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A NATURAL POZZOLAN DEPOSIT NEAR TULLY FALLS NORTH QUEENSLAND

by

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PLATES

Plate 1. Locality map of pozzolan deposit
Scale 1 inch to 1 mile.

SUMMARY

An iddingsitised olivine basalt ash is being used, by the Queensland Co-ordinator General's Department, as a natural pozzolan in the construction of the Koombooloomba Dam, Tully River, North Queensland.

Pozzolans are natural or artificial siliceous and aluminous substances which when mixed with lime instead of sand ordinarily used, form a watertight cement which will set under water. Almost all those in general use come from acid volcanic rocks and of particular interest in the case of the Queensland deposit is its satisfactory pozzolanic properties despite its basic composition.

As far as can be ascertained this is the first use of a natural pozzolan of volcanic origin in Australia in a major construction work.

INTRODUCTION

On the 19th September 1958, D.A. White and I examined a natural pozzolan deposit near Tully Falls in North Queensland, and later we visited Koombooloomba Dam on the upper Tully River to further our knowledge on its use.

The examination of the deposit was restricted to the quarry. The possible extent and topography of the deposit were obtained from aerial phtotographs.

The report is intended to record the properties and use of the Tully Falls pozzolan.

LOCATION

The pozzolan quarry is situated two to three hundred yards west of the Ravenshoe-Tully Falls road, about 3 miles north-west of Tully Falls and 11½ miles by road south from Ravenshoe.

DISTRIBUTION

The deposit was mapped by the Queensland Co-ordinator General's Department, who proved the deposit to a depth of over seventy feet.

A study of the air-photographs of the area shows the quarry to be located in about the middle of the deposit, which appears to extend about three miles north and south, and about one mile east and west of the quarry. Hills, probably granitic, surround the deposit on the north, west and south; the Tully River Valley forms the eastern boundary.

TOPOGRAPHY

The surface of the pozzolan deposit is practically flat, with some small creeks incised into it. To the east, the country is deeply dissected by the lower Tully River and tributaries. Westwards the country is steeply undulating.

VEGETATION

The deposit is covered by thick rain-forest.

HISTORY OF THE DISCOVERY, DEVELOPMENT AND TESTING OF THE POZZOLAN

Red, oxidized pozzolan initially mined in the quarry and used for surfacing the Ravenshoe-Tully Falls' road, proved unsatisfactory. When dry the pozzolan was very dusty, and when wet it slimed completely and formed an almost impossible mire.

The original investigations for the proposed Koombooloomba Dam were begun in about 1949 and the first rocks tested for use as aggregate were found to be reactive.

Whilst looking for more suitable aggregates, the Senior Construction Engineer of the Co-ordinator General's Department, Mr. R. Gipps, decided to see also if a suitable pozzolanic material might be locally available.

In early 1950 samples from the quarry were submitted for testing to the Division of Industrial Chemistry, C.S.I.R.O., Melbourne. After some time this initial testing proved the pozzolanic properties of the material revealed several interesting properties of the pozzolan:

(a) the material was an effective pozzolan even without heat-treatment.

(b) tests with alkali, to determine its reactivity showed that the reduction in alkalinity of the solution was very large (600 - 700 millimoles/litre); but the silica released from the pozzolan was negligible (up to 3 millimoles/litre). As these results were unusual further study was begun of the action of this material as a possible inhibitor of alkali-aggregate reaction in mortar.

Mr. C.L.W. Berglin was trained by C.S.I.R.O., in Melbourne, in pozzolan testing techniques and carried out routine testing of the pozzolan in the Engineering Department of the University of Queensland.

Initially, strength tests were made on lime-pozzolan-sand mixtures, followed by similar tests on portland cement-pozzolan mixtures to determine optimum replacement percentages of pozzolan for cement.

The following table summarises the results of these tests, which were kindly supplied by the Co-ordinator General of Public Works, Queensland.

	Strength at 7 days		Strength at 28 days		Strength at 90 days		Strength at 365 days	
	p.s.i.	relative %	p.s.i.	rel. %	p.s.i.	rel. %	p.s.i.	rel %
Darra cement with no replacement	2210	100	3340	100	3840	100	4150	100
Darra cement with 20% replacement	2100	95	3290	98.5	4590	120	4920	118
Darra cement with 30% replacement	1980	89.5	3330	99.7	4440	116	5180	125
Darra cement with 35% replacement	1820	82.3	2970	88.8	3820	99.4	4030	97.2
Darra cement with 40% replacement	1260	56.9	2310	69.2	3240	84.3	3310	79.8
Darra cement with 45% replacement	1290	58.3	1920	57.5	3380	88.0	2660	64.1
Darra cement with 50% replacement	750	33.9	1750	52.3	2510	65.3	2750	66.3

In practice the substitution percentages have ranged from 25% to 33⅓%; 30% replacement being the general rule.

The strengths obtained in the laboratory have not been reproduced in the field, but have proved satisfactory.

Strength tests on lime-pozzolan mixtures using both raw and calcined pozzolan gave consistently satisfactory results. Calcining up to 500-600°C did not appreciably beneficiate the pozzolan; an optimum calcining temperature of approximately 100°C was recommended.

I cannot agree in this aspect of the treatment of the pozzolan;

(a) Heating to 100°C would only drive off the water and is unlikely to effect any permanent change in the pozzolan. Determination of the moisture-content of the pozzolan and subsequent allowance for this content in the volume of water added to the concrete mixture would probably be just as effective as drying at 100°C. It would undoubtedly be cheaper and quicker.

(b) Both the C.S.I.R.O. and the University of Queensland tests indicated that the raw pozzolan was quite satisfactory.

(c) It appears as if the recommendation to heat-treat the pozzolan may have been dictated by convention.

In the early stages of construction of the dam the red, oxidised, pozzolan was used, but later development of the quarry exposed grey pozzolan which proved superior in the cement to the red pozzolan.

GEOLOGY

(a) General. As far as is known, the rocks of the area are all igneous consisting of granite and porphyritic granite which are overlain in places by basalt.

To the south-west, the basalt is mainly effusive, as shown by the recent regional mapping of the Bureau of Mineral Resources and the Geological Survey of Queensland; pyroclastics, particularly finely comminuted ones, are virtually unknown; but in the Tully Falls area, pyroclastic lavas are prominent.

I have been unable to locate on the air photos, any possible vents from which the volcanics were expelled. However a columnar basalt flow in a northern tributary of the Tully River, which joins the river near Cardstone several miles below the falls, must have originated from near the northern end of the pozzolan deposit, but its accompanying vent is not obvious on the air photographs. The obscurity of vents is unusual for the Tertiary basalt areas of North Queensland and suggests that the vents for the Tully River Volcanics have been:

(1) completely removed by erosion;

(2) so modified by erosion that it is not obvious from the air;

(3) obscured by thick rain forest.

(b) The Deposit. The quarry is about 120 yards long (north), 100 yards wide and 15-20 feet deep (Fig.1).

Fig.1. View south-west across pozzolan quarry.

The quarry walls consist of several feet of dark red soil overlying 6-8 feet of red, oxidized, pozzolan which grades down into grey, comparatively unweathered pozzolan.

The pozzolan is massive, with a marked absence of layering or bedding, apart from the colour changes due to weathering. Olivine basalt boulders up to 2-3 feet in diameter are scattered sporadically through the deposit (Fig.2). In the oxidised portion of the deposit the basalt boulders are usually completely weathered, but in the underlying grey part they are completely fresh. They do not have a weathered outer skin, such as would be expected if these boulders were unweathered kernels of flow-basalt. The exposures in the quarry suggest that they are volcanic bombs embedded in a basaltic ash.

Fig.2. Close-up of pozzolan showing compact "crumb texture" and an olivine basalt bomb.

When moist the grey pozzolan in situ is tough and mid-grey. The colour lightens with decrease in moisture content and when dry it is similar to Portland cement.

When dry, the pozzolan is extensively cracked, but still tough and has a compact "crumb" texture (Fig.2). Abrasion or impact readily reduces it to a fine dust which has a 60% greater Specific Surface Area than Portland Cement. (G. MacDonald, Co-ordinator General's Department, personal communication.) When immersed in water the pozzolan slimes readily.

PETROLOGY AND GENESIS

A thin section of the basalt ash was examined by W.B. Dallwitz, who described the material as finely comminuted, much altered and containing small fragments of iddingsitized olivine basalt.

Thin sections of the volcanic bombs have been described by the Queensland Geological Survey to contain flow-banded olivine basalt and iddingsitized olivine (W.E. Bush, personal communication).

The ash of the pozzolan deposit was probably derived from old flow-basalt by violent explosive activity and the bombs derived from magma emitted during the eruption.

The absence of lithification and the almost undissected surface of the deposit suggest it is of Pleistocene or Recent age.

POZZOLANIC PROPERTIES

Mielenz, Greene and Schieltz (1951) remark (p.319) "Andesites, basalts, basaltic tuffs and ashes are inferior or wholly unsatisfactory in quality as pozzolans ." Yet, the Tully Falls pozzolan of basaltic composition is apparently satisfactory. Obviously then the pozzolan contains unusual properties which account for its pozzolanic properties.

Mielenz et al. (1951, p.317) have proposed ten groups of pozzolans called "Activity Types". In Activity Type 3a, kaolinitic clay is the active ingredient and altered pumicites and tuffs are included in this group. The alteration product of the Tully Falls pozzolan has not been determined, but it could be kaolin and this would account for some, if not all, of the pozzolanic activity. The fine comminution of this basaltic ash could also contribute to the possolanic properties.

In a discussion of Activity Type 3a, Mielenz et al. (1951) states (p.322) "all clayey pozzolans must be calcined at temperatures over 1000°F to induce optimum activity and reduce water requirement........ All clayey pozzolans require grinding to develop proper fineness." The experiments at Koombooloomba Dam have shown that calcining and fine grinding do not appreciably beneficiate the grey pozzolan.

It is possible the fine comminution of the pozzolan accounts for this anomaly.

CONCLUSION

Further experiments on the Tully Falls pozzolan are required to determine the "active ingredient" or "ingredients" responsible for its pozzolanic properties.

The results of these experiments would be of considerable assistance in locating further pozzolan deposits, not only in North Queensland but elsewhere in Australia, where Tertiary basalt pyroclasts are exposed.

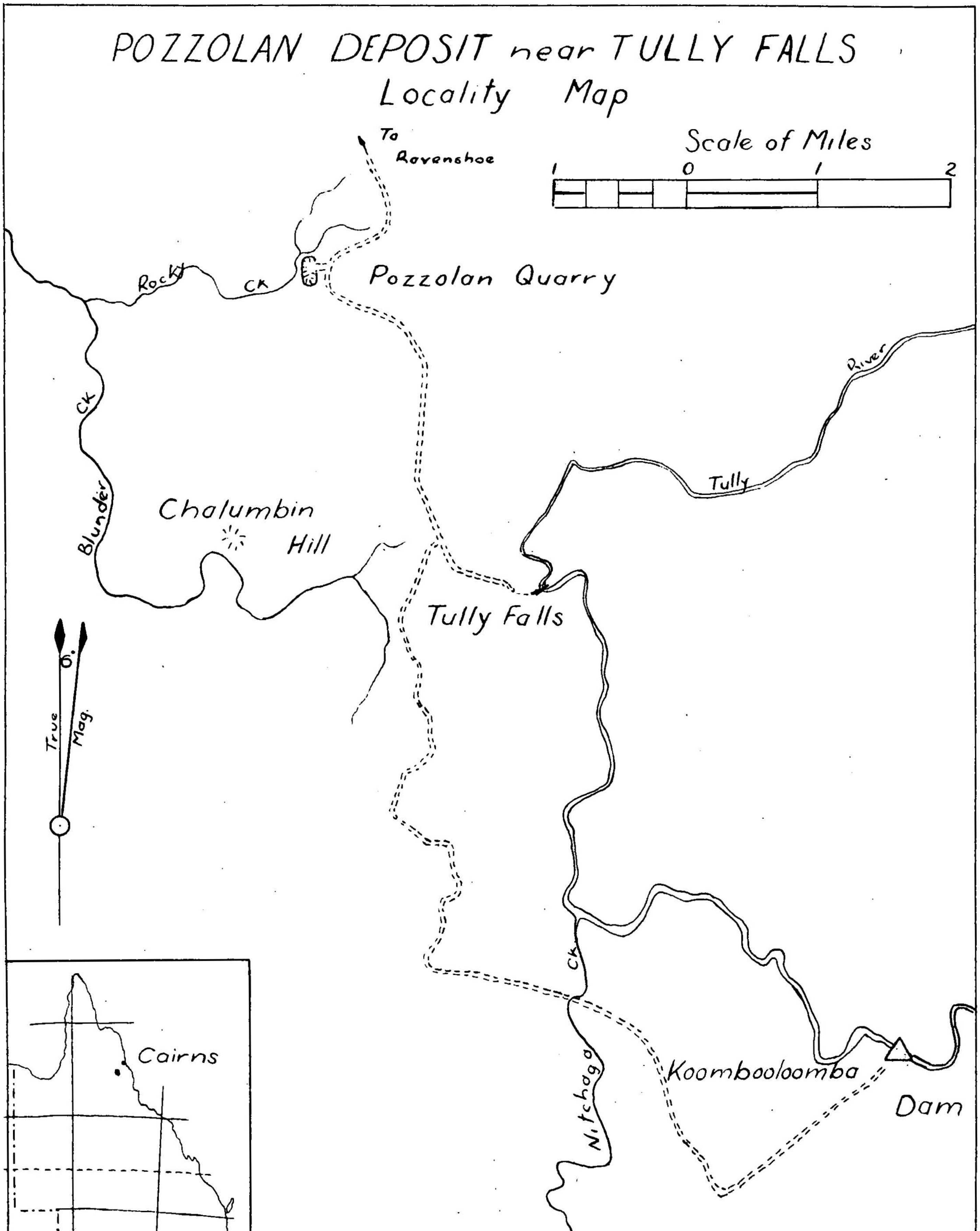
ACKNOWLEDGMENT

I wish to thank Mr. J.E. Kindler, Chief Engineer, Co-ordinator General's Department, Queensland for details of the discovery and subsequent testing of the pozzolan.

REFERENCE

Mielenz, R.C., Green, K.T., and Schieltz, C.N., 1951 - Natural Pozzolans for Concrete. Econ. Geol., 46(3), 311-328.

Fig 1.


POZZOLAN DEPOSIT near TULLY FALLS
Locality Map
Scale of Miles
1
0
1
2
To Ravenshoe
Pozzolan Quarry
Rocky
CK
CK
Blunder
Chalumbin
Hill
Tully Falls
Tully
River
True
Mag.
6°
CK
Nitchaga
Koombooloomba
Dam
Cairns