STATE OF OREGON

DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

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**G M I SHORT PAPER**

NO. 15

# RECONNAISSANCE GEOLOGY OF LIMESTONE DEPOSITS in the WILLAMETTE VALLEY, OREGON

by

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Geologist
Department of Geology and Mineral Industries

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Price 15 cents

# FOREWORD

The need for cheap agricultural limestone in the Willamette Valley was the incentive for the study which this report represents. Such stone is cheap only if low in cost per unit of carbonate or neutralizing value. Therefore, the low carbonate limestones of the Willamette Valley are not cheap compared to much higher grade stones from southwestern and northeastern parts of the state. Because of low neutralizing value, Willamette Valley deposits have areas of distribution restricted to a relatively small radius in competition with higher grade stone.

One of the objects of the study was to search for deposits higher in grade than the known limestone beds at Dallas and Marquam. Higher grade stone comparable in quality to deposits in the southwestern and northeastern parts of the state was not found, and it seems likely that all the limestones of the Willamette Valley are geologically similar so that the chances of finding higher grade stone in quantity in the valley are extremely poor.

F. W. Libbey,
Director

May 21, 1946.

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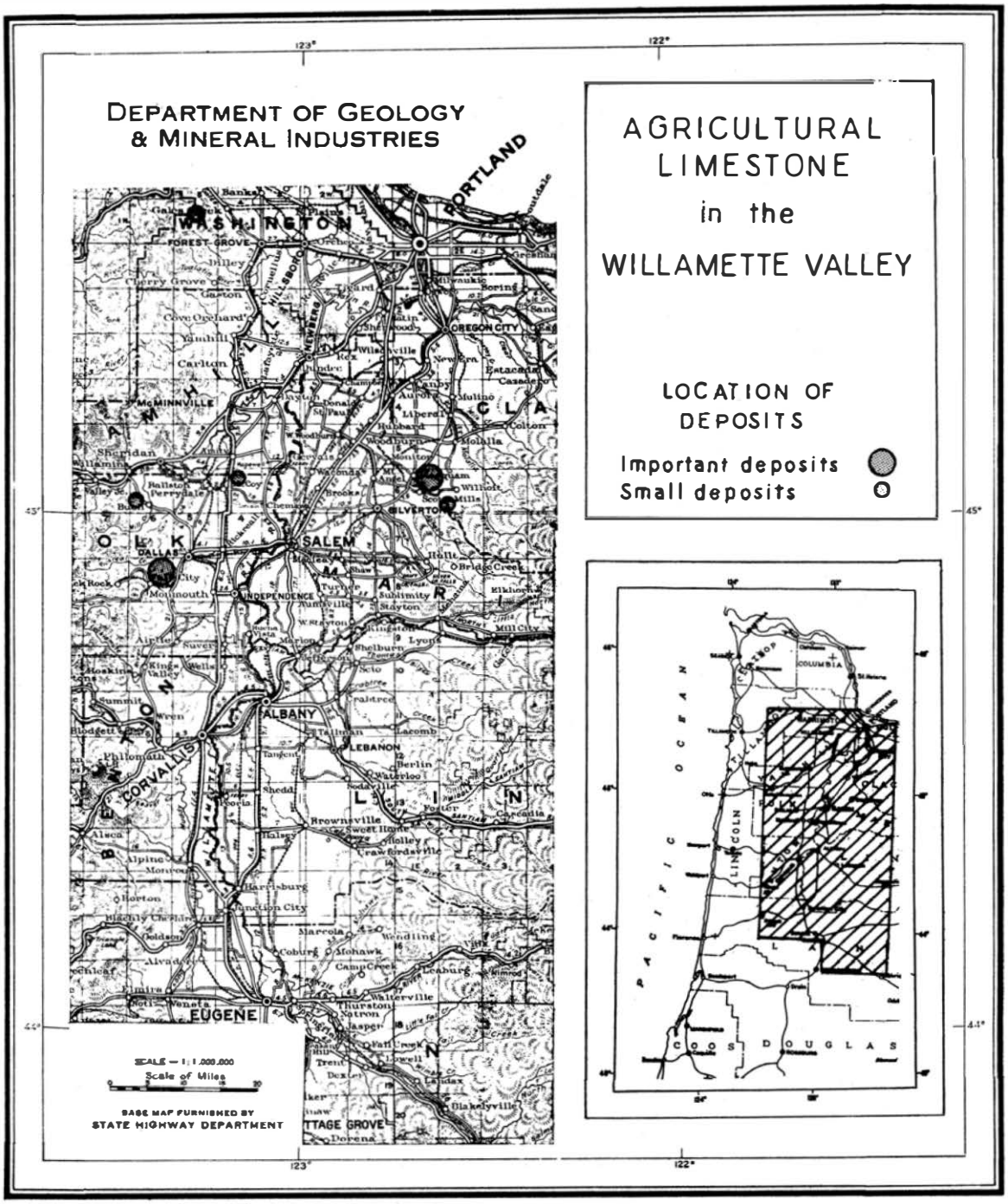
DEPARTMENT OF GEOLOGY
& MINERAL INDUSTRIES
AGRICULTURAL
LIMESTONE
in the
WILLAMETTE VALLEY
LOCATION OF
DEPOSITS
Important deposits
Small deposits
PORTLAND
SALEM
ALBANY
CORVALLIS
EUGENE
LEBANON
OREGON CITY
McMINNVILLE
DALLAS
FOREST GROVE
HILLSBORO
STAYTON
SILVERTON
MOLALLA
COLUMBIA
LINCOLN
COOS
DOUGLAS
PACIFIC OCEAN
SCALE — 1:1,000,000
Scale of Miles
BASE MAP FURNISHED BY
STATE HIGHWAY DEPARTMENT
123°
122°
45°
44°

## INTRODUCTION

The soils of the Willamette Valley require 1,000,000 tons of agricultural limestone to neutralize acidity; they will need 400,000 additional tons annually in order to maintain them in that condition and to provide calcium for growing crops. This statement was made by Dr. R. E. Stevenson of Oregon State College in the Oregonian of December 24, 1944.

Early in 1940 the Oregon Department of Geology and Mineral Industries undertook a field survey of the occurrences of limestone in the Willamette Valley with the object of determining what deposits might be utilized at least in part to fill the need for agricultural stone. Wartime application of Departmental energies to the study of more strategic minerals has postponed publication of this report.

During the field survey, metallurgical tests were made in the laboratories of the Department and by the U. S. Bureau of Mines to determine, insofar as facilities permitted, whether the low-grade limestone of the valley could be beneficiated. The results were published in 1940 as G.M.I. Short Paper No. 4 by Clemmer and Clemmons[1].

The survey of the Dallas, Marquam, Amity, and miscellaneous deposits was made by the writer in 1940, and the Clear Creek deposit was visited early in 1946. The report on the Buell deposit was revised by W. D. Lowry and R. S. Mason of the Department's staff who examined the deposit in March 1946. Acknowledgement is made of the generous assistance of Messrs. T. T. Leonard of Silverton and J. B. Bywaters of Dallas in the compilation of data on the Marquam and Dallas deposits.

## GEOLOGICAL SETTING

The lower Willamette Valley is a relatively level plain, from 5 to 25 miles wide and more than 100 miles long, which is interrupted here and there by low rolling hills and north- and northwest-trending ridges. A few spurs from the adjoining Cascade Range to the east and from the Coast Range to the west extend out into the valley and break its monotony.

The Willamette Valley is in part a downwarped structural basin, in part the result of erosion by the river and its tributaries. The floor of the valley is largely covered with Pleistocene and Recent gravels, sands, and silts. Pleistocene terrace deposits also occur up to an elevation of several hundred feet along the valley borders. Bedrock in the valley is predominantly composed of gently east-dipping lower Tertiary sandstones and shales, with some tuffs and breccias along the eastern and southern borders. Basaltic flows and intrusions out through or are interbedded with these sediments at a number of places.

The Coast Range on the west is essentially a broad, irregular, and more or less complicated arch or fold in lower Tertiary sediments, basalt flows, and agglomerates. East of the valley, in the Cascade Range, the sediments interfinger and grade into fragmental volcanic material. They are there overlain by lava flows with varying amounts of interbedded tuffs and breccias.

The great series of sandy and shaly sediments, totaling nearly 2 miles in thickness, which makes up the bedrock of the Coast Range and Willamette Valley, was deposited in or near shallow seas, the shores of which fluctuated but were probably never far from the present eastern border of the valley. The ancient volcanoes of the Cascades were at the same time active, and the material from them became interbedded with the sediments along the shoreline; the finer ashy material was added to the sediments laid down in deeper waters. In certain embayments of these seas favorable conditions occurred, although not frequently, for the growth of marine organisms with calcareous shells. These organic remains piled up in the embayments to appreciable thicknesses, and were later consolidated to form lens-shaped deposits with a relatively high lime content, resulting in the only limestone deposits of

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[1] References at end of paper.

substantial size in the valley. Calcite also occurs in low concentration associated with and included in the basalts and pyroclastics at several places along the western edge of the valley.

## SUMMARY OF DEPOSITS EXAMINED

Twenty-five localities reported to contain limestone were visited. Only four of these gave evidence of being of such size and grade as to warrant present consideration as possible sources of commercial agricultural limestone. Detailed descriptions of these four deposits are given in the following pages. The other reported occurrences are recorded as to location, character, and grade in an accompanying table.

Limestone between Dallas and Falls City in Polk County is for convenience called the Dallas deposit. It is the only one which has probable reserves of the order of tens of millions of tons. The major part of the deposit is owned by the Oregon-Portland Cement Company. The Lime Products Company (which also owns the Marquam deposit located about 1 mile north of the Marquam post office) controls most of the remainder. Apparently that portion of the deposit owned by the latter company is somewhat higher in grade, and is sold exclusively for agricultural purposes. The Oregon-Portland Cement Company's deposit is being quarried wholly for the manufacture of cement at Oswego near Portland.

The Marquam deposit may contain a few million tons, but the amount has not been proved. The calcium carbonate content varies considerably in different parts of the deposit.

Indications are that the Buell deposit in northern Polk County averages more than 50 percent calcium carbonate with reserves which may be moderately large but have not been proved.

The Amity deposit in northeastern Polk County, although of fair grade, appears to be small and has a heavy overburden. It is probably not of commercial value.

## DESCRIPTION OF DEPOSITS

### Dallas deposit — Polk County

Owners and area: Oregon-Portland Cement Company, 111 S.E. Madison Street, Portland 14, Oregon, (925 acres); Lime Products Company, Dallas, Oregon, (186 acres). E. W. Smith, G. F. McBee, and George Gohrke, all of Dallas, Oregon, also own land in part, at least, underlain by limestone.

Location: The Dallas limestone bed crops out in the northeast portion of T. 8 S., R. 6 W., from 2 to 4 miles southwest of Dallas, Polk County, on the western edge of the Willamette Valley. Two quarries have been developed, the north quarry by the Oregon-Portland Cement Company in the northwest corner of sec. 12, and the south quarry by the Lime Products Company near the center of the east edge of sec. 11. Limestone possibly underlies a large part of a tract of nearly 1000 acres in the E½ of sec. 11, the NW¼ of sec. 12, and the S½ and NE¼ of sec. 1. It may also occur in the extreme northwest corner of sec. 1, southeast corner of sec. 2, and in the northeast corner of sec. 14.

Development: The Oregon-Portland Cement Company quarry now covers an area of more than 5 acres; the quarry of the Lime Products Company, a half a mile south is much smaller, covering less than 2 acres. The face in the former varies up to 50 feet in height; the latter up to 30 feet. Both quarries are served by a 3-mile railroad spur; the Oregon-Portland Cement Company has an additional half mile of narrow gauge track from quarry to crusher and bunkers.

Topography and miscellaneous: The limestone beds occupy the western slopes of two small valleys which drain in opposite directions, north into Rickreall Creek and south into the Little Luckiamute River. The local relief is about 300 feet; the slopes are gentle. The north quarry is about 600 feet in elevation; the south about 500 feet.

Geology: The limestone occurs at the base of a marine series of Cowlitz age, (Schenk, 1936) composed largely of tuffaceous sandstones and shales which dip gently to the east and south. The limestone horizon is at least 75 feet thick at the south quarry (although only 50 feet is exposed) and more than 50 feet thick in the north quarry where basalt, believed to be the equivalent of the Tillamook volcanics, (Warren, 1945) is exposed in the floor. Fossils from the limestone have been identified by Stokesbary (1934).

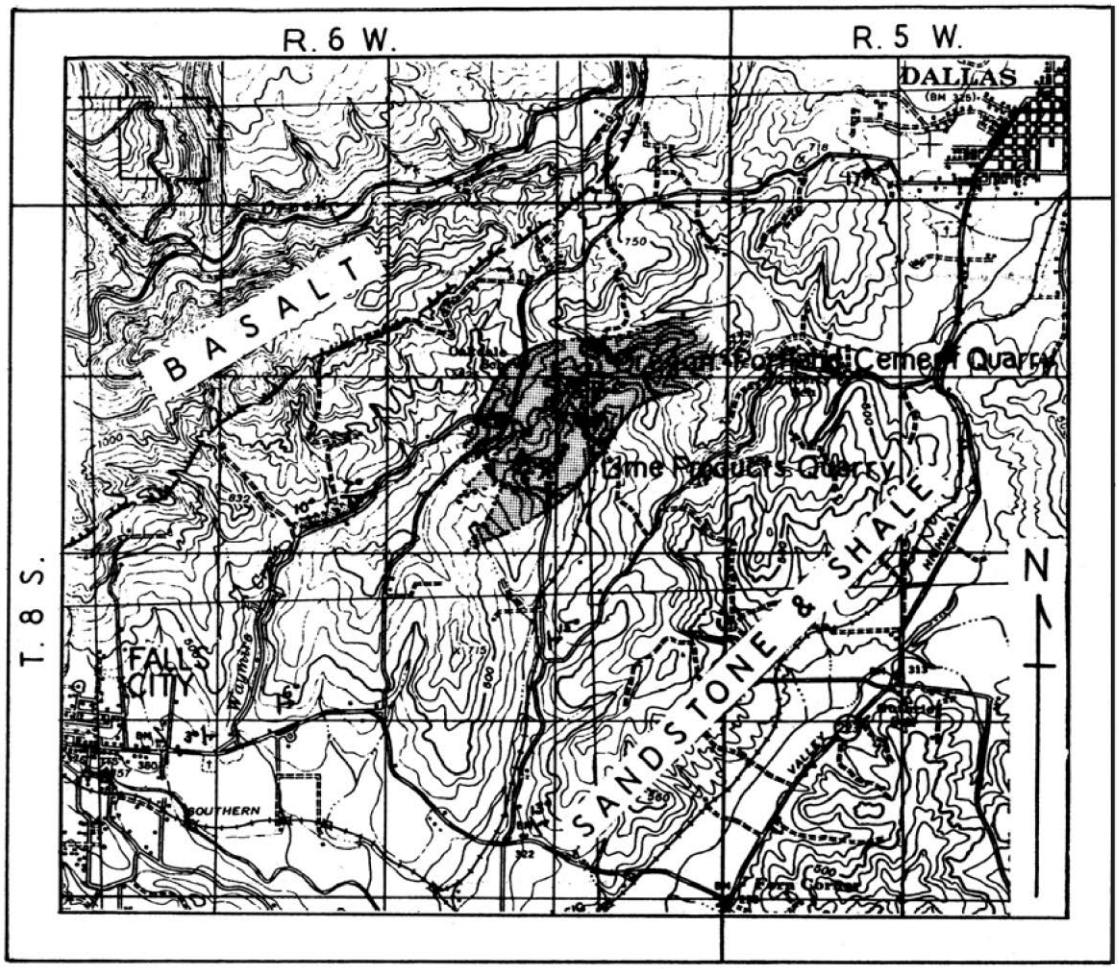
Dallas limestone crops out as a dark gray, massive rock, which weathers first to a light buff color, and then to deeper shades of iron-oxide red. The porous, brown sandy residual material is developed, first by solution of the lime, then by alteration of the tuff grains. The weathering profile as exposed in the quarries consists of a red clay soil from 2 to 10 feet deep, followed by porous leached limestone from 2 to 6 feet thick. This zone extends downward for several tens of feet into the limestone along joint planes, as well as outward from the joints along bedding. The main joints occur in 2 sets, the first strikes nearly north, and the second strikes east. They are spaced from a few feet to tens of feet apart. Bedding is best shown by light and dark banding rather than by bedding plane separations. Beds in the south quarry dip up to 14° to the south, in the north quarry about 5° east. The regional dip is generally easterly, at low angles.

Hand lens examination of fresh specimens shows the rock to be composed of subangular grains of calcite, rounded grains of quartz and feldspar, and occasional small subhedral crystals of pyrite all of which lie in a very fine-grained kaolinitic matrix. The average size of the larger grains usually does not exceed 1.0 mm (1/25 inch). The larger grains occupy more than 50 percent of the volume of the rock.

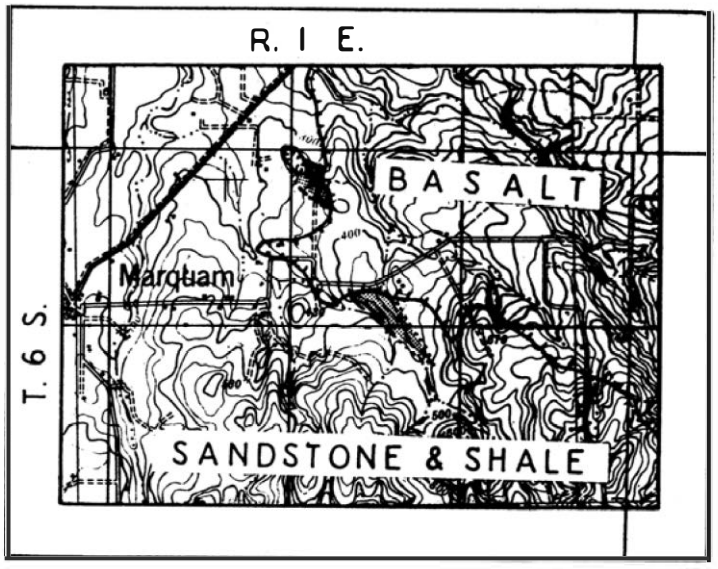
In thin section the Dallas limestone is seen to be a sedimentary rock originally composed of limy shells of foraminifera (minute, mainly marine, organisms) and larger shell fragments in a matrix of sand and shale composed of feldspar, a few quartz grains, and clay. It has undergone some recrystallization of the calcium carbonate and kaolinization of the feldspathic sand grains. Calcium carbonate is now distributed through the rock as calcite crystals, subhedral in outline and rarely exceeding 1 mm in length, and as particles less than 0.1 mm in size in the kaolinitic matrix. It also occurs as calcareous shells of foraminifera. Many of these shells have been obliterated by the recrystallization of the calcium carbonate. Others remain as mere outlines in subhedral crystals of calcite. The average size of the original foraminifera was 2 mm. Other minerals large in grain size are secondary pyrite, well-rounded quartz and feldspar grains, a few grains of biotite mica, and magnetite. A very fine-grained kaolinitic matrix lies between the larger grains. The kaolin of this matrix is in part common in origin with the other sedimentary minerals in the rock and in part formed by the alteration of feldspathic sand grains.

Mineral Composition of Dallas Limestone

| | | Percent |
|---|---|---|
| Calcite (crystalline calcium carbonate) | | 65 |
| Foraminifera and fragmental shells | 20% | |
| Fine-grained (original) | 5 | |
| Recrystallized (secondary) | 40 | |
| Feldspar (kaolinized) | | 10 |
| Kaolin | | 15 |
| Pyrite | | 5 |
| Magnetite | | 1 |
| Other minerals (quartz, biotite, garnet, and mica) | | 4 |
| | Total | 100 |




Topography by 29th Engineers, U. S. Army, U. S. Geological Survey.




# DALLAS and MARQUAM LIMESTONE DEPOSITS

Approximate extent

Basalt contact

Scale $\frac{1}{62500}$

1 $\frac{1}{2}$ 0 1 2 3 Miles

The secondary nature of much of the calcite, combined with the reported lower grade of limestone towards the base of the lens, suggests that the higher grade of the upper portion of the deposit is in part, at least, due to enrichment by solution and redeposition.

Grade and reserves: The stone varies in $CaCO_3$ content from less than 50 to as much as 80 percent. It is said that a grade of more than 70 percent can be maintained at the Lime Products quarry by hand picking. According to J. B. Bywaters, superintendent of the Oregon-Portland Cement Company, stone from the north quarry averages as shipped about 55 percent $CaCO_3$.

Available reserves in the Dallas deposit are moderately large. Allison (1933) estimates nearly half a million tons of stone as accessible to the present Lime Products quarry; the much greater extent of the deposit to the north has been fairly well proved. The Oregon Portland Cement Company quarry has been producing at a rate of 200 tons a day, and the superintendent feels that 20 years operation on other parts of the property is a conservative estimate. This would amount to a reserve of a little more than 1 million tons adjacent to the northern quarry.

The quarry of the Oregon Portland Cement Company is served by a 3-mile rail spur from a branch of the Southern Pacific Railway near Bridgeport. Stone is hauled from the quarry to bunkers by means of a gas locomotive over half a mile of narrow gauge track.

At the quarry of the Lime Products Company stone has been shoveled by hand into trucks and hauled about 200 yards to a bunker which serves the crushing plant.

Three drill holes immediately north and east of the Lime Products quarry (see plate 3) showed that the bed was at least 70 feet thick at this point and that the grade of the limestone decreases with depth from more than 70 percent $CaCO_3$ to about 40 percent within this thickness.

Marquam deposit — Clackamas County

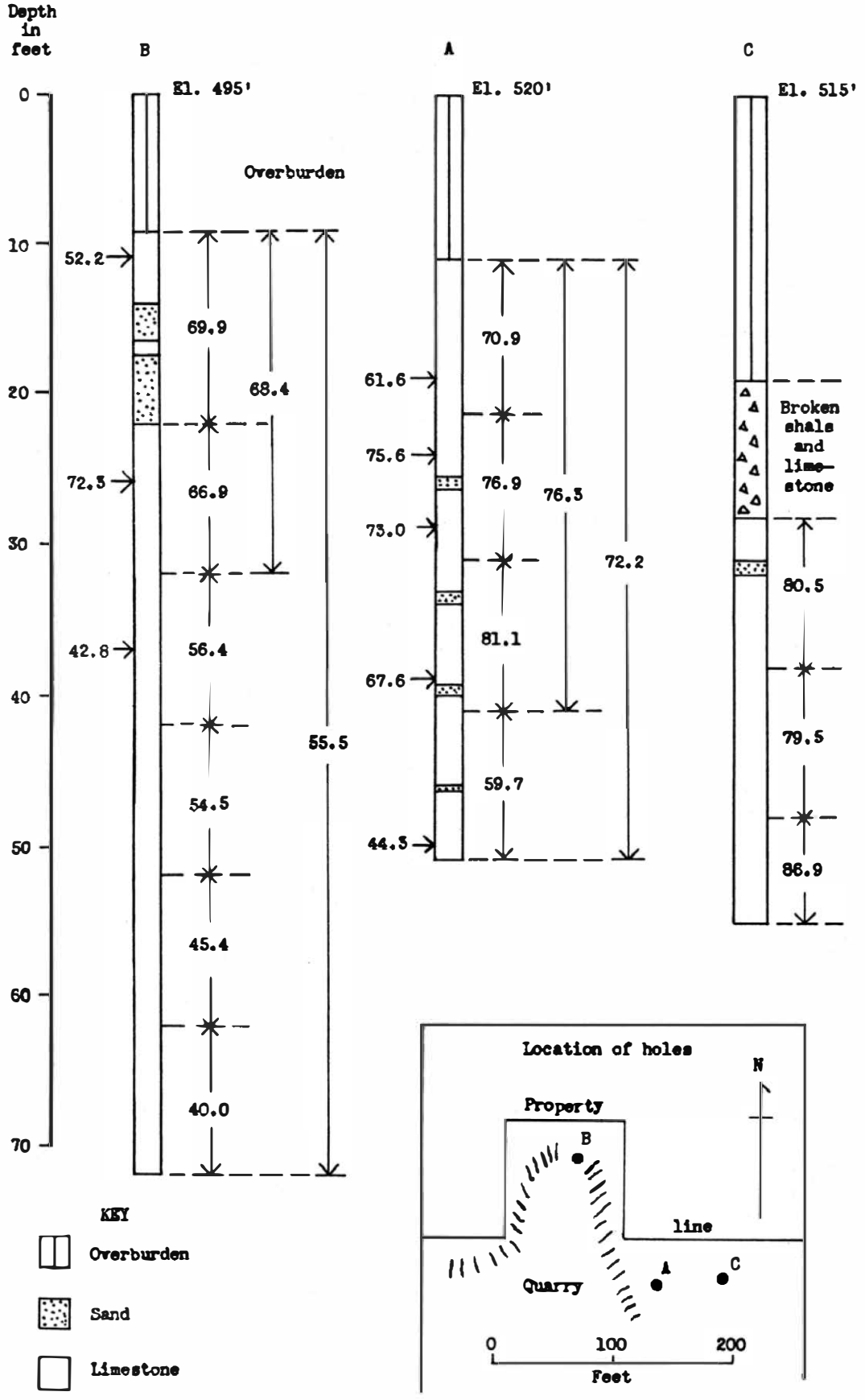
Owner: T. T. Leonard, Silverton, Oregon.

Location: Sec. 2, T. 6 S., R. 1 E., Clackamas County, 1 mile northeast of Marquam. Two deposits were examined, one in the center of the NW¼ of sec. 2 and one in the center of the S½ of the same section. Eckel (1913) reported limestone near Marquam underlying "a narrow area of perhaps 100 acres." Hodge (1938:368) reports a deposit in the NW¼ of sec. 2 and NE¼ of sec. 3 covering 10.38 acres, and another in the SE¼ NW¼ sec. 2 covering 3.96 acres.

Topography: The deposits lie upon the gentle west slope of the main north-trending ridge, at elevations varying from 325 to nearly 400 feet. The country is open, with only a few clumps of oak and fir. Much of the area is cultivated.

Geology: The limestone occurs as lenses in sandy tuffs, grits, and conglomerates, both massive and well-bedded, which have low dips to the south and southeast. Conglomeratic phases overlie the lime lenses at two localities. Fossils, both foraminifera and megafossils, indicate Vaqueros age, correlative with the Illahe-Mohama formation of Thayer (1939:6-7) and the Butte Creek beds of Harper (1941, unpublished map of Molalla quadrangle). The marine sediments interfinger with and are overlain by the continental Molalla formation to the east, but at this locality they are unconformably overlain by dense glassy to porphyritic and scoriaceous basalts. These lavas apparently flowed out over a more or less mature topography, as the elevations of the contact are variable and irregular. The porphyritic phase of the lava contains about 20 percent phenocrysts (up to 6 mm diameter) of plagioclase in a dense black aphanitic groundmass.

# LIME PRODUCTS QUARRY
## Drill Hole Sections and Analyses
## (Percentages $CaCO_3$)



The limestone is composed of broken shells, largely small oysters, and is more accurately described as a shell marl which has been leached at the surface (as well as in some interbedded horizons) and cemented below the water table by the dissolved lime. Well-rounded andesitic (?) cobbles are associated with the limestone, substantiating its near-shore origin. The secondarily enriched zone, usually less than 5 feet thick, is the "high-grade," and runs as high as 65 percent $CaCO_3$, while the "primary zone" below is only 25 percent $CaCO_3$. The leached zone near the surface is very low in lime content.

Economics and development: The northern deposit was tested, according to Hodge (1938:268), by 14 drill holes averaging 14 feet in depth, and an average thickness of 9 feet was estimated to give reserves of 5 million tons assaying 70 percent $CaCO_3$. More recently the two deposits examined were again drilled by the present owner. Samples were taken in 5½ foot lengths, in 13 holes averaging 11 feet in depth. Results of analyses[2] of samples are as follows:

| Hole No. | Sample No. | Thickness in feet | Location and coordinates* | $SiO_2$ % | CaO % | $CaCO_3$ % (calculated) |
|---|---|---|---|---|---|---|
| A | 1 | 0 - 5.5 | Hole 70 ft. S. of house | 33.2 | 23.5 | 41.9 |
| | 2 | 5.5 - 12 | (340'N - 400'E) | 29.6 | 25.5 | 45.5 |
| B | 3 | 0 - 5.5 | Hole 100 ft. SW. of house (350'N - 290'E) | 28.0 | 29.7 | 53.1 |
| C | 4 | 0 - 5.5 | Hole 90 ft. W. of house | 24.0 | 30.2 | 53.9 |
| | 4A | 5.5 - 12 | near fence (460'N - 290'E) | 32.2 | 23.8 | 42.5 |
| | (Composite sample assays 3.2 percent $MgCO_3$) | | | | | |
| D | 5 | 0 - 5.5 | Hole 210 ft. SW. of house | 33.2 | 24.4 | 43.6 |
| | 5A | 5.5 - 12 | (200'N - 290'E) | 31.6 | 20.6 | 36.8 |
| E | --- | 0 - 3 | Hole 400 ft. SW. of house | | | 48.7 |
| | | 3 - 6 | (140'N - 130'E) | | | 42.7 |
| | | 6 - 10 | | | | 36.9 |
| F | 7 | 0 - 12 | Pit 120 ft. NE. of barn (75'N - 280'E) | | | 35.72 |
| G | 6 | 0 - 5.5 | Hole 25 ft. E. of well at | 31.6 | 20.6 | 36.8 |
| | 6A | 5.5 - 12 | house (450'N - 450'E) | 35.6 | 17.1 | 30.5 |

*Coordinates measured from a point 130 feet west of the northwest corner of the barn at the south edge of the area by the road.

Limestone was mined for several months in 1943 and ground on the property in a hammer mill. An area 300 feet long and nearly 100 feet wide was stripped of 2 to 5 feet of soil and leached rock overburden; the open cut is some 90 by 40 feet long and 8 feet deep. Mr. Leonard reports that by careful sorting the average grade was maintained as high as 60 percent $CaCO_3$, and that many assays from individual strata were higher than this, one running as high as 79.6 percent $CaCO_3$.

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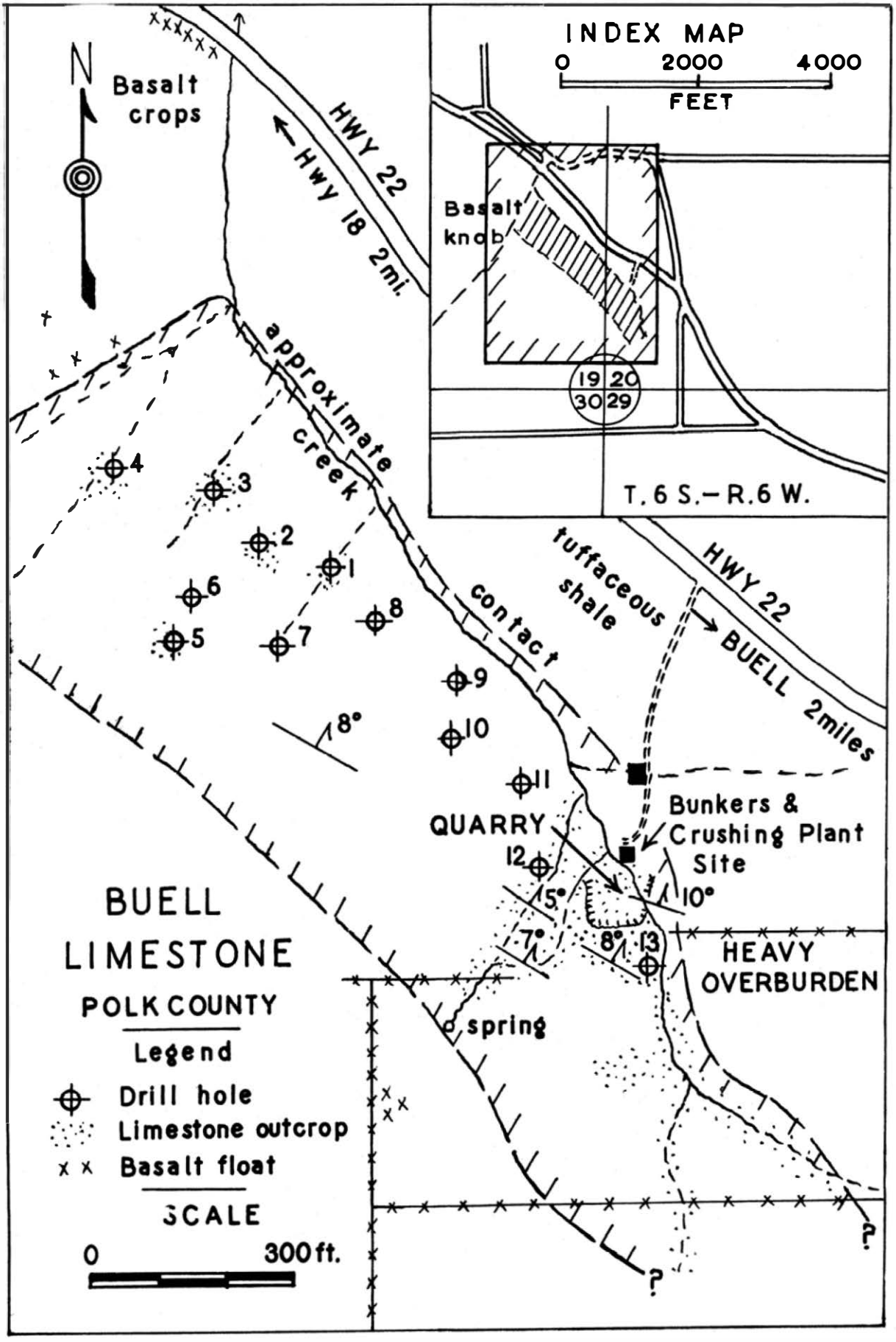
[2] By L. L. Motz, assayer, Oregon Department of Geology and Mineral Industries.

PLATE 4


INDEX MAP
0 2000 4000
FEET
Basalt knob
19 20
30 29
T. 6 S. – R. 6 W.
N
Basalt crops
HWY 22
Hwy 18 2mi.
approximate creek
tuffaceous shale
contact
HWY 22
BUELL 2miles
Bunkers & Crushing Plant Site
QUARRY
HEAVY OVERBURDEN
spring
1
2
3
4
5
6
7
8
9
10
11
12
13
8°
15°
10°
7°
8°
?
?
BUELL LIMESTONE
POLK COUNTY
Legend
Drill hole
Limestone outcrop
Basalt float
SCALE
0 300ft.

Buell limestone[3] Polk County

Lessee: Buell Lime Products Company, a closed corporation made up of A. N. Duncan, president, 12 Ladd & Bush Bank Building, Salem; William A. Duncan, Charles A. Goodwin; and William M. Goodwin, in charge of quarry operations.

Owner: H. W. Schmidt, Route 1, Sheridan, Oregon, formerly the T. B. Stone estate.

Location and area: The deposit is about 2 miles west of Buell and 3½ miles southeast of Willamina. It lies a short distance south of State Highway 22. The property contains 750 acres in secs. 19, 20, 29 and 30, T. 6 S., R. 6 W., W.M. From the property it is 2.6 miles northwest by way of State Highway 22 to its junction with State Highway 18 at Wallace Bridge over the South Yamhill River. A branch of the Southern Pacific Railroad roughly parallels State Highway 18. The area is drained by a small creek which flows northward into the South Yamhill River.

History and development: The deposit was noted by Hodge (1938:267) who stated that the Oregon Portland Cement Company investigated the occurrence in 1932 and reported that the average content of calcium carbonate of material from six drill holes, with an average depth of 44 feet, was 27.16 percent. J. E. Allen, Department geologist, examined the deposit in 1940. Allen (1940) reported that the limestone bed strikes N. 60° - 70° W. and dips 6° - 10° N. E. Operation by Buell Lime Products Company began February 11, 1946, and the first work consisted of putting down 13 diamond drill holes along the strike of the limestone bed. By March 8, 1946, quarrying operations had begun and William M. Goodwin, in charge, estimated 3000 tons of limestone had been quarried. A well-graveled road has been built to the site of the bunkers (see plate 4) which are being constructed. Equipment being used in the development of the property includes two bulldozers, an air compressor, and jackhammers.

Geology: The limestone crops out in many places on a dip slope south of an intermittent northwest-flowing creek (see plate 4). The bed strikes N. 60° W. and dips 8° to the northeast. The areal extent is not known, although its extension southward probably could be determined easily as there is little or no overburden in that direction. The limestone beds dip northward under a belt of tuffaceous shale which is exposed in the highway cuts and which forms the heavy overburden east of the quarry. On the west the limestone abuts against a basaltic hill, as indicated by Allen (1940). Basalt is exposed along the northern base of this hill in the highway cuts, where it appears to be overlain by the same tuffaceous shale as that which overlies the limestone farther east. Basalt may disconformably underlie the limestone, but no angular relationship could be determined from the available exposures.

Recent drilling shows that the limestone bed has an average thickness of about 20 feet; in one hole it attains a thickness of 26½ feet. Drill cores indicate that the limestone is underlain by greenish sandstone which may be similar in character to that exposed in the east bank of the South Yamhill River 2.6 miles to the west at the junction of State highways 18 and 22. There a rather massive limy bed in the upper part of the bank overlies bedded dark-colored grits which have an apparent dip of 11° to the south.

The Buell deposit is somewhat similar in appearance and composition to the Dallas limestone deposits 10.5 miles to the southwest, and both appear to lie disconformably on older basalt. Although fossils occur in the Buell limestone, no attempt has been made to collect and identify them. If the Buell deposit does occupy a stratigraphic position similar to the Dallas limestone, it would be of upper Eocene age.

The limestone is massive and slightly jointed. It is a dense gray rock with both carbonaceous and clastic fragments. The rock weathers brown near the surface and any samples taken from outcrops may not give a true indication of the grade of the deposit.

[3] Report by W. D. Lowry and R. S. Mason, Oregon Department of Geology and Mineral Industries.

Analyses[4] of several samples are as follows:

| Sample No. | Description | CaO | MgO | $SiO_2$ | Neutralizing value | $CaCO_3$ % (calculated) |
|---|---|---|---|---|---|---|
| P-4525 | 6½ ft. channel sample from face of quarry | 27.72% | 2.16% | 29.06% | 53.91% | 49.4 |
| P-4526 | Grab sample taken near middle of above channel | 27.42 | 1.41 | 37.40 | 52.14 | 49.0 |
| P-4527 | Grab sample taken near hole 1 | 42.77 | 1.25 | 14.10 | 78.91 | 76.4 |
| P-4528 | Grab sample taken near hole 3 | 28.73 | 2.84 | 24.94 | 57.04 | 51.3 |
| P-4529 | Grab sample taken near hole 5 | 35.93 | 2.00 | 18.58 | 68.17 | 64.1 |

The Buell Lime Products Company submitted two composite samples of the diamond drill cores from holes 1 to 10 inclusive to Charlton Laboratories of Portland for analysis. The results are listed in the table below:

| Sample description | CaO | MgO | Neutralizing value | $CaCO_3$ % (calculated) |
|---|---|---|---|---|
| 1. Average material, holes 1 to 10 inclusive | 32.0% | 1.47% | 61.6% | 57.1 |
| 2. "High-grade" material, holes 1 to 10 inclusive | 34.3 | 1.21 | 63.6 | 61.2 |
| 3. Core from hole 13 | 43.8 | 0.95 | 80.2 | 78.3 |

The following is a record of the diamond drilling results furnished by William M. Goodwin:

| Hole No. | Depth | Thickness of limestone | Remarks |
|---|---|---|---|
| 1 | 19 | 19 ft. | Bottomed in limestone |
| 2 | 21 | 21 | " " " |
| 3 | 20 | 20 | " " " |
| 4 | 19 | 19 | " " " |
| 5 | 25 | 20 | Bottomed in "greenish country rock" |
| 6 | 24 | 19 | do |
| 7 | 19 | 14 | do |
| 8 | 21 | 20 | do |
| 9 | 21 | 20 | Bottomed in limestone |
| 10 | 29 | 18.5 | Bottomed in country rock |
| 11 | 18 | 18 | Bottomed in limestone |
| 12 | 22 | 22 | " " " |
| 13 | 24 | 23.5 | Bottomed in country rock |

[4] By L.L. Hoagland, chemist, Oregon Department of Geology and Mineral Industries.

As indicated by the Buell Lime Product's Company's diamond drilling program, the thickness of the limestone is rather uniform along the strike of the bed between hole 13 on the east and hole 4 on the west, a distance of about 1500 feet. Outcrops indicate a continuation of the limestone northward from the drill holes to the creek where the bed dips beneath younger sediments.

Assuming that the limestone bed has an average width of 300 feet between hole 13 on the east and hole 4 on the west (as indicated by drilling and outcrops) and an average thickness of 20 feet, a total of 9 million cubic feet of limestone is indicated. The measured specific gravity of the limestone from the quarry face is 2.3. Thus a total of 645,840 short tons of limestone is indicated.

Assuming that the limestone extends from the contact northwest of hole 4, as shown on Plate 4, and using a width of 600 feet ( from the creek to 50 feet above the hole farthest up the slope) an inferred tonnage of 1,550,000 tons is obtained.

If the limestone bed extends southward the amount of limestone available in the deposit may be appreciably greater. Quarrying of any eastward extension of the limestone bed would be hindered by a progressively thickening overburden.

Mr. Goodwin reported that the limestone in all the drill holes is similar in character, but the only figures indicating the average calcium carbonate content of the limestone bed are the results listed in the preceding tables. The calcium carbonate content of the samples from the unweathered quarry face is lower than that of the samples from outcrops and suggests a considerable variation in the grade of limestone in places. However, as indicated by the sampling to date, most of the limestone contains more than 50 percent total carbonates.

Amity deposit — Polk County

Owner: J. C. Richlie, Amity, Oregon.

Location: Three miles south of Amity in the foothills of the Eola Hills about one mile east of the Pacific Highway (U.S. 99W) in the NE¼ sec. 9, T. 6 S., R. 4 W., W.M., at an elevation of about 225 feet.

Geology: One and possibly two limestone lenses strike north and dip a few degrees west down the slope. They are exposed for only a few feet in thickness; the lower contact is covered. The limestone is interbedded with a fine-grained white fossiliferous tuff which is in turn overlain by a light-colored tuffaceous sandstone. Outcrops are scanty and the length of the lenses could not be determined. The lime content of the rock is variable, some assays being as high as 80 percent $CaCO_3$, but the average is probably closer to 50 percent. The overburden increases up the hill, which probably would make stripping too expensive for a commercial operation. The property has not been adequately explored, however, and a few test auger holes are justified.

Numerous small silicified gastropods and pelecypods, found weathered out in the field to the west of the lens, indicate a marine origin for the limestone lens.

Table 1.
Analyses of some Willamette Valley Limerock Samples

| Name of deposit and nearest town | Description of rock | Location | CaO | $CaCO_3$ | Insoluble |
|---|---|---|---|---|---|
| | | **Benton County** | | | |
| L. Lien Ranch Philomath | Green tuff-breccia | NW¼ sec. 24, T. 12 S., R. 6 W. | 6.0 % | 10.7 % | 58.6 % |
| G.A.Nyman Ranch Kings Valley | Green tuff-breccia | NE¼ sec. 16, T. 10 S., R. 6 W. | 20.7 | 37.0 | 35.9 |
| E. Radford Ranch Kings Valley | Green tuff-breccia | SE¼ sec. 15, T. 10 S., R. 6 W. | 20.8 | 37.2 | 35.2 |
| | | **Clackamas County** | | | |
| Marquam Marquam | Tuffaceous marl | Sec. 2, T. 6 S., R. 1 E. | (See text for analyses) | | |
| Old Kiln Scotts Mills | Tuffaceous marl | SW¼ sec. 29, T. 6 S., R. 2 E. | 24.6 | 44.0 | 48.1 |
| | | **Lane County** | | | |
| Cheshire Quarry Cheshire | Lime lenses in shale | N½ sec. 15, T. 16 S., R. 5 W. | 42.7 | 76.4 | 13.5 |
| | | **Polk County** | | | |
| Dallas Dallas | Gray limestone | T. 8 S., R. 6 W. | (See text for analyses) | | |
| G.F.McBee Ranch Dallas | Gray limestone | NE¼ sec. 12, T. 8 S., R. 6 W. | 25.4 | 45.4 | 29.2 |
| Amity Amity | White porous limestone | NE¼ sec. 9, T. 6 S., R. 4 W. | 43.9 | 78.3 | 1.4 |
| | Massive gray limestone | " " " " " " " " " | 27.1 | 48.4 | 19.5 |
| Buell Buell | Brown limy tuff | Secs.19 and 20, T. 6 S., R. 6 W. | (See text for analyses) | | |
| Wildwood School Hoskins | Gray sandy limestone | Sec. 2, T. 10 S., R. 7 W. | 11.7 | 20.9 | 68.6 |
| | | **Washington County** | | | |
| Clear Creek Gales Creek | Calcareous tuff and conglomerate | NE corner sec. 14, T. 1 N., R. 5 W. | 32.1 | 57.1 | ---- |

Table 2.
Summary of Willamette Valley Localities

| Locality | Character of deposit | Probable importance of outcrop as agricultural limestone |
|---|---|---|
| **Benton County:** | | |
| Beaver Creek Quarry, SE¼ sec. 10, T. 13 S., R. 6 W. | Calcareous patches and nodules in sandstone in quarry face. | Probably none. Quantity lacking. |
| Lien Ranch, NW cor. sec. 24, T. 12 S., R. 6 W. | Tuff conglomerate with some lime assays 11 percent. Not extensive as far as could be determined. | Very doubtful as lime content very low. |
| G.A.Nyman Ranch, NE¼ sec. 16, T. 10 S., R. 6 W. | Green limy lapilli-tuff, the secondary calcite being spotty; small in extent. Some assays as high as 37 percent. | Very doubtful as lime content is too low and spotty in occurrence. |
| E. Radford Ranch, center SE¼ sec. 15, T. 10 S., R. 6 W. | Tuff conglomerate with small amounts of lime, occurrence spotty; assays less than 40 percent. | Very doubtful as lime content is too low and spotty in occurrence. |
| **Clackamas County:** | | |
| Coal Creek Lime (3.4 mi. E. of Scotts Mills bridge) center N½ sec. 30, T. 6 S., R. 2 E. | 10 feet of shell marl intruded by basalt in quarry. | Doubtful; overburden too great; grade too low. |
| Marquam, sec. 2, T. 6 S., R. 1 E. | See text of report. | |
| Old Kiln (4.4 mi. E. of Scotts Mills bridge) center SW¼ sec. 29, T. 6 S., R. 2 E. | 10 feet of shell marl, dips 3° south-southeast in creek bank and in bluffs to north. Assays 44 percent. | Doubtful; overburden too great. |
| **Lane County:** | | |
| Cheshire Quarry, NE¼ NW¼ sec. 15, T. 16 S., R. 5 W. | Thin lenses of limestone with heavy overburden, maximum dimensions in quarry 1 X 30 ft. long. Assays 76 percent lime. | Very doubtful. Deposits too thin, discontinuous, with too heavy overburden. |
| 1½ mi. W. of Cheshire, SW¼ sec. 16, T. 16 S., R. 5 W. | Could not locate reported outcrops of calcareous tuff-conglomerate. Rock showing in road cuts zeolitic, not calcareous. | Very doubtful, as lime content reported by Zimmerman (27) is too low, and probably spotty in occurrence. |
| Lucas Ranch, sec. 1, T. 18 S., R. 4 W. | No outcrops exposed. Some float of amygdaloidal basalt, but vesicular fillings were of chalcedony. | Very doubtful. |
| **Linn County:** | | |
| H. Lerwell Ranch, sec. 16, T. 14 S., R. 2 W. | No limestone as reported could be found. All fine tuff. | Probably none. |
| **Polk County:** | | |
| Buell, E½ sec. 19, W½ sec. 20, T. 6 S., R. 6 W. | See text of report. | |

Table 2.
Summary of Willamette Valley Localities
(Continued)

| Locality | Character of deposit | Probable importance of outcrop as agricultural limestone |
|---|---|---|
| **Polk County (Cont.):** | | |
| Canyon Road, secs. 2, 10, and 11, T. 8 S., R. 8 W. | Limestone with shale interbeds outcropping in roadcuts. | Possible; not developed. |
| Dallas, NE¼ T. 8 S., R. 6 W. | See text of report. | |
| Luckiamute River, sec. 20, T. 9 S., R. 7 W. | Only thin calcite stringers were found along river in lava. | Probably none. |
| Mill Creek, NW¼ T. 7 S., R. 6 W. | Tuffaceous shales to 2 miles up creek, then all lavas. | Probably none. |
| Amity, NE¼ sec. 9, T. 6 S., R. 4 W. | See text of report. | |
| Ellendale, SW¼ sec. 25, T. 7 S., R. 6 W. | Pockets of marl lying upon basalt in quarry. | Probably none. |
| Rickreall Creek, Secs. 34, 35, 36, and 37, T. 7 S., R. 6 W. | All tuff and lava for 3 miles up creek. | Probably none. |
| Salt Creek, NE¼ T. 7 S., R. 6 W. | All tuffaceous shales and basalts. | Probably none. |
| Wildwood School, center sec. 2, T. 10 S., R. 7 W. | Limy tuff assays 21 percent. Probably not over 2-3 ft. thick. Heavy overburden; below water table. | Very doubtful, overburden too great. |
| Rock Creek Falls, center sec. 26, T. 6 S., R. 8 W. | Bedded shale and limy sandstone. Heavy overburden; relatively inaccessible. | Probably none. Too low in grade. Too heavy overburden. Too inaccessible. |
| **Washington County:** | | |
| Buxton-Vernonia highway, 59 mi. N. of summit, El. 890 ft. Center E. edge sec. 8, T. 3 N., R. 4 W. | Bed of gray sandy limestone, 1 ft. thick. | Very doubtful. |
| Cherry Grove, T. 1 S., R. 5 W. | Persistent reports of limestone occurring in hills west of town. | Not visited. |
| Gaston Quarry, SW¼ sec. 27, T. 1 S., R. 4 W. | 2 feet fossiliferous beds in massive bedded sandy tuff, heavy overburden of rock dipping into hillside. | Very doubtful. |
| J. Pongratz Ranch (well), Center S½ sec. 4, T. 2 N., R. 4 W. | No record on well was available to check report of limestone pierced by it. No limestone outcrops have been found in this locality. | Probably none. |
| Scoggins Creek Quarry, NW¼ sec. 27, T. 1 S., R. 4 W. | 1 foot fossiliferous beds in massive bedded sandy tuff. Heavy overburden of rock, dipping into hillside. | Very doubtful. |
| Clear Creek, sec. corner 10-11, 14-15, T. 1 N., R. 5 W. | 10-30 feet bed of tuffaceous limestone and limy conglomerate. | Inaccessible. |

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