	max. 4.0
Loss on Ignition (L.O.I.)	4.92	max. 10.0	max. 10.0
Moisture content	1.46	max. 3.0	max. 3.0
Exchangeable alkalies as Na_2O	--	--	max. 2.0

*Chemical analysis from Mines Branch Internal Report MS-AC-63-927.

TABLE 4

Physical Properties and Specification Requirements

Physical Properties	Test Sample CM-175	ASTM Specification (C 402 - 62T)	USBR Specification
Amount retained when wet-sieved* on No. 325 sieve, per cent	7.0	max. 12.0	max. 15.0
Pozzolanic activity index: With portland cement, at 28 days, percentage of control	100	min. 75	min. 85
With lime, at 7 days, psi	840	min. 600	min. 900
Change of drying shrinkage of mortar bars at 28 days, per cent	0.004	max. 0.03	max. 0.04
Autoclave expansion, per cent	0.09	max. 0.50	--

*Sieve analysis made on Alpine Air Jet Sieve apparatus.

CONCLUSIONS AND RECOMMENDATIONS

The sample of pumicite as received possesses pozzolanic properties and may be used as an admixture in portland cement concrete mixes.

The optimum amount of the admixture to be used should be determined by making a series of concrete test mixes incorporating different amounts of the above material. It is considered that such a program can be satisfactorily carried out by a commercial testing laboratory.

REFERENCE

1. V.M. Malhotra and G.G. Wallace, "A New Method for Determining Fineness of Cement", Mines Branch Investigation Report IR 63-119, Department of Mines and Technical Surveys, Ottawa (1963).

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VMM/NGZ:DV