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THE WELLS LIMESTONE, A.C.T., AS A SOURCE OF AGGREGATE.

by

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SUMMARY

Wells Limestone, situated 8 miles from Canberra in A.C.T., is a lens of massive limestone in a formation largely consisting of shales of Silurian age.

The gently undulating topography and the low relief of the area of outcrop itself do not provide an attractive quarry site, although the stone seems very suitable for use as aggregate.

Soil interpretation from shallow bores indicate considerable extensions of the deposit beyond the outcrop. 'Indicated' and 'inferred' reserves of limestone has been calculated, although further proving of reserves should be done before it is decided to establish a crushing plant at the deposit.

INTRODUCTION

The deposit known locally as Wells Limestone is situated near Wells Station in the Australian Capital Territory, approximately 8 miles north of Civic Centre, Canberra. Access from Canberra is by the Federal Highway, then by gravel road to Gungaderra Homestead which is situated about one mile south of the deposit. The Department of Works has improved the road to the Homestead and has gravelled the track from the Homestead to the deposit to provide all-weather access for heavy vehicles.

In the vicinity of the deposit the topography is gently undulating and limestone crops out mainly on the flank of a low ridge between two small water courses which trend in a southerly direction. The deposit does not provide an attractive quarry site because the maximum relief in the area of outcrop is only 16 feet. Furthermore, the western boundary of the outcrop is in part only 12 feet higher than the depression which forms the headwaters of the watercourse situated west of the deposit. The plan accompanying the report (A.C.T. 3-15) was made by plane table and stadia.

PREVIOUS INVESTIGATION AND DEVELOPMENT

The existence of limestones within Silurian sediments north and north-east of Canberra has been known for many years but the examination of these deposits as possible sources of aggregate followed geological mapping by Dr. Öpik, of the Bureau of Mineral Resources, who had noted a number of lenses of limestone in the northern corner of the A.C.T. Preliminary geological maps of a number of these lenses were made by the Bureau in early 1951 and preliminary exploration carried out at the same time by the Department of Works proved that the Wells Limestone deposit was the only one from which significant tonnages were likely to be obtained. A preliminary map of this deposit was made, a pit was sunk to 10 feet on the outcrop and a grid was laid out for diamond drill holes at angles of 45° from the vertical to prove the stratigraphic sequence within the deposit. However, on account of the difficulties anticipated in drilling the limestone, no reasonable quote for the work could be obtained and the scheme was abandoned.

Subsequently, the deposit was opened up in a small way by the Department of Works with the idea of hauling the limestone to a crushing plant in Canberra. This has resulted in the present small open cut (approximately 20 feet maximum depth) and small stockpiles of limestones, with associated clay, are at grass.

No detailed investigation of reserves of limestone was required for this venture but the question of reserves is now important because the Department of Works is considering Wells Limestone as a possible site for a new crushing plant to be delivered early in 1953.

GENERAL GEOLOGY

Rock Outcrops

Rock outcrops at the deposit consist of massive limestone and small exposures of boulders of ironstone and surface quartzite or "grey billy".

Crystalline limestone, in most places white, grey or buff in colour, crops out as boulders or plates one to four feet in thickness, elongated with the strike, in a roughly wedge-shaped area. The average strike of the limestone is 10° with steep dips averaging about 75° to the east. No reversals of dip have been observed and the deposit appears to be situated on the flank of a major fold. None of the exposures show any trace of intercalated shale within the limestone and, although shale intercalations would not outcrop as prominently as the limestone, it is probable that the deposit consists of massive limestone. Exposures of the limestone show little metamorphism, but exceptional quartz veins do occur. The only one noted is exposed in the face of the cut and is almost vertical. The width of the vein increases in depth from about 6 inches near the surface to 15" at the bottom of the cut and may widen farther in depth. Limestone on both sides of the vein has been re-crystallized into coarse calcite crystals for a width of about 6 inches but no other metasomatic effects and no pyrite mineralisation were observed.

Exposures in the pit near Station "C" (see Plan) show two small faults and similar small dislocations, probably with associated faulted clay, are to be expected elsewhere in the deposit, but there is no evidence at present of major faults within the limestone. There is little evidence to establish the plunge of the limestone but lineations within the rock suggest a low plunge to the south of the order of 5°. In some places the limestone is coarsely bedded and shows solution cavities, many of which are controlled by bedding planes.

There is little doubt, judging by the occurrence of limestone elsewhere in Silurian sediments near Canberra, that the Wells Limestone is a roughly lenticular bed within shaly sediments and the wedge-shaped area of outcrop suggests that the lense is faulted on its northern margin or that limestone continues for some distance to the north under soil cover. Likely extensions of the limestone will be discussed in the next section.

Ironstone crops out towards the south-eastern corner of the area mapped and fragments and boulders of the same material are scattered over the low ridge in the southern and western portions of the area. Some of the ironstone pebbles are concretionary and may be of pedological origin but the outcrop and most of the fragments are not the results of soil processes. The surface quartz is found in boulders on the low ridge and particularly in the north-eastern corner of the area near Station "E", where it clearly overlies the limestone. The quartzite is normally a hard, glassy rock, the result of silicification of sand grains and pebbles of quartz and quartzite. The association of reddish soil, pisolites of ironstone and grey billy at first suggests that a lateritic profile may be involved but more detailed work has shown no evidence of lateritization.

Investigation by Shallow Bores

As most of the area concerned is covered by soil an attempt had to be made to interpret the geology by the examination of shallow bores. These were sunk by the Department of Works who made available a mechanical post-hole digger capable of digging, in soil, a hole of 22 inches diameter and 8-9 feet depth. The position of these holes and the geological interpretation are shown on the plan.

The interpretation of the results is by no means clear-cut because in no case did the hole reach definite bedrock, and interpretation had, therefore, to be based on soil and rock fragments. Holes in heavy pedocalcic soil containing boulders or fragments of primary limestone are fairly certainly overlying limestone and those in any more sandy soil with fragments of shale are equally sure to overlie sediments which have at least some sandy shale content but the occurrence of fragments of secondary limestone - probably due to locally restricted drainage in the soil - complicated interpretation in a number of holes.

The eventual interpretation on the evidence available is shown on the plan. The limits of massive limestone have been extended to the south-east and north but the general shape of the deposit remains much the same as that of the outcrop. There is evidence, perhaps not conclusive, of a major fault or fault zone on the eastern side of the limestone and this may constitute, in part, the western boundary of the deposit. There may well be more limestone than is shown on the plan in the south-western corner of the deposit between hole 1 and the fault but holes 1, 13 and 9 show a white kaolinitic clay with fragments of quartz and of limestone - probably of secondary origin - and as the clay seems more likely to be related to shale than to limestone, this area is best left out of the reserves until further information is available.

Towards the southern limit of the area mapped, holes 20, 4, 17 and 27 appear to overlie limestone but it is prudent at this stage to interpret these as representing small isolated lenses of limestone in shales along the strike of the main lens or perhaps in the case of holes 4 and 17, the lensing out of the main limestone. In any case, they have been excluded from the reserves.

If the northern extension of the limestone body, based entirely on soil interpretation, proves to be correct then some additional reserves can confidently be southt north of this inferred boundary because, in the absence of any evidence of a westerly trending fold to cut off the limestone, and with only a low plunge to the south, the northern end of the deposit could be expected to taper northwards. Unfortunately, auger holes at the northern end of the area found deep soil cover, far from outcrop, and are regarded as inconclusive.

The evidence from auger holes and outcrop, therefore, suggests the picture of a major lens of massive limestone in a sedimentary formation consisting mainly of shale and sandy shale with some smaller lenses of limestone intercalated with shales along the strike of the main limestone. This formation is displaced by a major fault, to the immediate west of which the rocks consist of shale and porphyry or tuff with no limestone. Outcrops of ironstone on the probable fault suggests that at least some of the ironstone is the result of the introduction at some places of iron-bearing solutions along the fault. The most logical explanation of the billy or surface quartzite overlying the limestone is linked with the occurrence of Lower Devonian lavas which form part of the Majura hills about ½ mile east of the deposit. These lavas almost certainly extended farther westward in Devonian time and probably caused silicification of gravel and scree on the surface which they overrode, just as Tertiary basalts have produced similar billies in parts of eastern Australia. The surface quartzite, therefore, probably represents an exhumed Lower Devonian land surface. The origin of the ironstone is not clear, but some have probably been introduced by hydrothermal solutions along the fault, some by pedological processes akin to iron introduced by the over-riding Lower Devonian volcanics.

WELLS LIMESTONE AS A SOURCE OF AGGREGATE

As a rock, Wells Limestone appears very suitable for use as aggregate. The main deposit is massive with little or no interbedded shale, and exposures show no fine-bedding or cleavage which would produce flaky rock. The rock would be easier crushed than any other type of suitable aggregate offering in Canberra. The percentage of quartz from veins can be expected to be very small.

There is no evidence to suggest that the rock could give rise to expansive reactions in concrete but it would be advisable to test the limestone for stripping tendencies when used with bitumen in road construction. The subject of stripping will not be discussed in this report, but, in general, recent experience in both U.S.A. and New South Wales indicates that although limestone is one of the few rocks likely to provide satisfactory bonding with bitumen without recourse to additives, this should not be taken as a general rule because some limestones, unaccountably, do strip to a considerable extent. It is therefore, a standard practice by Main Road Authorities to test each limestone deposit before using.

The main disadvantages of the Wells Limestone as a source of aggregate stems from its topographic position. The production of large tonnages could be achieved only by quarrying down into the deposit and the heavy clay associated with the limestone will be an embarrassment, at least until the top 20 feet of the deposit is benched off. Most of this clay is concentrated in the upper ten feet of the deposit, but in places it persists in cracks down to 20 feet and may be expected in smaller amounts below that level. A washing plant would probably be necessary to ensure continuous production, at least until the uppermost part of the deposit had been removed. The problem of ground water should also be considered. The present cut, at a maximum depth of 20 feet below the surface, drains readily, because water collected disappears down cracks in the limestone, but if the water table, or a perched water table, is reached by the cut, constant pumping would be required. There is little evidence on which to base an estimate of the level of the water table, but it would be prudent to expect the water table somewhere between 40 and 70 feet from the surface.

RESERVES OF LIMESTONE

The following estimates of reserves (shown on table 1) have been calculated at this stage for the express purpose of indicating to the Department of Works the order of probable reserves so that the Department can decide whether further exploration is warranted. If the order of reserves makes Wells Limestone an attractive site for the new crushing plant, further proving of reserves will be required. If, on the other hand, the limestone is to be used as an auxiliary supply to a plant established on a larger deposit, such as that at Mugga, there seems little reason to spend money at present on more accurately defining reserves at Wells Limestone.

TABLE I

RESERVES OF CRUSHABLE ROCK

WELLS LIMESTONE

(in Cubic Yards)

CATEGORY	SECTION	AREA (sq. feet)	RESERVES Depth from Surface.						
			0-10'	0-20'	0-30'	0-40'	0-50'	0-70'	0-100'
Indicated Reserves	Outcrop	266,800	49,000	123,000	202,000	281,000	360,000	518,000	755,000
Inferred Reserves	Probable extensions of Deposit	291,000	54,000	135,000	221,000	307,000	393,000	566,000	824,000
Total Reserves			103,000	258,000	423,000	588,000	753,000	1,084,000	1,579,000

Factors used to convert volume of deposit to crushable rock -

	Estimated Percentage of Crushable Rock.		
	0-10'	10'-20'	below 20'
Outcrop	50%	75%	85%
Probable extensions (overburden removed)	50%	75%	75%

The following points should be noted in evaluating the reserves given on Table 1.

1. The reserves are shown in two categories - Reserves based on the area of outcrops are regarded as "indicated" reserves because there is little doubt that the steeply dipping limestone will persist downwards to 100 feet. Reserves based on probable extensions of the deposit are obviously less reliable and are regarded as "inferred" reserves.

2. In these preliminary calculations no account has been taken of surface contours because the relief is so small as to have little effect on the order of reserves.

3. An attempt has been made to show the reserves as the volume, in cubic yards, of "crushable rock" by reducing the calculated volume of sections of the deposit by factors which, as near as can be judged, allow for clay, solution cavities and rock other than limestone. These factors, (shown in Table 1,) are necessarily rather arbitrary although they are based on exposures, particularly those in the cut.

4. No allowance has to be made for the removal of overburden in the area of outcrop but in the area of probable extension of the limestone, overburden consisting of clay soil (with boulders of quartzite and ironstone in some places) ranging in thickness from 4 feet to more than 9 feet (maximum thickness unknown) will have to be removed.

ADDITIONAL EXPLORATION

This could be carried out by means of costeaning by bulldozer, by sinking pits or by drilling. Bulldozing has already proved ineffective where boulders of limestone in clay are involved, and pitting probably provides the least information for the money spent. Moreover, neither of these methods provides information of the character of the deposit at depth. It is recommended, therefore, that if proving of reserves is warranted, money available should be allocated, in the first place, to drilling.

However, it is fairly certain that only percussion drilling will be possible, with the grave disadvantage that the holes must be vertical. As the deposit has an average dip of about 75° a vertical hole to a depth of 100 feet only penetrates a stratigraphic thickness of about 26 feet. Hence exploration by a small number of percussion drill holes is not likely to provide much reliable data on the percentage of shale within the deposit. On the other hand, the drill holes would establish the depth of overburden at points, the type of rock at depth, and would provide data on ground water.

It is impossible to indicate at this stage the minimum number of holes which would be necessary to adequately prove the reserves but if the writers' assumptions and interpretations are largely correct it should be possible to prove the reserves with 5 holes, each drilled to the lower limit of the proposed workings. The cost of this minimum programme at a contract price of 37/6 per foot for percussion drilling, would range from £500 to £1,000 depending on the depth of the proposed workings, and hence on the reserves required. Complications in either structure or lithology may double the amount of drilling required to prove reserves. A layout for exploratory drill holes will be provided if required, and if percussion drilling is done these holes will need to be carefully logged to provide the maximum amount of geological information.


WELLS LIMESTONE
A.C.T.
SCALE
50 0 50 100 150 200 250
FEET
GEOLOGY by L.C. NOAKES and W. J. PERRY.
REFERENCE
pl primary limestone
?pl probably primary limestone
sl secondary limestone
?sl probably secondary limestone
wp weathered porphyry
?wp probably weathered porphyry
sf shale fragments
?sf probably shale fragments
inconclusive
approximate boundary of massive limestone outcrop
limits of limestone inferred from shallow bores.
dip and strike of limestone
contours, levels from arbitrary datum
auger hole showing number and depth
plane table station.
fence.
probable fault . concealed
Dump limestone and clay
scattered boulders of ironstone
true
magnetic
N
ACT 3-15