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THE EVALUATION OF A LIMESTONE FROM GHANA AS A SOURCE OF HYDRAULIC LIME

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MINERAL PROCESSING DIVISION

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SUMMARY OF RESULTS

Tests on the limestone received from Ghana showed it to have a low silica content and a low hydraulic index. Because of these, the raw material will not produce a natural cement of good quality. However, the limestone has a fairly high content of magnesia (MgO), and could be used to produce a fairly good magnesian hydraulic lime.

A series of calcination tests, based on a two-hour firing period, indicated that the most active form of lime is produced at a temperature approaching 1900°F. Compressive strength tests on 2-inch cubes indicate that a fairly satisfactory hydraulic lime can be produced from this limestone. This lime could be used in the manufacture of a cheap building product, for example, building blocks.

Quicklime produced from this limestone should be tested as a stabilizing material for soils native to Ghana. It may prove to be effective as a binder in road base construction.

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INTRODUCTION

The Geological Survey of Ghana has located several fairly extensive deposits of siliceous (?) magnesian limestone in the northern regions of Ghana. Because of the great demand for cheap building materials for village housing, the Government of the Republic of Ghana has inquired of several British Commonwealth countries whether a relatively inexpensive natural cement could be produced from their limestone.

Two 100-pound samples of limestone from Ghana were received by the Mineral Processing Division of the Mines Branch, Department of Mines and Technical Surveys. An investigation was carried out to determine whether a cementitious material could be produced from this limestone.

PROCEDURE

Each limestone sample received was crushed to minus $1\frac{1}{2}$ in. in size. Two representative portions of the crushed limestone were taken from each test sample and ground for chemical analyses.

It was first necessary to determine a time-temperature relationship that would produce a reactive lime from this limestone. To this end, the $\frac{1}{2}$ to $1\frac{1}{2}$ in. fraction was screened from each limestone sample. The minus $\frac{1}{2}$ in. fraction was not tested. Six 4-pound portions were riffled from each graded sample and labelled 1-A to 1-F and 2-A to 2-F. These, in turn, were placed in corresponding pairs in a preheated glo-bar furnace and calcined for 2 hours at different temperatures. The carbon dioxide content of each resulting lime sample was determined by a chemical analysis according to ASTM Designation C25-58.

The analyses for carbon dioxide indicated that the most active lime obtained from a $\frac{1}{2}$ to $1\frac{1}{2}$ inch fraction over a 2-hour calcining period was produced at a temperature approaching 1900°F. A 12-pound test sample was, therefore, riffled from each of the two original limestone samples and calcined for 2 hours at 1900°F. The resulting lime products were pulverized to the fineness required by ASTM Designation C141-55, whose limits specify "...... a residue of not more than 0.5 per cent on a No. 30 sieve and not more than 10 per cent on a No. 200 sieve ......"

Both products were sealed in air-tight containers until required for physical tests. Four physical tests were performed: (1) Fineness; (2) Normal Consistency; (3) Time of Setting and (4) Compressive Strength. Each test followed the procedure outlined by ASTM Designation C141-55, Specifications for Hydraulic Hydrated Lime for Structural Purposes.

TEST RESULTS

Petrographic Study

A petrographic examination of the limestone from Ghana revealed that it is a fine-grained dolomitic limestone. A full account of the study is included as an Appendix to this report.

Chemical Composition

The results of chemical analyses on the two pulverized limestone samples are given in Table 1. The figures shown are averages of two individual analyses made on each sample.

TABLE 1

Chemical Analyses*

Constituents	Limestone Samples No. 1 %	No. 2 %
CaO	32.99	31.70
MgO	17.12	18.09
SiO_2	4.26	3.47
Fe_2O_3	1.14	1.10
Al_2O_3	1.20	1.10
CO_2	-	-
SO_3	<0.01	<0.01
L.O.I.	43.04	44.32
H_2O	-	-

* Refer to ASTM Designation C25-58.

Calcination Tests

Table 2 gives the results of the calcination tests performed on the twelve samples riffled from the Ghanaian limestone.

TABLE 2

Results of Calcination Tests

Sample No.	Time hr	Temperature °F	CO_2 %
1-A	2	1700	17.70
2-A	2	1700	22.08
1-B	2	1900	0.34
2-B	2	1900	0.33
1-C	2	2100	0.22
2-C	2	2100	0.35
1-D	2	2300	0.10
2-D	2	2300	0.25
1-E	2	1800	9.83
2-E	2	1800	9.20
1-F	2	2000	0.38
2-F	2	2000	0.39

Physical Tests

Table 3 shows the results of the physical tests performed on the quicklime produced by calcining the two 12-pound limestone samples for 2 hours at 1900°F.

TABLE 3

Quicklime Physical Test Results

ASTM Reference	C141-55		C187-58	C191-58	C141-55	
Quicklime Sample	Fineness Retained on No. 200 Sieve %		Normal Consist. %	Time of Setting hr-min	Compression Test psi	
	Sample	ASTM Limit	Sample	Sample	Sample	ASTM Limit
No. 1	8.0	10.0	79.5	19-00	265	Not less than 350
No. 2	8.0	10.0	103.0	15-00	365	

DISCUSSION

In appraising a raw material for the manufacture of a hydraulic cement, it is customary to determine its hydraulic index; this can be determined from its chemical analysis. Such an index is merely a first approximation and is a quotient which results from dividing the sum of the silica and alumina percentages by the CaO percentage of the rock in question. Natural cements have indices ranging from 0.4 to 1.5.

The average hydraulic index for the Ghanaian limestone in question is 0.15, which indicates a raw material of potentially low hydraulicity. This fact, coupled with the low silica content, supports an assumption that the Ghanaian limestone would not produce a natural cement of good quality. This limestone may, however, be considered for the production of a magnesian quicklime.

A relatively new use for lime is in soil-stabilization of road bases and sub-bases.[1] Tests carried out by L. W. Lu et al[2] have pointed out the fact that strengths seem to be related to the calcium-magnesium ratio and to the use of quicklime vs hydrated lime. It was found that 'dolomitic' quicklime, when added in amounts of 4 to 9 per cent by weight of the soil, usually gave a strength advantage of 50 to 100 per cent over other limes. The 'dolomitic' quicklime is added directly to the soil to be stabilized and allowed to hydrate in place. 'Dolomitic' lime used in this way has given the first important soil-lime which has a satisfactory resistance to weathering. Lu notes that stabilized loess and till specimens cured for 1 to 12 weeks were found in many cases to show a strength gain through 12 cycles of wetting and drying.

Quicklime produced by calcining this Ghanaian limestone might prove effective as a soil stabilizer in this field of road construction.

CONCLUSIONS

The Ghanaian limestone represented by the samples investigated shows potential value as a raw material for the manufacture of a hydraulic lime. However, due to its low hydraulic index, this limestone is not recommended for use in the manufacture of a natural cement.

REFERENCES

1. R. S. Boynton and K. A. Gutschick, "Lime", Industrial Minerals and Rocks, Third Edition Seeley W. Mudd Series.

2. L. W. Lu, D. T. Davidson, R. L. Handy, and J. G. Laguros, "The Calcium-Magnesium Ratio in Soil-Lime Stabilization", Highway Research Board Proceedings, Washington, D.C., 1957.

APPENDIX

PETROGRAPHY OF GHANA LIMESTONE

by

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Megascopic Description

Two large samples, as received, were examined superficially, and a few fragments of each were selected for close study.

The two bulk samples were similar in most respects, consisting of fragments of buff to reddish tan, stratified, very fine-grained limestone. Stratification is effected by slight colour changes in adjacent narrow bands (1-3 mm) and darkening of a few lamellae by dendritic growth of iron oxides. A hydrochloric acid etch test indicated that the rock is a fine-grained dolomite or dolomitic limestone; the calcite content is variable from fragment to fragment. Sample No. 1 contains approximately 5% of dark reddish brown, calcite-rich limestone, impregnated with small nodular growths of oxides.

Microscopic Description   Thin Sections TS-172-60, TS-173-60, TS-171-60

The first two thin sections are similar mineralogically and represent most of the rock. The rock is ultra-fine grained, almost cryptocrystalline. The variation in colour between bands results from different proportions, and colour, of fine impurities; the lighter bands are cleanest, and contain more large crystals (0.05 - 0.1 mm) of carbonate. Dark bands containing oxides also contain a higher proportion of large crystals (0.05 - 0.5 mm), and calcite.

Thin section TS-171-60 represents the red-brown limestone. The rock is microgranular, and crystals are distinctly rhombic in form. Oxides are abundant and dispersed.

Mineralogical Composition

TS-172 and TS-173				TS-171
Grain Sizes (mm)	%	Mineral	%	Grain Sizes (mm)
0.005 - 0.02	2	Calcite	95	0.02 - 0.05
.001 - 0.02	96	Dolomite	1	" "
-	1	Quartz	1	0.02 - 0.05
0.001 - 0.05	< 1	Oxides	3	" "
.01 - .06	< 1	Sericite?	-	

The rock is a fine-grained dolomite; a few bands of calcium limestone must be present in the deposit.

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