DEPARTMENT OF MINES
SOUTH AUSTRALIA

GEOLOGICAL SURVEY

MINERAL RESOURCES DIVISION

LIGHTWEIGHT AGGREGATE PROJECT
SUMMARY OF INVESTIGATIONS 1959-66

by

D. NICHOL
GEOLOGIST

Rept.Bk.No. 70/148

28th September, 1970

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ABSTRACT

Laboratory tests by AMDEL between 1959 and 1966 of samples supplied by the Geological Survey indicated that the Tapley Hill slate should be suitable for the manufacture of lightweight aggregate.

Systematic sampling of this formation and other argillaceous rocks in the Adelaide area is proposed.

A comprehensive bibliography is attached.

INTRODUCTION

This project was initiated by Hosking and Sheridan (1960), during their study of the role of mica in the bloating of clays; a study prompted by an abstract of a Russian article published in 1958, and the accumulation of a large quantity of mica-waste from the Radium Hill mill. While their work indicated that mica has little or no effect on the bloating ability of clay, these authors recommended:-

1. Tests to determine the relationship between clay composition and bloating susceptibility.
2. Collection and test firing of Adelaide clays.

3. Test for possible gas additives which increase bloating susceptibility.

The second phase of the project involved the collection of argillaceous rocks and unconsolidated muds and clays within 15 miles of Adelaide to be tested for their bloating ability (Olliver, 1961). According to Madigan, (1962) tests indicated that the beds with the greatest potential as source material for lightweight aggregate are:-

1. The Tapley Hill slate.
2. Some Recent estuarine muds and clays.
3. Slate and phyllite from the Mount Lofty shale quarry.
4. Red Wilpena Group siltstones and slates at Hallett Cove.

Subsequent more detailed pilot tests in a rotary kiln of samples from these four groups (Madigan, 1963) indicated that the Halletts Cove slate and the Mount Lofty material have a bloating range too small to show promise as commercial bloating material, while the Tapley Hill slate and the Recent clays had a much higher potential. Recommendations were made for:-

1. Further testing of the Tapley Hill Slate.
2. Further investigation and testing of Recent clays from:-
    a. Section 3070, Hundred of Port Adelaide.
    b. Section 1012, Hundred of Port Adelaide.
    c. Section 104, Hundred of Yatala.

Further to these recommendations the Director of Mines indicated that no further work was to be undertaken in Section 104, Hundred of Yatala, and deferred work on the other two clay deposits in Sections 1012 and 3070, Hundred of Port Adelaide, until completion of a survey of the potential of these deposits. Thus subsequent testing was restricted to the Tapley Hill slate. In these tests (Madigan, 1965), it was shown that the Tapley Hill slate, used in the bloated state as a lightweight aggregate, would be suitable in lightweight concrete used in walls, slabs, and concrete masonry units such as are used in house construction, but not for use in structural concrete.

It is however noteworthy that the Tapley Hill slate behaves similarly to the Reids Victorian shale (used commercially in the manufacture of lightweight aggregate in Melbourne) in the pilot kiln and thus may be more satisfactorily bloated in a commercial kiln.

In a follow-up project on the Tapley Hill slate (Madigan, 1966), a product suitable for making lightweight concrete of structural grade was obtained by injecting sand into the kiln during the bloating operation to produce a "coated aggregate", and then selecting the desired quality for the cement-mix. This stage was sufficiently promising to suggest that the formation would be worth further investigation to determine whether it contains more uniform and less weathered material from which a more uniform expanded product might be obtained. It is at this stage that the project now stands.

CONTROLS OF THE BLOATING PROPERTIES OF ARGILLACEOUS SEDIMENTS

The mechanism of bloating is essentially unknown. The resulting problem is that the field geologist does not know what type of clay to look for and must go through the arduous process of collecting all clays within his area and submitting them for testing. The problem of the analyst is that he does not know what to analyse for and must submit all samples to firing tests.

Due directly to the uncertainty about the mechanism of bloating it is not possible to rely on chemical or petrological examination for diagnostic purposes.

For bloating to occur, some mineral or compound, or combination of minerals or compounds must be present that will dissociate or react to liberate a gas at the moment when the mass of clay or shale has fused to a melt sufficiently viscous to prevent the escape of the gas. By no means all clays and shales possess the chemical and physical properties necessary to fulfil this condition.

Several ideas have been put forward:-

1. Bloating ability = f (chemical composition) : (Riley, 1951)

$$= f\ (Al_2O_3 : SiO_2 : \text{fluxing agents})$$

By investigating compositional limits required for bloating, an "area of bloating" was defined within which the chemical composition of a clay must fall if it is to react. However it does not follow that a clay will bloat if its chemical composition falls within the area since the constituent(s) which produces the gas (as yet unknown) may or may not be present.

2. Bloating ability = f (mineralogy) : (Everhart, 1959)

It was established that average $\frac{\text{illite}}{\text{kaolinite}}$ ration is approximately 2.7 for bloating clays and approximately 1.6 for non-bloating clays. However, again the gas producer may or may not be present.

3. <u>Possible gas producers</u> -(various authors)

Pyrite, haematite, other iron compounds, carbonaceous material, hydroxyl minerals, dolomite, calcite, magnesite, ankerite, siderite and gypsum.

4. While the mechanism of bloating remains unknown, several suggestions have been advanced for the nature of the gas responsible for bloating - water vapour, sulphur dioxide, oxygen and carbon dioxide.

a) H_2O, steam - however Hosking and Sheridan (1960) were unable to induce bloating by the addition of mica to a series of non-bloating clays.

b) SO_2 - but sulphide lacking clays still bloat.

c) O_2 (by dissociation of ferric oxide) - not supported by thermodynamic data.

d) CO_2 - carbonate minerals normally all dissociate below 900°C, that is, well below the temperature at which bloating clays normally become pyroplastic.

The current opinion (not without indirect support) holds that CO_2 is the gas responsible, and its occurrence is a result of retention due to non-equilibrium conditions prevailing during flash heating.

A lack of understanding of the mechanism of bloating has also largely contributed to the unwieldy number of variables present in the method of laboratory testing for bloating ability:-

1. The length of the kiln.
2. The diameter of the kiln.
3. The rotational speed of the kiln.
4. The slope of the kiln.
5. The rate of feed.
6. The residence time in different parts of the kiln.

7. The nature of the fuel used to heat the kiln.
8. The initial temperature in the kiln.
9. The range of variation in temperature in the bloating zone.
10. The variation in pressure in the kiln.
11. The size of the material introduced.
12. The shape of the material introduced.
13. The composition of the material introduced.
14. The homogeneity of the material introduced.
15. Firing in an oxidising or reducing atmosphere.

This lack of understanding has contributed also to the uncertainties over control (in terms of additives) of reactions which occur in the kiln including:-

1. Adhesion to the walls of the kiln.
2. Agglomeration.
3. Balling.
4. Ringing.

Also, any advances in the mixing of clays to produce special purpose lightweight aggregates are held up until this mechanism is thoroughly understood.

PROPOSED INVESTIGATION

It is suggested that the form of the present study should incorporate the recommendations of the previous workers on the project and in places enlarge upon the scope of their studies. A basic study of the mechanism of bloating should also be incorporated. This may be broken down as follows:-

I. To supplement the reconnaissance sampling by Olliver and an economic assessment of the feasibility of the following areas.

a. Testing of clays in existing quarries - in the Adelaide area.

b. Investigation of the Woolshed Flat shale near Gawler.

c. Investigation of the Woolshed Flat shale and Balhannah shale in the Tea Tree Gully area.

d. Investigation of the Saddleworth Formation between Elizabeth and One Tree Hill.

e. Investigation of the Wilpena Group shales - Burslem Hill, Bull Knob - Philcox Hill area (S.E. Adelaide).

f. Investigation of the lower Burra Group shale near Warrakilla Hill.

II. Systematic sampling across the strike of particular exposures of the Tapley Hill slate in areas where no restrictions to quarrying exist.

III. a. A survey of the potential reserves of the clay deposits in Sections 3070 and 1012, Hundred of Port Adelaide, since it has been established that these can be satisfactorily bloated in a commercial kiln (Madigan, 1963).

b. Test the above mentioned recent clays in a pilot rotary kiln and test the strength of the product (if satisfactory) in a concrete cylinder.

V. Follow up any promising results obtained in Section I.

VI. Follow a basic study of the factors controlling the bloating ability of argillaceous sediments by submitting selected samples for mineralogical and chemical investigation.

Douglas Nichol.

D. NICHOL
GEOLOGIST

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BIBLIOGRAPHY

AUSTIN, C.R., NUMES, J.L., SULLIVAN, J.D., 1942. Basic factors involved in the bloating of clays. Amer. Inst. Min. & Met. Eng. Trans. v.148 p.149-160.

BROWN, W.P., 1958. Lightweight aggregate in concrete building construction. Commonwealth Engineer. Vol. 56. No. 5. p.62-69.

BURWELL, A.L., 1954. Oklahoma Geol. Surv. Min. Rpt:24, p.1-2.

CHEMICAL ABSTRACTS. 52-10537(b) June 1958.

COLE, W.A., 1954. Classification of lightweight concretes.

ZETTERSTROM, J.D.,. U.S. Bur. Min. Res. I. 5065.

CONLEY, J.E., 1942. Waste slate as a raw material source of lightweight aggregate. Amer. Inst. Min. & Met. Eng. Trans. Vol148. pp.161-166.

CONLEY, J.E. and others, 1948. Investigation of lightweight aggregates from clay and shales. Rept.Invest. U.S. Bur. Min. Res. No. 4401.

EHLERS, E.G., 1958. The mechanism of lightweight aggregate formation. Bull. Amer. Ceram. Soc. v.37 p.95.

EVERHART, J.D., 1959. "If clay or shale makes lightweight aggregate". Brick and Clay Recor. v. 134 No. 5 p.58-59.

FRYER, C.N., 1958. Expanded shale lightweight aggregate. The Australian Builder - October 1958.

HAMLIN, H.P., and TEMPLIN, G., 1962. Evaluating raw materials for rotary-kiln production of lightweight aggregate. U.S. Bureau Min. Information. Circular 8122.

HILL, R.D., and CROOK, D.N., 1960. Some causes of bloating in expanded clay and shale aggregates. Aust. I. of Applied Science Vol. II No. 3. p.374-384.

HOSKING, P.K., and SHERIDAN, G.D., 1960. Lightweight aggregate - The role of mica in bloating of clays. S.Aust. Dept. of Mines Rept. (Unpub.) Rept.Bk.No. 51/32.

JACKSON, T.E., 1903. Trans Ceram. Soc. (Engl.) p. 43 (in discussion of paper by A. Hopwood).

MADIGAN, D.C., 1962. Laboratory testing of clays and shales. Min. Rev. Adelaide v.117, p.47. Amdel Report No. 191

MADIGAN, D.C., 1963. Lightweight aggregate Rotary Kiln Tests. S.Aust. Dept. of Mines Rept. (Unpub.) Rept. Bk. No. 57/100.

1965 Lightweight aggregate - Tapley Hill Shale (1). Min. Rev. Adelaide v.123 p.40.

1966 Lightweight aggregate from clays and shales. AMDEL Bulletin No. 1 - April 1966. p.10-18.

1966 Lightweight aggregate - Tapley Hill shale (2). Min. Rev. Adelaide v.125 p.40.

MURRAY, H., and SMITH, J., 1958. Lightweight aggregate potentialities of some Indiana shales. Indiana Dept. of Conservation, Geol. Surv. Report of Progress No. 12 (1958).

OLLIVER, J.G., 1961. Report on Reconnaissance Sampling - Lightweight Aggregate Project. Min. Rev. Adelaide v,114. p.41.

PLUMMER, N., and HLADIK, W.B., 1951. The manufacture of lightweight concrete aggregate from Kansas clays and shales. Kansas Geol. Surv. Bull. No. 91.

REIDS LIGHTWEIGHT AGGREGATE PTY. LTD., 1960. a) Shalite - Lightweight aggregate for structural concrete. b) Shalite Information Bulletin No. 1. c) Shalite Information Bulletin No. 2.

RILEY, C.M., 1950. Minnesota Geological Survey. Summ. Rpt. No. 5.

RILEY, C.M., 1951. Relation of chemical properties to the bloating of clays. J. Amer. Ceram. Soc. V.34 p.121-129.

SULLIVAN, J.D., AUSTIN, C.R., and ROGERS, E.J.,1942. Expanded clay products. Amer. Inst. Min. & Met. Eng. Trans. v.148. p.139-148.

ZETTERSTROM, J.D., and COLE, W.A., 1956. Expansion of clays and shales from North and South Dakota in a rotary kiln. U.S. Bur. Min. Res. I. 5202.