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Economic Geology of Carbonate Rocks Adjacent to the Snake River South of Lewiston, Idaho

by

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C. N. Savage

ABSTRACT

Permian and Triassic rocks containing a high percentage of calcareous shales, limestones, and marbles, crop out about 22 miles south of Lewiston, Idaho and Clarkston, Washington, adjacent to the Snake River at Lime Point. Younger granitic intrusive and extrusive basaltic rocks are also present in the area. The main carbonate formation is probably equivalent to the Martin Bridge of the Wallowa Mountain region.

Examination of previously published and unpublished reports, together with recently acquired field data, suggest that the Lime Point area has a probable reserve of over 626 million short tons of commercial-grade carbonate rock suitable for production of portlant cement, agricultural and commercial lime, and for other commercial uses. The average of main constituents in the rocks in percentages is

CaO	53.3	SiO_2	2.5
MgO	0.8	P_2O_5	0.035
$Fe_2O_3 + Al_2O_3$	0.8	$CaCO_3$	95.0 (calculated)

Based on a commercial classification of carbonate rock, the Lime Point rocks fall just below high-calcium limestone or in the limestone category. Most so-called impurities are negligible in these rocks.

An analysis of the regional economy suggests that if locks are included in a dam, soon to be constructed south of Lewiston, the carbonate rocks at Lime Point would become competitive with and perhaps even replace some existing lime rock raw material sources in the region. Finished lime products or raw materials produced from Lime Point could be shipped by water from Lewiston-Clarkston ports to Astoria and to any Pacific Ocean port.

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ECONOMIC GEOLOGY OF CARBONATE ROCKS ADJACENT TO THE SNAKE RIVER SOUTH OF LEWISTON, IDAHO

INTRODUCTION

LOCATION, EXTENT, AND ACCESSIBILITY

Sizeable quantities of potentially valuable carbonate rock are located in Nez Perce County, Idaho, about 22 miles south of the Lewiston, Idaho-Clarkston, Washington metropolitan area (Fig. 1 and Plate 1). These limy rocks, on both sides of the Snake River, near its confluence with the Grande Ronde (Fig. 2) were formerly exploited for small quantities of lime. Analyses indicate that some of the largest quantities of lime are present in rocks located in sec. 2, T31N, and secs. 27 and 34, T32N, in R5W (Boise Meridian). These lime-bearing rocks crop out in a zone 0.2 to 1 mile in width, extending about 1.2 miles toward the northeast from Lime Point on the Snake River. Other more impure carbonate rocks, including intercalated limy shales and phyllites, occur locally with noncarbonate rocks in an area extending both north and south of Lime Point. These mixed rocks crop out slightly north of Captain John Creek and extend southward approximately to the vicinity of Garden Creek.

In the past, the economic potential of these limy rocks has been limited because of relatively poor access to the region, and because of lack of local markets for lime products. Although passengers have been transported by boat from Lewiston to this site and beyond, practically on a year-around basis; under present conditions barge transportation of bulky commodities such as limerock would probably be limited to 8 or 9 months per year. Dams now being planned for installation on the Snake River, when completed, will produce slack water for cheap year-around transportation from the Lewiston-Clarkston area to and from Lime Point and vicinity. The carbonate rocks at Lime Point would then be accessible to all docks downstream from Lewiston-Clarkston, including ports on the Snake and Columbia drainage systems, and ports on the Pacific Ocean in general.

Access to the Idaho (east) side of the Snake River in this region, at present, is by roads trafficable only with 4-wheel drive vehicles in dry weather. From the north, access to the limy rocks is from Waha across the water divide along the valleys of Madden and Captain John creeks (Plate 1). Adequate, improved, all-weather roads are available from Lewiston to Waha. A poor road along the Snake River from the mouth of Captain John Creek extends to within about 1.5 miles of the Lime Point carbonate rock deposits.

From the southeast, poor quality access roads have been cut by bulldozers to the heads of Dough, Chimney and Middle creeks, and to the mouth of Corral and Garden creeks. These roads into the southern area may be reached from the Waha Lake road. However, travel on all eastside roads must be by permission of private property owners, From the west side of the Snake, an improved all-weather road extends some 28-30 miles south from Clarkston, Washington to the mouth of the Grande Ronde (Fig. 1). In some sections this is only a one lane road. Vehicular access from this road to the carbonate rocks on the east side of the river would be impossible without a service bridge for vehicles.

RELIEF, DRAINAGE, AND CLIMATE

The east wall of the Snake River Canyon, east of Lime Point, rises somewhat in excess of 5,000 feet in elevation. This is almost 4,400 feet above the river level. On the east, the canyon rim (southwest of Winchester) is a broad plateau covered with Upper Columbia River Basalt flows. At Lime Point, the terrain has been eroded into steep gullies separated by grass-covered ridges. These ridges have steep north-facing slopes with less steep southerly slopes. Relief in the Lime Point area is from 1,200 to 2,200 feet. Lime-bearing rock extends from about the level of the river to approximately 3,000 feet elevation (an ideal situation for gravity movement of any mineral commodity).

Seasonal streams occupy most of the tributary canyons of the Snake in this area; however, several principal tributary valleys are occupied by perennial springs that produce year-around stream flow. Stream flow in the Snake River Valley is year-around, but the water level is subject to several feet of seasonal fluctuation.

The Snake River Canyon normally has mild winters and hot summers and is essentially an area of semiarid climate. Maximum precipitation occurs in the winter months, mostly in the form of rain. Total annual precipitation is on the order of 10 to 15 inches.

PREVIOUS INVESTIGATIONS AND ACKNOWLEDGMENTS

One of the first to describe the rocks in the Lime Point area was I. C. Russell (1897 and 1901). Shedd and Eckel described the limestones and gave analyses of the rock in separate publications (1913). In 1916, C. A. Fisher, a consulting engineer, prepared an unpublished report on the Lime Point area. Rock analyses were also given by Hodge (1938). Gullixson (1954) reported rock analyses of samples taken principally from Lime Hill (Washington) on the west side of the Snake.

More recently (1954-1959) the Ideal Cement Company explored the Lime Hill area and developed approach roads; however, the data obtained have not been made available for general publication. During the same period, Libbey (1957) reviewed some of the previously published rock analyses.

In 1960, two students, M. O. Glerup (University of Idaho) and R. E. Shumway (University of Washington), studied and mapped the rocks of the Lime Point and Lime

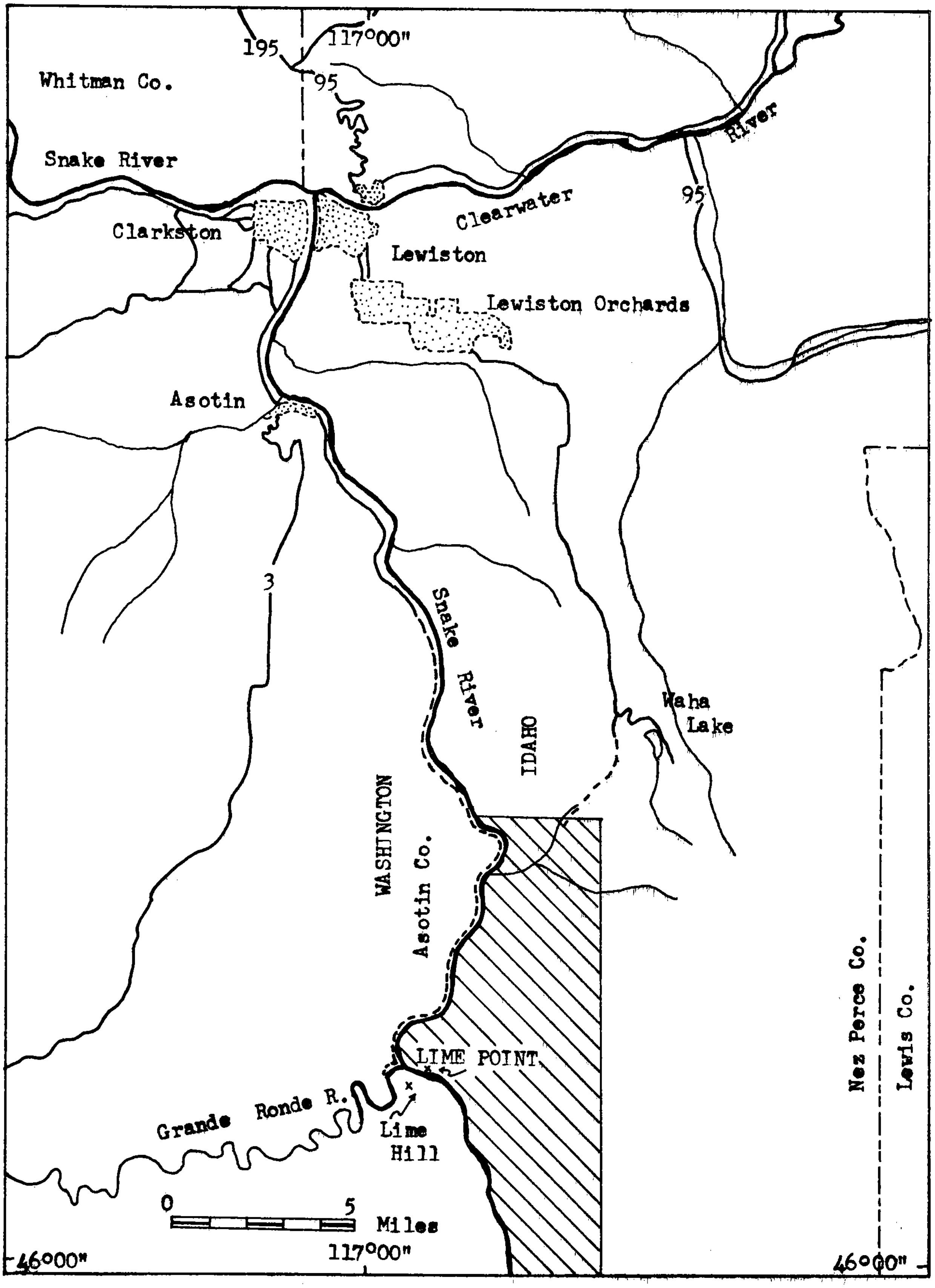

Figure 1. Location of Lime Point map area, Nez Perce County, Idaho

Hill districts, respectively. Later, Mills (1962) published a map and excerpts taken from Shumway's dissertation on the Lime Hill deposits. Mills also presented several new rock analyses from the Lime Hill area, and stated that many of the previously published analyses of the carbonate rocks in the area probably showed excessively high calcium carbonate content. He stated that none of the limestone at the Lime Hill site should be classified as "high-calcium" limestone.

Also in 1960, Thomas and Harsted Associates of Seattle, prepared a report outlining the probable economic impact of Asotin Dam on the Lewiston area. This report included information on the potential of the carbonate rocks south of the proposed dam site.

Because of a steadily increasing interest in the possible economic value of the Lime Point carbonate rocks, it seemed appropriate to prepare the following report on the economic geology of this area. This report is based upon some recent field investigation and compilation from earlier reports. Much credit for the contents must go to the earlier investigators mentioned above; among these, M. O. Glerup's unpublished thesis has been used extensively as a source of data. Glerup's geologic maps have been published here with only a few changes (Plates 1 and 2).

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ROCKS AND ROCK MATERIALS

GENERAL ROCK TYPES

The Lime Point map area lies southwest of Lake Waha, at a lower elevation than the lake on an extension of the northeast-trending Craig Mountain Upland. The upland consists of a large fault-scarped anticlinal (monoclinal?) structure composed of various rock types representing several geologic periods. The rocks have been deeply dissected and sculptured into major canyons, part of the Snake River drainage system. At Lime Point, the rocks exposed may be grouped into the following categories:

(1) Relatively recent materials of sedimentary origin:
clay, silt, sand, and gravel deposits by running water that have accumulated along stream valleys and on more gentle slopes; bedded silty volcanic ash and clay remnants of fluviatile and lacustrine origin; and silty loess and ash of atmospheric origin.

(2) Relatively recent igneous rocks of volcanic origin:
basalt and intermixed fragmental material of explosive origin, intercalated with 14 or more lava flows; and intrusive basalt and diabase dikes.

(3) Igneous rocks of intermediate age:
granitic rocks, including granodiorite and biotite quartz diorite, in the form of stocks or cupolas, locally with gneissic structure.

(4) Older sedimentary and metamorphic rocks deposited in a marine environment:
mixed clastic, pyroclastic, and chemical or biochemical sedimentary and metasedimentary rocks, including tuff (greenstone); calcareous and noncalcareous shale, argillite, and schistose and phyllitic shale; limestone and marble; quartzitic sandstone; and metaconglomerate.

(5) Older igneous rocks of volcanic origin:
extrusive andesite (greenstone) and rhyolite flows(?); and intrusive andesite and dacite sills(?) and dikes.

The oldest rocks in this area are difficult to differentiate because of their degree of metamorphic alteration. Undoubtedly more than one episode of uplift, faulting, and extensive erosion have helped to obscure stratigraphic relations. Thicknesses, in most instances, have been impossible to determine accurately.

For convenient reference, the local section of rocks and rock materials in the Lime Point area has been outlined in an approximate time-stratigraphic column and presented in Table 1. This table includes brief descriptions, tentative correlations and assignments to a geologic age. Formations and materials are listed in their proper geologic order; for example, the youngest units are at the top of the table and the oldest rocks are at the bottom.

ROCK SECTION IN THE LIME POINT MAP AREA

Seven Devils Group

The oldest rocks exposed in the Lime Point area are the group previously called the "Seven Devils Volcanics" by Anderson (1930, p. 13). They consist mainly of deformed and metamorphosed andesite, andesite porphyry, and tuff; however, also included are calcareous and noncalcareous sedimentary rocks (Table 1).

Commonly called "greenstones", these rocks are collectively dense, fine-grained and greenish-gray in color. The calcareous layers occur as local, lens-shaped marble facies. This Seven Devils Group underlies about 6.5 square miles of the southwest portion of the Lime Point map area, and similar rocks occur west of Lime Point on the opposite side of the Snake, in the Lime Hill area. Although fossils are yet to be found in this group at Lime Point, the lithology and stratigraphic position of these rocks are similar to fossil-dated Permian rocks not far away in eastern Oregon. The presence of bedded tuffs, andesite flows and limestones in the Seven Devils Group suggests a submarine, volcanic environment of deposition.

Folding, faulting, metamorphism and uplift probably exposed this Permian rock section prior to the beginning of Triassic sedimentation. Although an unconformity is not clearly exposed, it is assumed to be present because of local, basal metamorphosed conglomerates of probable Triassic age. These occur near the presumed base of the Triassic rock section. The conglomerates contain recognizable Permian rock types.

Lower Sedimentary Group ("Series")

The so-called lower Sedimentary "Series" or Group (Table 1), probably were once sedimentary rocks, although deformation and metamorphism have altered the original materials to the extent that they resemble the older underlying Permian metamorphic rocks. In some outcroppings the rocks can be identified as former conglomerates, sandstones, limestones, shales and volcanic tuffs. The finer sediments have been converted to metasediments such as argillite, phyllite, and schist. Late Triassic fossils have been collected from rocks considered equivalent to the Lower Sedimentary Group at exposures in Oregon.

The basal metaconglomerate and sandstone (tuffaceous?), found in some of the lower strata, are probably equivalent to Wagner's (1945, p. 4-5) Pittsburg Formation exposed near Pittsburg Landing (south of Lime Point). Medium light-gray, coarse-grained

TABLE 1. ROCK UNITS IN THE LIME POINT AREA SOUTH OF LEWISTON

Geologic Age: Era	Geologic Age: Period		Formation or Unit		Brief Description
Cenozoic	QUATERNARY		Alluvium and Colluvium, including slopewash and stream deposits, and wind deposited silt		Includes recent ash, clay, silt, sand, and gravel along valleys and on more gentle slopes. Not all alluvial deposits are shown on the geologic map.
			UNCONFORMITY		
Cenozoic	TERTIARY (Miocene)		COLUMBIA RIVER GROUP "Upper" Basalt Fm. (Picture Gorge Fm.?) and Latah members "Lower" Basalt Fm. (Yakima Fm.?) and Latah members		Brown to black basalt flows, with local columnar jointing. Also interbedded grayish-white to buff, fossiliferous (flora) ash, tuff, clay, and silt; massive to finely laminated beds. These rocks cut by basalt feeder (?) dikes; thickness of total sequence over 2,300 ft.
			UNCONFORMITY		
Mesozoic	CRETACEOUS		IDAHO BATHOLITH (Cupolas?)		Intrusive granitic stocks or cupolas including granodiorite and biotite quartz diorite. Varied textures, coarse to fine. Some gneissic structure. Local quartz veins containing traces of gold and copper sulfides. Quartz veins may be early Tertiary in age.
Mesozoic	TRIASSIC (Late)	Lucile Group ("Series")	HURWAL FORMATION	Andesite and dacite dikes and sills (?)	Includes an upper greenstone facies of former shales and volcanic rocks, locally schistose. Lower unit includes calcareous shale, siliceous limestone, argillite, and phyllite. Cut by calcite veinlets.
Mesozoic	TRIASSIC (Late)	Lucile Group ("Series")	MARTIN BRIDGE FORMATION	Andesite and dacite dikes and sills (?)	Light to medium gray and black massive and thin units of limestone, marble, phyllite, and sandstone (fine thin lenses). Cut by calcite veinlets. Contains some fossils. Upper and lower units tend to be massive up to 420 ft. thick. Total thickness of formation about 2,000 ft.
Mesozoic	TRIASSIC (Late)	Lucile Group ("Series")	LOWER SEDIMENTARY GROUP ("SERIES") (Pittsburg Fm.?)	Andesite and dacite dikes and sills (?)	Light gray to black, with basal conglomerate, coarse marble and limestone, some quartzitic sandstone. Some argillite, phyllite and chloritic schist.
			UNCONFORMITY		
Paleozoic	PERMIAN	Seven Devils Group	SEVEN DEVILS GROUP ("VOLCANICS") (Clover Creek Greenstones? of NE Oregon)	Andesite and dacite dikes and sills (?)	Green to grayish-green metamorphosed complex of lava flows, fragmental volcanic rocks (pyroclastics), and calcareous and noncalcareous sedimentary rocks. Locally dense fine-grained "greenstone" with some coarse marble beds. Probably these rocks were deposited in a submarine, volcanic environment. Approximately 3,000 ft. thick (Shumway, 1960, p. 4)

marble, and black, pyritic limestone crop out in some places above the metaconglomerate in the Lime Point area. Quartzitic sandstone appears to form the upper unit of this group of rocks. The Lower Sedimentary Group occupies an area of about four square miles to the southeast in the Lime Point map area (Plate 1).

Martin Bridge Formation

The Martin Bridge Formation, named by Chaney (1933, p. 4) at exposures in the Wallowa Mountains, has the highest carbonate content of any of the limy rocks in the area. This formation in the Lime Point area is conformable with the underlying Lower Sedimentary Group (Table 1). Principally a marble, but locally not unlike a limestone, the Martin Bridge Formation is light- to medium-gray, or almost black in color. It is massive to thin-bedded cryptocrystalline to fine-grained; a siliceous and argillaceous rock. The total formation is about 2,000 feet thick and includes several minor fine-grained sandstone members. Lens-like, these sandstone members are up to 20 feet thick.

Numerous veins of calcite occur in some exposures of the Martin Bridge Formation. These veins may represent "healed" fracture systems. Upper and lower more massive, resistant carbonate units are as much as 42 feet thick. Some of the thinner limy layers in the formation have been metamorphosed, producing a calcareous phyllite. Locally, deformation has resulted in minor folds on the limbs of larger regional folds.

According to Glerup (1960, p. 15-16), fossil fragments are locally abundant in this formation. During the present investigation, one fossil zone was located about one-half mile northeast of Lime Point. Here, fragments of crinoid stems were plentiful. At the same locality, partly preserved fragments of a depauperate? fauna were assembled; this represented gastropoda, pelecypoda, and diminutive ammonites. These fossils indicate a marine environment somewhat unfavorable to life.

Alliger (1942, p. 1) reported the occurrence of rocks equivalent to the Martin Bridge Formation at localities to the east of Lime Point. These yielded fossils assignable to late Triassic-Early Cretaceous time. Wagner's (1945, p. 5) Lucile "Series" in the Riggins area was said to be Late Triassic in age, and it is considered equivalent to the Martin Bridge and overlying Hurwal Formation in Oregon.

The Martin Bridge Formation at Lime Point (Fig. 2 and Plate 2) is judged to underlie at least two or more square miles of terrain immediately northeast of Lime Point. In general, this formation dips steeply northwest and strikes northeast.

Hurwal Formation

The Hurwal Formation (Smith and others, 1941, p. 13) is represented in the Lime Point area by two distinct units lying conformably above the Martin Bridge Formation

(Glerup, 1960, p. 16). The lower unit was formerly a limy shale with intercalated argillaceous limestone. It was metamorphosed to produce a gray to brownish-gray, siliceous phyllitic rock. The upper unit is a greenish-gray metasediment, probably representing former shales and volcanics, such as ash and tuff. The top of this unit is cut by a major erosional unconformity that separates the formation from the overlying basaltic lava flows and recent sediments.

The thickness of the Hurwal Formation could not be determined accurately; however, in the Lime Hill district immediately west of Lime Point, Shumway (1960, p. 24) estimated the entire thickness of the Triassic sedimentary rocks to be 3,480 feet. Faulting in the Hurwal portion of this Triassic section, plus extensive erosion at the top of the formation, makes it virtually impossible to arrive at a reliable thickness figure for the section.

Although fossils have not yet been discovered in the Hurwal, it is probably correlative with Late Triassic rocks in the Wallowa Mountains, and also with the upper portions of Wagner's (1945, p. 5) Lucile "Series" south of Lime Point.

Perhaps it should be pointed out here that Morrison (1961) called attention to a major angular unconformity between Triassic sediments and a series of overlying Jurassic rocks at a locality near the mouth of Slate Creek. A 1,000 foot section of rocks, only 9.5 to 10 miles upstream (south) from Lime Point, was also mentioned by Imlay (1964, p. 2), the section consists of:

> ... black, thin layered, evenly bedded, hard and noncalcareous shale. It contains some quartz sandstone and chert pebble conglomerate, has a clean, cross-laminated basal sandstone including large limestone boulders, and contains quartz diorite sills. Notably scarce in fossils some Jurassic ammonites from the formation dated the beds.

This formation has not yet been found in the Lime Point area, but Jurassic beds could occur somewhere in the region; perhaps outside of the map area to the north of Captain John Creek or to the east of Waha Lake. If present, rocks of Jurassic age may be hidden by overburden or may occur under the top of the Columbia Plateau lavas.

The uppermost Mesozoic rocks exposed in the Lime Point area appear to be the Hurwal beds. The Hurwal Formation extends over more than 5 square miles of the map area; however, it probably extends still farther north out of the map area. Thickness of the Hurwal beds is difficult to determine. In the Wallowa Mountains, Palen (1955, p. 50) reported a thickness of 1,800 to 2,800 feet.

Columbia River Group and Latah members ("Formation")

According to Glerup (1960), Columbia River lava flows and intercalated Latah sedimentary rocks have accumulated to a total thickness exceeding 2,300 feet in this area (Plate 1). The contact between the lavas and sediments, and the underlying Hurwal Formation is unconformable, a major erosional interval of considerable duration.

The Columbia River Group represents both the "Upper" and "Lower" flows of Bond (1963, p. 9-12) (Table 1). Near the level of the Snake River, the earlier Lower Basalt is dark, chocolate-brown with a waxy luster. It contains prominent labradorite phenocrysts up to one-eighth of an inch thick. The Upper Basalt is not so extensive over the area, but lies at higher elevations to the east. It is blue-black to lighter shades of black, and contains scattered crystals of plagioclase up to three-eighths of an inch in diameter. The Upper Basalt weathers to shades of light-gray or light-blue. The Lower Basalt weathers to shades of brown and orange-brown. Upon weathering, Lower Basalt flows also tend to disintegrate readily into a coarse granular sand. Both flows are finely crystalline. The Upper Basalt is less systematically jointed than the Lower Basalt. Because of the expansion of clay minerals and the alternation of flow centers, the permeability of the Lower Basalt is less than that of the Upper Basalt (according to Bond), hence spring lines frequently mark the contact between the two flows.

The successive flows of Columbia River Basalt (Tertiary in age) tended to interfere with the drainage of contemporary streams. As a result, surface water was ponded intermittently behind lava dams permitting the deposition of sedimentary materials. These sedimentary materials are chiefly impure, siliceous volcanic ash, herein called the Latah members of the Columbia River Group.

The Latah members occur at several localities in the Lime Point area. Grayish-white to buff colored, loose to firmly consolidated or compacted clay, ash, and silt; locally, these beds contain plant fossils consisting of leaves and seeds from Tertiary (Miocene) flora. Sequences of ashy layers, representing the Latah member, were examined along the north canyon wall of Captain John Creek about 2.5 miles from its mouth (Fig. 3); about 1.5 miles above the mouth of Billy Creek on the north side of the valley; and at several sites near the mouth of the valley that parallels the map contact of the Martin Bridge Formation near Lime Point (Plate 1). The beds at each of these sites is from 8 to 10 feet thick. Commonly, lava flows lie both above and below the outcroppings of the locally faulted ashy beds.

Along the lower reaches of many tributaries to the Snake River, eroded banks or white to gray-white ash and silty valley fill are exposed. These are thought to represent slopewash carried into position and deposited by normal stream drainage. The silty ash is believed to have been derived in part from erosion of Latah beds; however, most of the material probably came from relatively recent slope accumulations, resulting from volcanic eruptions of Mt. Mazama at Crater Lake, Oregon (about 6,600 years ago), and older eruptions at Glacier Peak, Washington (about 12,000 years ago). Similar eruptions yielding great clouds of volcanic ash, probably contributed the above described ash beds that occur with silt and clay in the older

Latah member beds. The actual volume of all these siliceous ash beds is difficult to assess because they are widely distributed and commonly faulted or covered with talus and basalt.

Andesitic and dacitic dikes

Glerup (1960, p. 19) called attention to grayish-green andesitic and dacitic dikes that seem to intrude only Permian rocks on the one hand or Permian and Triassic rocks on the other. In other words, these intrusive rocks may have been emplaced intermittently from the Permian on through the Triassic; they do not appear to cut rocks younger than the late Triassic. These intrusive bodies range from a few inches to several feet in thickness, and are difficult to distinguish from invaded country rock.

Granitic rocks

Glerup (1960, p. 18-19) found coarse-grained granitic dikes cutting the Seven Devils Group, "Lower" Sedimentary Group, and the Hurwal Formation; granitic rocks, believed to be stocks or cupolas rising from deeper seated rocks related to the Central Idaho batholith, are exposed at three localities in the Lime Point map area. Black and white, biotite-quartz diorite and granodiorite are exposed in Captain John, Chimney and Corral creeks. These intrusions commonly exhibit gneissic structure, and resemble rocks found downstream on the Snake; for example, at "Upper" and "Lower" Granite close to Wawawai, Washington. Finer-grained granitic rock in the area is less commonly foliated.

Other granitic rock relations are as follows: Lower Basalt of the Columbia River Group lies on the eroded surface of granitic rock in Captain John Creek. Huge blocks of Triassic limestone occur as large xenoliths in granitic rocks of the same general locality. Total granitic rock known to be exposed in the map area is approximately one square mile. These granitic rocks are probably correlative with the Idaho batholith as implied above, and are quite likely Cretaceous in age.

Locally, granitic rocks are cut by quartz veins exhibiting lean iron and copper sulfide mineralization. Although not verified, reportedly some gold has been found in these rocks. Prospect pits and short adits in Captain John and Chimney creeks are evidence of former prospecting. Traces of copper carbonate bloom give credence to the reported presence of copper-bearing sulfides. The quartz veins are probably associated with a late granitic stage, perhaps as late as early Tertiary time.

Basaltic and diabasic rocks

A number of basaltic and diabasic dikes, some rather large, appear to cut rocks of all ages including some of the earlier Columbia River Group. These are probably feeder dikes of Tertiary basalt flows (Plate 1).

Figure 2. Lime Point (left of center) and Lime Hill (right of center), looking southeast up the Snake River. Mouth of Grande Ronde River is at right edge of photo.

Figure 3. Latah member beds of volcanic ash ("pumicite") on east side of Captain John Creek valley.

After 16

GENERAL STRUCTURAL AND GEOLOGIC HISTORY

In general, rocks in the Lime Point area have experienced considerable folding (major and minor), faulting, igneous intrusion, uplift and erosion. Unconformities mark the principal episodes of erosion. Except for easternmost portions of the overlying cover of basaltic lava flows, the principal structure of the layered rocks consists of a northeast trend or strike, and a steep northwesterly dip (Plate 1). A major fault zone with a steep dip, also trends northeasterly across the map area.

Because of the above-mentioned high degree of deformation and metamorphism experienced by rocks of Permian age, it is difficult to interpret their geologic history, except in a general fashion. The Seven Devils Group represents fairly large thicknesses of volcanic and detrital sediments, carbonate sediments, and lava flows, and some intrusive rocks. The sedimentary rocks appear to have accumulated in a submarine environment, i.e. on a Permian ocean bottom. Lack of good bedding structures makes it difficult to determine the exact attitude of these Permian rocks. Undoubtedly they suffered from effects of early diastrophism, were uplifted, and then eroded before deposition of late Triassic marine sedimentary materials commenced. A gap (lacuna) of missing or eroded rock at the top of the Permian represents a time break, although this break in the record is not everywhere clearly visible.

Lithologies again demonstrate a submarine environment of deposition during late Triassic time, and volcanism was still prevalent in this episode. Triassic strata trend northeast in accord with the larger regional tectonic picture. Deformation of the older rocks appears to reflect an important middle to late Mesozoic orogeny, perhaps resulting from the emplacement of the large granitic masses. It is difficult to determine how much folding may have occurred before or during the emplacement of the stocks of Cretaceous granitic rock. However, the presence of a recognizable unconformity between the Permian and Triassic beds does indicate diastrophism that resulted in at least an uplift of some sort. Another stage of extensive erosion is indicated by the major unconformity separating granitic rocks from overlying basalt flows. This erosional interval resulted in the unroofing of the granitic intrusive rocks.

It seems safe to assume that major faulting accompanied the late Paleozoic uplift of the Permian volcanic and sedimentary rocks, and that faulting occurred again during the emplacement of the granitic cupolas from an underlying batholithic mass. Finally, it is quite apparent that major faulting continued into post-Miocene time displacing the basalt flows which had spread over the eroded late Cretaceous-early Tertiary terrain.

A major fault zone (previously mentioned) trends approximately northeast across the Lime Point area (Plate 1), disrupting post-Miocene(?) or later, Columbia River lava flows. Ferrians (1958) concluded that the vertical displacement of lava along the northwest side of this belt of nearly vertical faults, was more than 2,000 feet. Crustal segments were depressed on the northwest in relation to those which were elevated on the southeast.

Bond (1963, p. 61-65) described the structural framework of this region, and called attention to three major structures: (1) the Uniontown Anticline on the north side of the Clearwater River Valley, (2) the Lewiston Syncline (sometimes called the Lewiston Plateau), and (3) the Craig Mountain Anticline (uplift or monocline) south of the Clearwater Valley. It has long been recognized that the Craig Mountain Sector, south of Lewiston, is a kind of anticlinal structure and related fault zone. The fault scarp is visible on the north side of Waha Lake upland. A nearly vertical group of faults cross the Snake River from the Lime Hill (Fig. 2) side in Washington, trend northeast into the Lime Point area (previously noted), and then swing toward the east forming the Waha escarpment. The faulting continues to strike northeast toward the headwaters of Jacks Creek forming the Clearwater escarpment.

The average strike of the bedded rocks in the Lime Hill-Lime Point district is about N32°-34°E, however, strikes may be as much as N46°E. Variations undoubtedly reflect secondary faulting and folding. All dips are commonly northwest, with an inclination of 30° to 75°, some beds are nearly vertical, while others are overturned. The Hurwal Formation tends to strike a little more to the northeast than the Martin Bridge Formation, for example, up to N50°E. This suggests that an angular unconformity separates the two formations.

Glerup (1960, p. 21) commented that the attitude of one of the massive carbonate beds in the Martin Bridge Formation: "is an indication that after considerable vertical displacement--relaxation followed and the limestone rotated to the south."

The Columbia River Group represents at least 12 to 14 or more, basaltic lava flows poured out upon a surface of considerable erosional relief. Some of these lavas may have flowed into a large pre-existing valley occupied by a river ancestral to the Snake, and located at approximately the same position as the present river axis. Evidence of relatively temporary ponding of tributaries to the ancestral Snake River by Miocene lava dams has already been cited. The many small ponds thus formed became settling basins where clay, silt, sand and ash accumulated to produce the Latah beds (Fig. 3). As noted above, locally these beds contain a fossil record of the abundant flora of the Miocene, a time of more moist climate than that experienced at present, in the map area.

ECONOMIC GEOLOGY

ORIGIN, CLASSIFICATION AND USE OF CARBONATE ROCKS

Origin and classification

Because of the nature of their origin, lime-bearing rocks are variable in composition. They are derived chemically and biologically as precipitates that include general rock detritus. Carbonate rock materials commonly accumulate in an aqueous environment as sediments in lakes, shallow seas, streams and springs. The Lime Point carbonate rocks south of Lewiston are of marine origin.

The common term "limestone" is often incorrectly applied to all carbonate rocks that bubble or effervesce with the application of cold, dilute hydrochloric or acetic acid. However, the total content of calcium carbonate in naturally occurring, high-calcium rocks is less than 100 percent (equivalent to 56 percent CaO). Pure carbonate of lime, or calcium carbonate ($CaCO_3$), is approximated by the mineral calcite.

Actually many rock types may contain lime cement or may be slightly limy, but the name "limestone" probably should be limited to those rocks which contain no less than 80 percent calcium carbonate. Other limy rocks may be given specific names prefixed by the adjective "limy". It is convenient to use the term "carbonate" rocks for all types of rock that contain an appreciable amount of calcium carbonate, particularly if they contain 54 percent or more $CaCO_3$. Table 2 (Savage, 1964) was designed to be useful as a commercial classification for such carbonate rocks. It will be noted that the term "magnestone" is proposed in the table for commercial carbonate rocks that contain calcium carbonate plus a high percentage of magnesium oxide (MgO).

Use of carbonate rocks

It has been truthfully stated that there is virtually no substitute for lime products in chemical and industrial usage. This reflects the fact that, except for petroleum and coal, as mineral commodities in the United States, carbonate rocks outrank all others in dollar value. In 1962, the total reported value of U.S. manufactured cement and lime products was approximately 1.3 billion dollars. By 1963, production of the raw materials--broken limestone and dolomite--exceeded 488 million short tons valued at close to 62 million dollars (Table 3) (Cotter, 1964). This type of rock commodity in recent years has accounted for over 68 percent of the value of the crushed stone industry. The total production of all carbonate rock raw material is increasing, and in 1963 approached half a billion short tons, valued at nearly 715 million dollars (Fig. 4)!

Other products manufactured from calcium and magnesium rocks are too numerous to list here. Lime (mentioned above), for example, has over 7,000 uses. General use categories for carbonate rock products may be catalogued as chemical and physical including: (1) calcium and calcium compounds; (2) lime and cement; (3) dimension, crushed and broken stone, sand and dust; and (4) a great variety of miscellaneous uses (e.g., chicken grit).

The volume of carbonate rock produced for physical uses, that is, for aggregate and ballast, including riprap, fill, etc., is largest, accounting for about 63 percent of total usage (Fig. 8). Cement accounts for about 18 percent; and fluxing stone, agriculture, and lime and dolomite (dead burned) each accounts for close to 4 percent.

Qualitative requirements

Commercial carbonate rocks normally contain impurities of iron oxide (Fe_2O_3), alumina (Al_2O_3), magnesia (MgO), silica (SiO_2), phosphorus (P_2O_5), and sulfur (S). Traces of other elements may also be present. As might be expected, the amount of impurities contained in a given rock sample determine the potential usefulness of the material as a commodity (Table 2). However, contrary to common opinion the "purest" or highest-calcium limerock is not always the most desirable for a specific industrial use, and most physical uses permit a wide range of impurities.

When subjected to pressure and temperature changes, which may also result in deformation, limerock may become recrystallized to marble. This does not interfere with many commercial uses; in fact, recrystallization may increase the desirability of carbonate rock for many uses in the building industry. Much of the higher-calcium-bearing rock in the Lime Point area is recrystallized to marble.

Workability, color, texture and hardness are most important considerations for commercial dimension stone or for other building materials. Attractive coloration, banding and textural features commonly increase the value of marble or limestone. In fact, such variations may produce a premium trimstone.

So-called "cement rock" is naturally endowed with the proper ingredients---including clay, silica, and iron---to produce portland cement. On the other hand, a variety of rocks containing the proper ingredients may be blended to achieve the same correct proportions for manufactured cement. The wide varieties of rock types in the Lime Point area should lend themselves very well to such a blending process.

Quantitative requirements

Carbonate rock is a low unit value, bulky commodity; therefore, whenever such rock is being considered for possible commercial use, it is always necessary along with quality, to consider carefully such factors as accessibility and quantity. In the final analysis, potential values of carbonate rocks will be determined not only by the accessibility of the rock material, but also the accessibility and existence of large markets for raw material and finished products.

TABLE 2. COMMERCIAL CLASSIFICATION OF CARBONATE ROCKS 1/ 2/

by

C. N. Savage

(Range of composition rounded to nearest percent)

Rock type	Principal minerals: Calcite ($CaCO_3$)	Principal minerals: Dolomite $Ca,Mg(CO_3)_2$	If dolomite present: Magnesium Carbonate ($MgCO_3$)	Range of principal compounds: Calcium Oxide (CaO)	Range of principal compounds: Magnesium Oxide (MgO)	Range of principal compounds: Carbon Dioxide (CO_2)
Super-calcium limestone	98-100	0-2	0-1	56	0-trace	44
High-calcium limestone	95-98	2-5	1-2	55-56	trace-1	44
Limestone	80-95	5-20	2-9	51-55	1-4	44-45
Magnesian or dolomitic limestone	54-80	20-46	9-21	44-51	4-10	45-46
High-magnesian limestone or magnestone	0-54	46-100	21-46	30-44	10-22	46-48

1/ Most limestones contain small percentages of material considered "impurities" * by specific industries.
General limits relative to use are listed briefly below (percent):

Cement Upper limits: SiO_2 17 Al_2O_3 5 Fe_2O_3 3 MgO 5 K_2O+Na_2O 1 P_2O_5 1
Lower limits: $CaCO_3$ 72 $SiO_2+Al_2O_3+Fe_2O_3$ 20
Note: May use blast furnace slag, or shale for source of SiO_2 and Al_2O_3, additives $CaSO_4$ 2-3 added to clinker as retarder before grinding, source may be gypsum

Flux, etc. Bessemer iron--Upper limits S 0.5 P_2O_5 0.01
Blast furnace charge-- Upper limits $MgCO_3$ 20-30 $Al_2O_3+Fe_2O_3$ 4 SiO_2 3-4
Patching and lining--Lower limits $MgCO_3$ 35
Open hearth--Upper limits $MgCO_3$ 20 SiO_2 1 S 1 P_2O_5 1

Glass High-, low-calcium or magnesian limestone low in Fe, S, and P_2O_5

Calcium carbide Highest purity $CaCO_3$ 97+ Upper limits SiO_2 1.2 Al_2O_3 and Fe_2O_3 0.5 MgO 0.5 P_2O_5 0.01

Non-hydraulic limes**	High-calcium	Low magnesian	High magnesian
	Upper limits $MgCO_3$ 6	$CaCO_3$ 68-95	$CaCO_3$ 54-72
	Lower limits $CaCO_3$ 91	Range $MgCO_3$ 5-29	Range $MgCO_3$ 28-46
Hydraulic limes	Low: Carbonates 91-97	Moderate: Carbonates 84-91	High: Carbonates 77-84
	Other*** 3-9	Other*** 9-16	Other*** 16-23

(*Information from several published sources, including Illinois State Geol. Sur. Rept. Invest. 49)
(**less than 3 other constituents) (*** Principally $SiO_2+Al_2O_3$)

2/ Adapted from: Savage, C. N. 1964, Limestone and related materials in Mineral and Water Resources of Idaho: U.S. Govt. Printing Office, Washington, D. C., p. 112

TABLE 3. Limestone and dolomite (crushed and broken stone) sold or used by producers in the United States, by uses*
(Thousand short tons and thousand dollars)
(Cotter, 1964)

Use	1962		1963	
	Quantity	Value	Quantity	Value
Concrete and roadstone	276,878	$365,098	292,976	$380,893
Flux	26,081	36,821	27,185	39,322
Agriculture	23,029	39,348	25,956	44,195
Railroad ballast	5,065	6,578	4,923	6,410
Riprap	10,016	12,253	10,690	13,229
Alkali manufacture	2,840	3,188	2,955	3,282
Cement-portland and natural	83,318	92,886	86,842	92,646
Coal-mine dusting	400	1,667	539	2,268
Fill material	440	330	383	296
Filler (not whiting substitute):				
Asphalt	3,208	6,955	1,994	5,012
Fertilizer	448	1,132	457	1,133
Other	351	1,567	419	1,921
Filtration	79	141	62	117
Glass manufacture	1,337	4,294	1,492	4,781
Lime and dead-burned dolomite	19,356	32,959	21,450	36,024
Limestone sand	1,706	3,103	1,759	3,234
Limestone whiting 1/	838	9,639	785	9,298
Mineral food	692	3,847	618	3,793
Paper manufacture	271	821	358	1,099
Poultry grit	161	1,333	160	1,342
Refractory (dolomite)	322	563	769	1,297
Sugar refining	623	1,506	646	1,580
Other uses 2/	1,741	4,253	2,125	5,472
Use unspecified	1,753	2,518	2,805	3,282
Total	*460,953	*$632,800	*488,348	*661,926

1/ Includes stone for filler for abrasives, calcimine, calking compounds, ceramics, chewing gum, fabrics, floor coverings, insecticides, leather goods, paint, paper, photograph records, plastics, pottery, putty, roofing, rubber, wire coating, and unspecified uses. Excludes limestone whiting made by companies from purchased stone.

2/ Includes stone for acid neutralization, calcium carbide, cast stone, chemicals (unspecified), concrete products, disinfectant and animal sanitation, electrical products, magnesia, magnesite, magnesium, mineral wool, oil-well drilling, patching plaster, roofing granules, stucco, terrazzo, and water treatment.

*Figures do not include values for crushed and broken marble, or limestone and marble used as dimension stone.

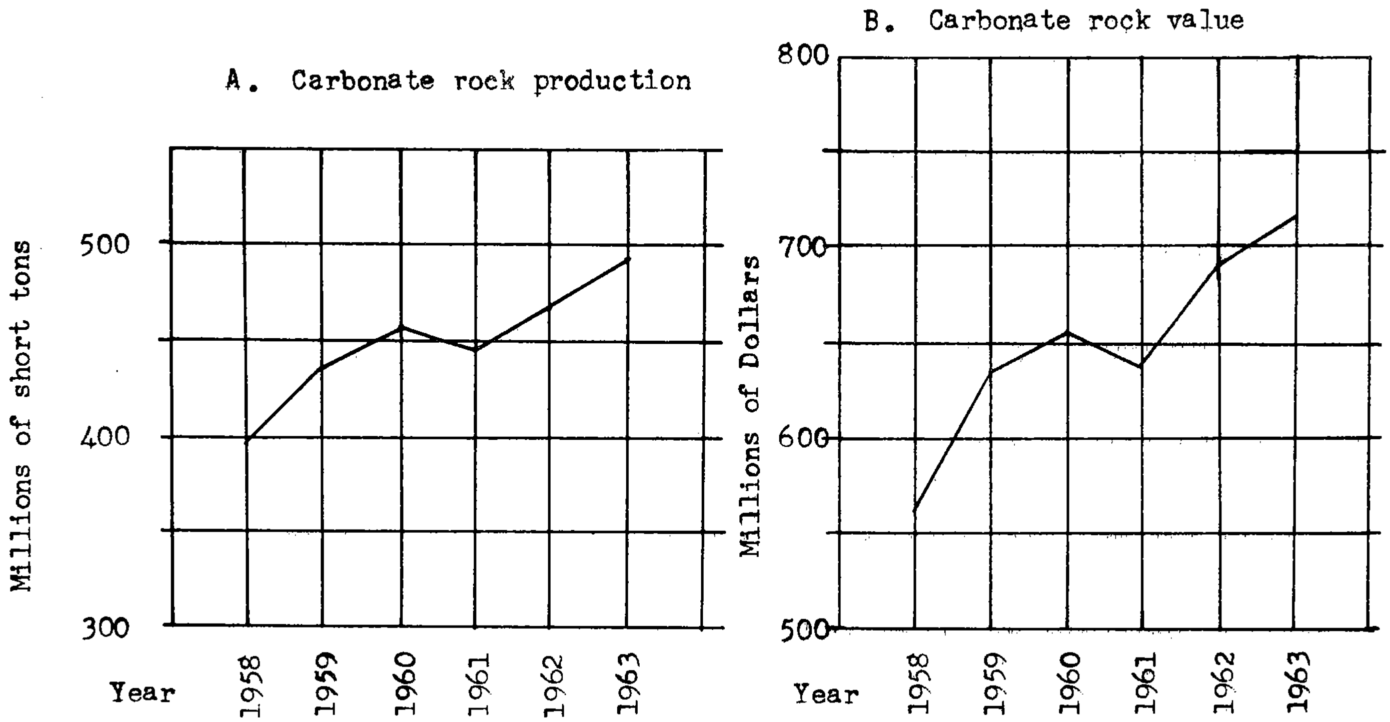

Figure 4. Production and value of carbonate rocks in the United States, 1958-1963, including broken and dimension stone.

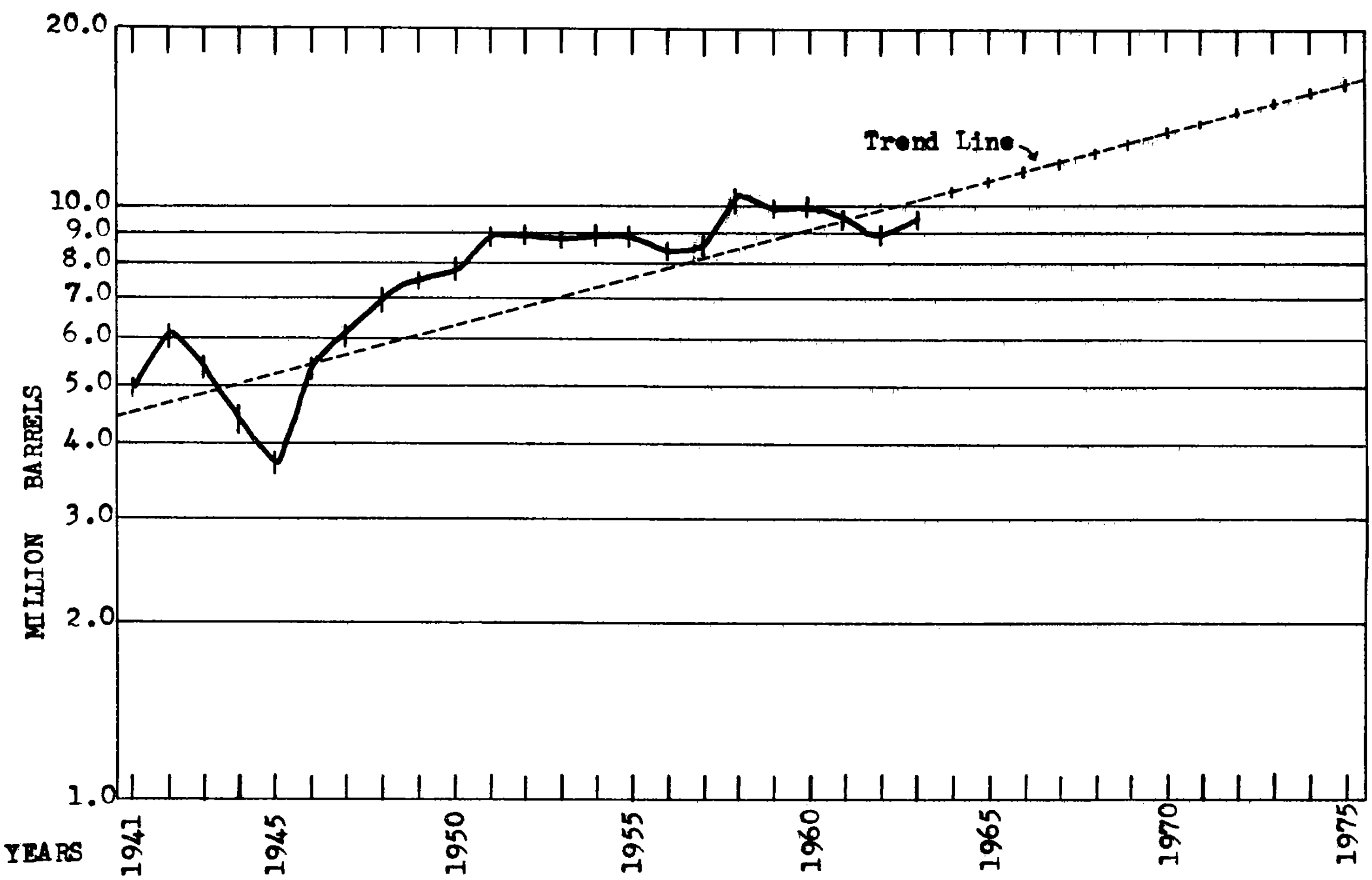

Figure 5. Shipments of Portland cement, total for Washington, Oregon and Idaho (Data from U. S. Bureau of Mines, Albany, Oregon)

Before 17

To be considered for use in the cement industry, a limestone deposit should be no less than 10 feet, and probably 50 feet thick. Areal extent, depending upon structural attitude, should be large enough to yield at least a 20 year supply of raw material for a prospective plant. A small plant, one with a capacity of about 889,000 barrels of cement per year, would require at least 48 million cubic feet of limestone, and about 16 million cubic feet of shale as an additive (when needed), in proximity to a proposed plant site (Savage, 1964, p. 113).

In the lime industry, approximately 1.8 tons of limestone (55 percent CaO) are required to produce about 1 ton of quicklime. Thus, reserves of raw material must be carefully balanced against the desired productivity of a lime plant, as for the cement plant. In the Lime Point area there is a large supply of carbonate rock, which is of a quality suitable for a variety of uses.

For most physical uses, a volume of carbonate rock comparable to that required for a small cement plant (discussed above) should be considered as a minimum commercial supply. For use as a premium trimstone a smaller reserve may be developed economically.

THE CARBONATE ROCKS AT LIME POINT

Previous use

Sporadic attempts to produce small quantities of lime from the carbonate rocks of the Lime Point area are attested to by the presence of abandoned lime kilns at several sites in the area (Fig. 6). Although no records have been found, reportedly, some of these kilns were used in the late 1800's to produce a little lime. This product was shipped downstream on the Snake River for local use.

By 1916, Fisher (p. 4), reported that the Lime Point area had been subdivided into five claims totaling 565 acres, located as follows:

Sunflower claim: S1/2, SE1/2, SE1/4, sec. 28; and Lot 1, sec. 33; all in T32N, R5W (Boise Meridian).

Sunshine claim: Lot 5 and SE1/4, SE1/4 sec. 28; and Lot 1, sec. 33; all in T32N, R5W (Boise Meridian).

Highland claim: SW1/4, NE1/4, SE1/4, NW1/4; and NE1/4, SW1/4, sec. 27; all in T32N, R5W (Boise Meridian).

Cable claim: SE1/4, NE1/4; N1/2, SE1/4; and SW1/4, SE1/4, sec. 27; all in T32N, R5W (Boise Meridian)

Cactus claim: Lot 2, sec. 34; T32N, R5W (Boise Meridian).

At about this time, a small plant reportedly was constructed by the "Idaho Portland Cement Co."? in Washington, adjacent to the Snake River, between Lime Point and Asotin. The plant was planned for processing limerock. There is no evidence that it was so used. Several buildings including a machine shop were said to have been built near Lime Point, and a drift about 160 feet long was driven into the Martin Bridge Formation on the west side of Lime Point about 60 feet above the river level.

Glerup (1960, p. 34) pointed out that a marble quarry was operated in Chimney Creek at some date in the past (Plate 1). An easily dressed, gray, medium textured building stone apparently was recovered at the operation site. Glerup reported that "over a million tons of marble are still exposed at the quarry site" and "could be quarried without undue difficulty." Glerup also called attention to a "granite" quarry near the mouth of Corral Creek that had been developed for recovery of building stone (Plate 1). At the present time, the Lime Point map area is owned, or controlled by several ranchers who use the grazing lands nearby and by the Washington Water Power Co.

Quality of Lime Point carbonate rocks

Carbonate rocks in the Lime Point area appear to be suitable for several products, including both physical and chemical uses. In the past, many analyses of these rocks have been made; a few of these analyses have been brought together in Table 4. In general, the upper more massive member of the Martin Bridge Formation appears to contain the most lime (Table 4, samples 1Am2-2Am2) and approaches a high-calcium limestone (Table 2). The following is an average analysis of its main constituents in percentages:

CaO	53.3	SiO_2	2.5
MgO	0.08	P_2O_5	0.035
R_2O_3 ($Fe_2O_3 + Al_2O_3$)	0.08	$CaCO_3$	95.0

The lower massive member of the Martin Bridge Formation contains slightly less lime. According to Mills (1962, p. 243), carbonate rocks in the Lime Hill area to the west, which in part, certainly must be the equivalent of the Martin Bridge Formation, contain less CaO than was previously reported. He also stated that his analyses consistently indicated more impurities than suspected (Table 4, samples 8Am1 and 8Am2). I concede that the same may be true for the rocks on the east side of the river; here, too, the rocks are not all high-calcium limestones or marbles. However, in the Lime Point area, much of the Martin Bridge Formation may be classified as limestone or marble with reasonably high calcium content (Table 2). The rock contains sufficient CaO to make it entirely suitable for most commercial limestone uses.

Any comparison of the lime content of the rocks at Lime Hill with those of Lime Point should include a consideration of the possibility that the rocks of the two areas may not

TABLE 4. Carbonate rock and pumicite samples from Lime Point Map Area

Analyses in percentages
Rounded to nearest 0.5 except for P_2O_5. Not all analyses were reported to 100 %
(*Code number this report, see identification at end of table)

Sample No.*	$CaCO_3$ (Calculated)	$MgCO_3$ (Calculated)	Loss on ignition (CO_2, chiefly)	CaO	MgO	Acid insoluble (chiefly SiO_2)	R_2O_3 (Fe_2O_3+ Al_2O_3)	Fe_2O_3	Al_2O_3	P_2O_5	Other
$1A_{m2}$*	98.2			55.0	0.6	0.5	0.5	0.5	Trace		
$1B_{m2}$			43.1	55.5	0.2	0.5		Trace	0.5		0.3
1Cm2			39.7	52.0	0.4	5.0	1.8				
2Am2	98.1			55.0	0.1	0.7	0.4	0.3	0.1		
$2B_m$*	97.2			54.5	0.2	0.8	0.6	0.5	Trace		
$2C_m$	99.0			55.5	0.2	0.7	0.4	0.3	0.1		
$2D_m$	95.3			55.1	0.5	0.9	0.4	0.4	Trace		
$2E_m$	95.1			53.3	0.7	2.6	1.0	0.4	0.6		
$2F_m$			43.2	55.7	0.4	0.3		Trace	0.2		0.1
2Gm2			41.6	53.4	1.0	2.5	0.7				
$2L_{ms}$*			11.7	11.7	3.0	57.3		3.6	12.5		0.2
$2M_{ms}$			2.8	0.4	0.2	71.9		1.8	14.0		9.0
$2N_{ms}$			20.8	23.3	3.7	37.9		4.1	9.2		0.9
$2P_{ms}$			10.8	1.8	1.0	66.7		2.2	11.6		6.0
2Hm1*			38.0	45.0	1.3	11.9	3.4				
$2I_m$			41.2	50.3	2.3	4.8	0.8				
$2J_m$			42.0	37.2	0.8	4.0	15.7				
$2K_m$			35.8	34.9	1.4	17.2	12.0				
$3A_h$*			20.5	26.0	3.5	40.7	7.6				
$3C_h$			33.6	37.2	1.6	18.5	9.2				
$3D_h$			13.8	16.7	3.3	52.4	11.2				
$3E_h$			16.9	19.0	1.9	55.0	6.3				
$3F_h$			24.7	31.6	2.0	34.6	15.4				
$3G_h$			27.6	33.1	1.6	30.7	5.6				
$3H_h$			17.0	19.2	4.6	44.8	13.4				
4_{ls}*	71.6			40.2	0.3	19.0	5.1	1.2	3.9		
$5A_m$	55.3	3.1	21.8	31.0	1.5	21.8		4.8	10.3	0.25	
$5B_m$	97.3	0.1	43.0	54.5	0.1	1.1		0.7		0.04	4.0
6**			31.3	38.4	1.3	13.8		4.6	7.0		
$7A_p$*				4.3	1.6	66.3	15.0				
$7B_p$				0.9	1.2	73.8	15.9				
$7C_p$			4.1	1.8	0.8	68.0		2.3	15.9		7.2
$7D_p$						55.0	8.2				
$7E_p$						56.7	19.7				
$7F_p$						56.1	16.8				

TABLE 4. Carbonate rocks and pumicite samples from Lime Point Map Area (Continued)

Sample No. *	$CaCO_3$ (Calculated)	$MgCO_3$ (Calculated)	Loss on ignition (CO_2, chiefly)	CaO	MgO	Acid insoluble (chiefly SiO_2)	R_2O_3 (Fe_2O_3+ Al_2O_3)	Fe_2O_3	Al_2O_3	P_2O_5	Other
8Am1	83.3			46.8	1.7	5.1	1.5			0.03	
8Bm2	85.9			48.3	0.63	6.0	1.2			0.03	

* m Martin Bridge Fm
m 2 Upper Martin Bridge Fm
h Hurwal Fm
p Pumicite
m l Lower Martin Bridge Fm
m s Martin Bridge shaly member
l s Lower Sedimentary Group

**Analysis of natural cement rock for comparative purposes
Ohio Geol. Survey, 1924, Bull. 28, 4th Series, p. 193

SAMPLE CODE FOR TABLE 4

C. A. Fisher Report, (1916), samples analysed by von Schulz and Low, Denver, Colo.

- 1A Drift at Lime Point, composite from walls, Lot No. 1. (Martin Bridge Fm.)
- 2A Surface samples continuing SE across Lime Point from the approximate end of drift, Lot No. 2. (Martin Bridge Fm.).
- 2B General vicinity of Lime Point ridge, Lot No. 3. (Martin Bridge Fm.)
- 2C NE on Lime Point ridge, Lot No. 4. (Martin Bridge Fm.).
- 2D NE on Lime Point ridge, W of 2C, Lot No. 5. (Martin Bridge Fm.)
- 2E W of 2D at uppermost exposure of Martin Bridge Fm(?), Lot No. 6.
- 4 From shale pit E of Lime Point, Lot No. 10. (Lower Sedimentary Group)
- 7A Analysis of "pumicite," gulch NW of Lime Point, Lot No. 7.
- 7B Analysis of "pumicite," gulch NW of Lime Point, 700 ft. W of drift, Lot No. 8.

H.S. Gale Report, in Eckel (1913), samples analysed by A. B. Lort, U.S. Bur. Standards.

- 1B Drift at Lime Point, composite from walls, No. 2.
- 2F Average of samples across Lime Point ridge, No. 3.
- 2L Average of 44 samples shaly layers in Martin Bridge Fm(?), NE from Lime Point, No. 4.
- 2M Shaly facies, Martin Bridge Fm(?) near crest of ridge, No. 5.
- 2N Shaly pit, Martin Bridge Fm.(?) on flank of ridge, No. 6.
- 2P Schist, Martin Bridge Fm.(?) No. 7.
- 7C Clayey pumicite(?), valley fill, Lime Point gully, No. 1

Glerup Report, (1960), samples analysed by Huey-rong Hsi, Idaho Bur. Mines and Geol.

- 2G Average of 8 samples across Lime Point ridge, mostly in Upper Martin Bridge Fm., massive unit, Nos. 2,4,5,6,7,8,11,and 12.

Sample code for Table 4. (Continued)

Glerup Report

2H	Average of 6 samples across Lime Point ridge, mostly in Lower Martin Bridge Fm., massive unit, Nos. 1,3,13,14,19 and 17.
2I	Middle Martin Bridge Fm., Lime Point, No. 9.
2J	Middle Martin Bridge Fm., Lime Point, No. 10.
2K	Highest Martin Bridge Fm., Lime Point, No. 16.
3A	Hurwal Fm., Camp Cr. area, No. 19.
3C	Hurwal Fm., near Madden Cr. mouth, No. 21.
3Hh	Horwal Fm., near old lime kiln up from mouth of Madden Cr., No. 20.

Savage, this report, (1964), samples analysed by George Hsu, Idaho Bur. Mines and Geol.

1C	Drift at Lime Point composite along walls, S L 164
3D	Hurwal, sampled 1.5 mi. up Billy Cr., S L 166
3E	Hurwal, sampled Madden Cr. near mouth S L 168
3F	Hurwal, sampled near old lime kiln up Madden Cr., S L 173
3G	Hurwal, 0.5 mi. up Billy Cr. S L 167
7D	Volcanic ash, "pumicite," S L 171 (Up Capt. John Cr.)
7E	Volcanic ash, "pumicite," Upper Billy Cr.
7F	Volcanic ash, 0.75 mi. up Billy Cr. S L 165
6	Natural cement rock, 1924, Ohio Geol. Survey Bull. 28, 4th Ser., p. 193.

Mills Report, (1962), samples analysed by Div. of Industrial Research, Wash. State U.

8A	Composite analyses of carbonate rock at Lime Hill, a continuation of Lime Point rocks to the SW into Washington, Lower massive unit (Martin Bridge Fm(?), A-1, 2,3,11, and 12.
8B	Same area as 8A, but representative of the Upper massive Martin Bridge Fm.(?), A4-10.

Gullixon Report, (1954)

5A-5B Composites taken in the Lime Point area, T-100 and T-140, respectively.

be wholly equivalent to each other. For example, slight changes in facies may occur between the two deposits, but more likely, is the possibility that some of the beds with higher lime content at Lime Point, may have been eroded or faulted out of the section at Lime Hill.

Judging by the analyses in Table 4, among other things, the rocks in the Lime Point area are well-suited as raw materials for portland cement. Furthermore, the higher-calcium rocks in this area could be easily blended with shaly materials that contain more SiO_2, Fe_2O_3 and Al_2O_3 to obtain the correct blend for a good quality cement product (Table 4, sample 6).

For other uses, rock suitable for fluxing in the open hearth or for use in a blast furnace is also available at this site. Only one analysis (Table 4, sample 5Am), shows sufficient P_2O_3 to pose a problem for some uses. This one sample may have been subjected to an analytical or recording error, because no other analyses show comparable amounts of P_2O_5. In general, the Martin Bridge Formation appears to have an average of from 0.03 to 0.04 P_2O_5 content. However, this amount is probably slightly higher than the limits of toleration permissible in the calcium carbide industry.

Various lime products could be produced from the raw materials present in the Lime Point area. The general content of CaO is reasonably high in a variety of local rocks, and potential contaminants are generally low in volume. Special attention is called to the possibility that large quantities of limy shales and schists may be present in the Hurwal Formation (Table 4, samples 3A-3G). This rock has commercial possibilities, particularly as a blending material to be used in conjunction with higher calcium stone for production of portland cement.

Table 4 contains analyses of the volcanic ash or "pumicite" deposits (samples 7Ap-7Ep). There is some question about the quantity, quality, and workability of these materials for commercial usage; however, the ash deposits are in proximity to potentially valuable carbonate rock with which it might be combined to produce a pozzolan product. They appear chemically suitable for pozzolan. There is also a possibility that the ash could be used in premium light-weight cement blocks.

Use of the Lime Point carbonate rock for dimension stone needs to be more thoroughly investigated, as does its potential as a broken stone commodity. Crushed basalt is used extensively in this area for ballast or aggregate, but if the Lime Point rock becomes readily accessible, this source of supply should certainly be considered for possible use in the ballast and aggregate industry. The traditional use of available basalt does not mean that it is better than carbonate rock for all uses. In fact, the reverse may be true.

Quantity of carbonate rock in the Lime Point area

The geologic maps that accompany this report show the areal extent of carbonate and other rock types in the Lime Point area. Plate 1 shows the whole area, while

Plate 2 is a geologic and topographic map of the Lime Point-Gold Hill sector. The latter contains the larger reserves of carbonate rocks. These rocks will probably be accessible to barge transportation in a few years provided federal dam construction projects are soon implemented. Because the deposits will be readily accessible for transportation to widespread markets, it seems economically feasible to make a reassessment of their economic potential.

In 1916, Fisher estimated that "high grade" limestone forming the northeast trending ridge at Lime Point (Plate 2), constituted an "above ground" reserve of about 9 million short tons (after application of a correction factor of 20 percent to cover possible computation errors or waste in recovery).

Gullixson (1954) calculated that there were over 309 million short tons of carbonate rock available in the Lime Point area (after application of a 30 percent margin of error factor).

Glerup (1960), using careful methods of estimating rock volume, stated that the reserve of carbonate rock at Lime Point (Martin Bridge Formation) was in the neighborhood of 626 million short tons of rock (a margin of error of 30 percent was deducted from his original total figure for calculated reserves). In my opinion, all the above estimates of volume, including Glerup's, are modest indeed.

Using Glerup's more realistic estimate, the 626 million short tons of available carbonate rock in the immediate vicinity of Lime Point (Plate 2) would provide raw material for a large cement plant (capacity of about 3.5 million barrels of cement per year) to operate for more than 750 years. In other words, the calculated volume of available carbonate rock represented by the Martin Bridge Formation alone, is very large constituting an ample supply of raw material for more than one industrial use, for a relatively long period of time.

Comments on rock recovery, water and power

Recovery of carbonate rock as a raw material should be relatively easy in the Lime Point area. The use of open pit and gravity methods and/or conveyor belts would be quite suitable for any recovery operation (Fig. 2). Preliminary processing plants could be constructed on the terrace level on the downstream side of the great bend in the Snake River; for example, where the Snake turns east downstream from its confluence with the Grande Ronde (Fig. 7). The flats at this site should be above any highwater level on the Snake,* and also relatively safe from threat of flash floods along valleys tributary to the Snake. Broken rock from recovery operations could be conveyed by belt to a crushing and sizing plant at this site and then conveyed downstream by barge to <u>any point</u> below Lime Point on the Columbia River System.

Water and power requirements connected with rock recovery could be obtained locally. The perennial streams mentioned earlier and the Snake River would be capable

*Maximum pool elevation behind Asotin Dam is planned for 856.5 feet, these river terfaces are between 850 and 1000 feet (plus) in elevation.

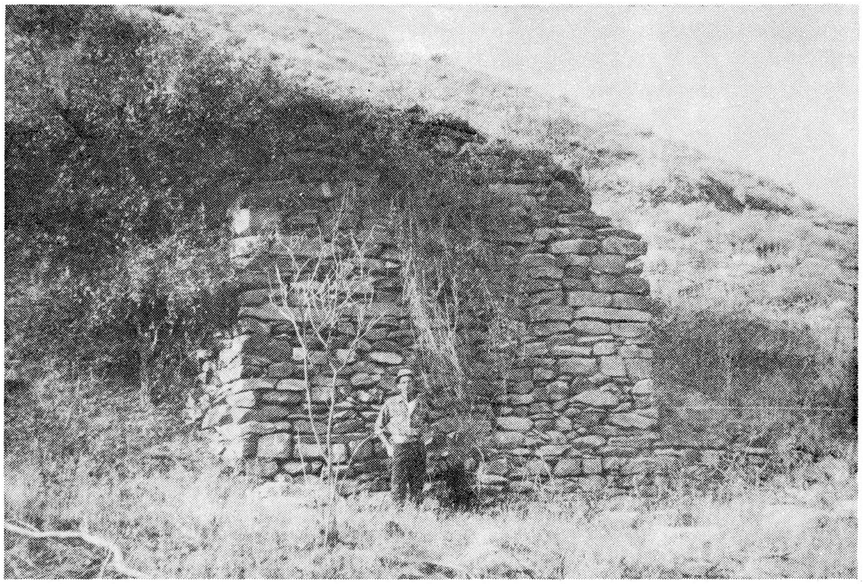

Figure 6. Old lime kiln on Madden Creek, Lime Point map area. Slope to rear composed of limy Hurwal tuffs and argillites.

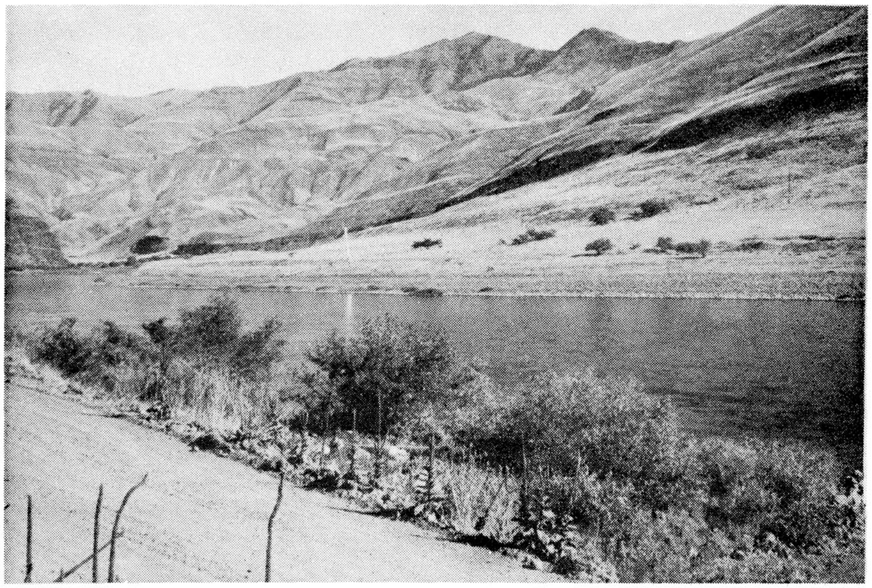

Figure 7. River terraces suitable for plant construction, just downstream from Lime Point on the Snake River, looking east toward Idaho.

of supplying considerable volume of water for plant operations. A power line is also available on the east side of the Snake River in this area. Furthermore, preliminary power generation at Asotin Dam will be on the order of 288,000 KW, providing additional power which could be fed into the regional system.

REGIONAL AND LOCAL ECONOMIC ANALYSIS

General situation

Many economists confirm the opinion that the Pacific Northwest has the capacity to become an industrial colossus. One indication of this possibility is the availability of potential power supply. Demand for this power is already great. Columbia Basin Inter-Agency Committee (1963, p. 2-5) recently pointed out that the region's abundant supply of hydroelectric power is a base for low-cost renewable energy and constitutes a major resource for the future of an already rapidly expanding economy. It is predicted that "total energy requirements will increase from 52 billion kilowatt hours in 1961 to 104 billion in 1971". In anticipation of this time, currently under construction, are several new power projects on the Columbia River System, including Bruces Eddy, Cougar, Foster, Green Peter, John Day, Little Goose, and Lower Monumental dams. Authorized projects include Libby, Lower Granite, Asotin and Strube.

The development and success of port facilities along the Columbia River System is another indication of the Northwest's potential capacity to expand industrially. There is no reason why, in the future, the Lewiston-Clarkston area should prove to be an exception to the prosperous ports already developed. The area should experience considerable economic growth. With the projected completion of Lower Granite Dam by 1970, the Lewiston-Clarkston area will be open to barge traffic which will tie the port into many Pacific Northwest industrial and potential industrial markets. Furthermore, all Pacific ports will then be within reach of North Idaho's industries and future industries. Commodities, too numerous to mention, will flow in both directions. The U.S. Army Corps of Engineers have derived the following estimates of savings from the potential Lewiston Port Area:

ESTIMATED ANNUAL SAVINGS FROM COMMERCE THROUGH LOWER GRANITE LOCKS FROM LEWISTON AND CLARKSTON PORTS 1975-2025 *

Upstream	Tons	Savings in Dollars
Industrial Chemicals	66,000	$ 305,000
Petroleum Products	226,000	888,000
Miscellaneous	20,000	104,000
Downstream		
Cement	66,000	136,000
Chemical Products	20,000	105,000
Grain	218,000	815,000
Limestone	1,400,000	3,503,000
Lumber and Poles	240,000	1,058,000
Paper Products	96,000	430,000
Sawdust Chips and Pulp	112,000	588,000
Woodpulp and Products	150,000	557,000
TOTAL	2,614,000	$ 8,489,000

After completion of Asotin Dam, the development of a port in the Lewiston area would undoubtedly enhance the economic development of the above-described extensive carbonate rock deposit. The presence of these deposits at Lime Point would warrant construction of the navigation locks which have been designed for Asotin Dam when the dam is built.

Both population and industry should experience rather rapid growth in the Lewiston-Clarkston area by the time Asotin Dam is complete. The total population of the metropolitan area (about 20,000 people) might conceivably become 180,000 people; with less than 50 years of growth. This is about twice the present population of adjacent Idaho and Washington counties in this region, and close to the population of Spokane.

The Lewiston-Clarkston area is particularly well-adapted for industrial expansion when it becomes a port area. Air, railroad, bus, and truck transportation is already established. Electric power, natural gas, and water resources are present and expandable. This region is also well-adapted to almost unlimited expansion of the wood products industries. Chemical industries should do exceedingly well in the region. Not the least of the local advantages are the large local sources of timber and carbonate rock. The potential of the carbonate rock will be treated in the following paragraphs.

*Idaho Image p. 2, Oct. 1964

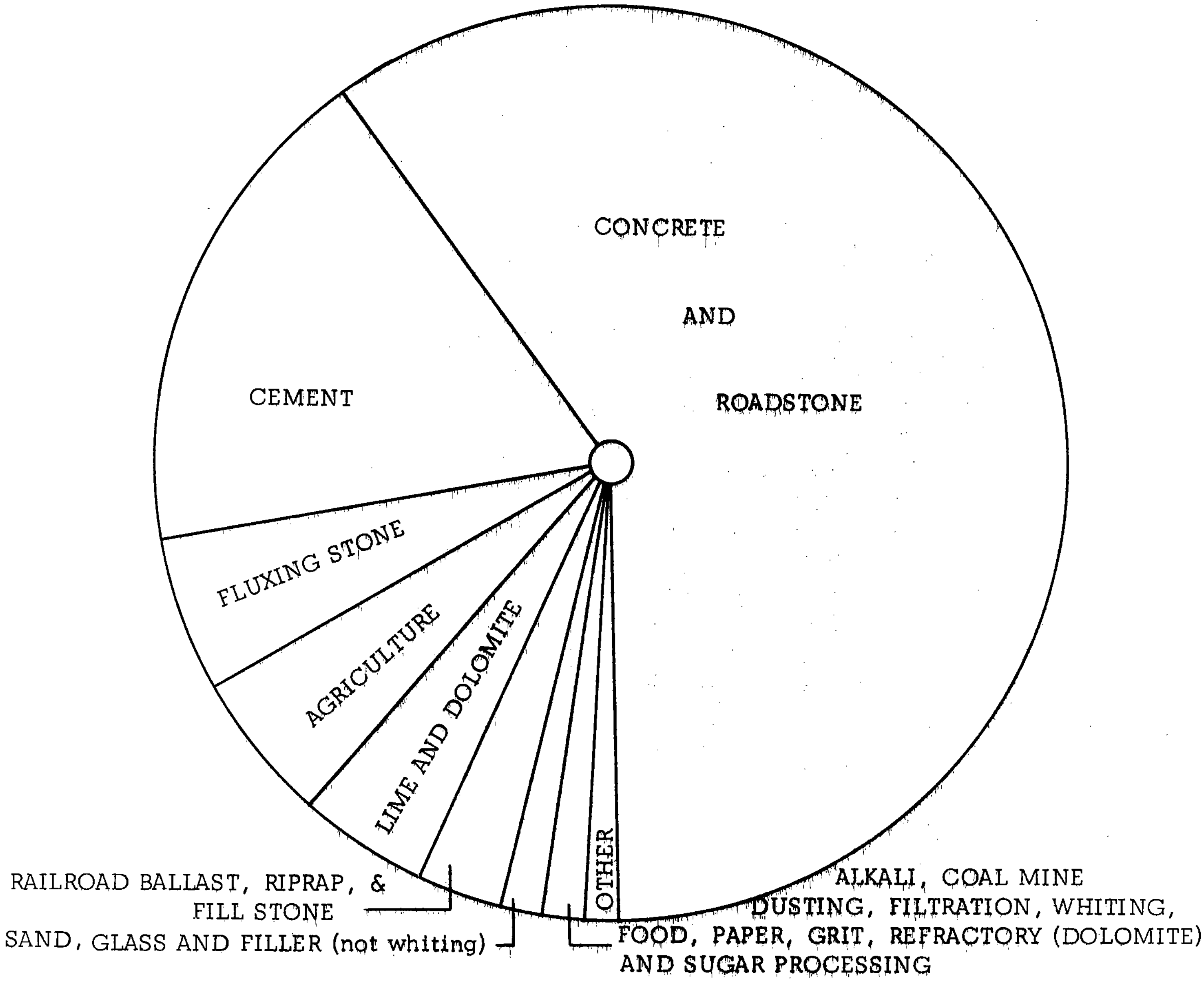

Figure 8. Relative volumes of crushed and broken limestone and dolomite by categories, used or sold in the United States in 1963. Does not include marble or carbonate rocks used for dimension stone. (Based on U. S. Bureau of Mines Preliminary Annual Report)

Potential of the carbonate rocks at Lime Point

Savage (1964, p. 115-116) summarized the potential of carbonate rocks in Idaho in a recently published report: Mineral and Water Resources of Idaho. It was pointed out that lime-bearing rock in Idaho has been used principally for agricultural stone, poultry grit, flux, sugar refining, cement rock, and lime. Small quantities have been used in construction--as dimension and broken stone. Lime used in Idaho sugar and paper industries has been produced in both Idaho and adjoining states. Some of this lime is reprocessed, thus the demand for raw stone for this use has decreased slightly.

While there is no evidence of urgent need for additional cement plants to supply Idaho markets, in the future an expanding western oriented market in Washington and Oregon could induce larger demands for cement and additional capacity to produce cement in northwestern Idaho, particularly, near existing raw materials. Figure 5 shows the volume of shipments of cement in the Pacific Northwest from 1941 to 1963. The trend line on this chart suggests a continued increase in demand for cement.

Williams and Roby conducted a market analysis in 1962 which indicated that additional markets for carbonate rock, other than the cement industry, exist in the northwest region. The available markets and current prices cited per short ton of stone were as follows:

> sugar production, \$2.75; paper making, \$2.71; smelter flux, \$1.40; agricultural stone, \$3.50; and ornamental stone, \$15.00.

It is important to note that in certain parts of North Idaho and in parts of western Washington and Oregon there may be an increased future demand for more agricultural lime. It has been demonstrated that lime additives have improved crop yield and have been of benefit in combating certain alfalfa diseases. Research upon the latter problem is being conducted at the University of Idaho.

According to Thomas (1960), Lime Point in the Lewiston-Clark area, might be expected to supply some part of the carbonate rock that will be used by the expanding cement industry in the Pacific Northwest (Fig. 5). It is pointed out that the delivered price of lime-bearing rock reflects: (1) production costs (including quarrying, crushing and loading, and capital depreciation) and (2) transportation cost to the consumer. Because unit costs vary with the magnitude of an operation, the large operation which could be operated for rock recovery at Lime Point should reduce cost of the stone for consumption. Thomas (p. 16) estimated that open-pit production at Lime Point would cost about 70 cents per ton at 1959-60 prices for limerock.

If barge transportation on the Columbia River System becomes available for shipping the carbonate rock and lime products from the Lewiston-Clarkston area, raw materials from Lime Point could compete successfully with any other similar raw materials all the way west to Astoria at the mouth of the Columbia. The area of influence in which these carbonate commodities could be delivered more cheaply than from any other source, falls just south of a line drawn from Lime Point north to Moscow, Idaho; thence northwestward to Odessa, Washington and south to Yakima; then west to Raymond on the west coast. The southern boundary of this area would lie just north of a line drawn southwestward from Lime Point to Pendleton and Prineville, Oregon; thence westward to Eugene and to the west coast just north of Coos Bay.

The Thomas report (1960) asserted that the carbonate deposits south of Lewiston would "unquestionably" provide for the cement needs of the above delineated area. It stated that the Oregon Portland Cement Company had indicated they could use an initial supply of 450,000 short tons of rock annually, if such rock were made available from Lime Point. The Thomas report also contained a letter released by Ideal Cement Company to the Inland Empire Waterways Association (1960). The letter indicated plans to build a cement plant in the Lewiston-Clarkston region were being considered. This plant would be competitive in northern Idaho, northeastern Oregon and eastern Washington. Alternatively, it was suggested that a cement plant might be built at Portland, Oregon. If the latter plant were constructed, it would be competitive in western Oregon and southwestern Washington. Savings on lime-rock shipments based upon barge transportation were estimated at about $1.25 per ton of rock. Ideal's proposed cement plant in the Lewiston-Clarkston area was planned to produce 1.5 million barrels of cement per year. In connection with this proposal, additional plans (1960) called for an eventual increase in plant output that would require about 1 million tons of limestone per year by 1970. Shipment of about 50 percent of the cement product would probably be to Ideal's Vancouver terminal.*

Considerable lime and limestone from the Lime Point area, if available, would probably be used in the area of influence, outlined above, for purposes other than making cement. Savings would be about $1.64 per ton of raw material or about 43 cents per ton for lime for agricultural use (Thomas report).

Finally, attention is called again, to volcanic ash deposits as potential material for cement manufacture. Pumicite deposits (Latah members) in the Lime Point area are interbedded with basalt flows at several sites (Fig. 3) and also occur as valley fill in several tributaries to the Snake River. There is probably no reason why some of these pumicite deposits could not be used for production of pozzolanic cement, or used in the lightweight building block industry. Unfortunately the volume of pumicite in the area has not been estimated. In fact, the deposits have not been carefully mapped. It is possible that the lack of volume, or potential quarrying problems might prohibit the extensive use of this volcanic ash product. Further exploration and consideration of these deposits for possible commercial use is recommended. Partial analyses of samples from the known deposits of volcanic ash are included in Table 4.

*It should be noted that Ideal Cement Company holds leases in the Lime Hill carbonate rock area just west of Lime Point.

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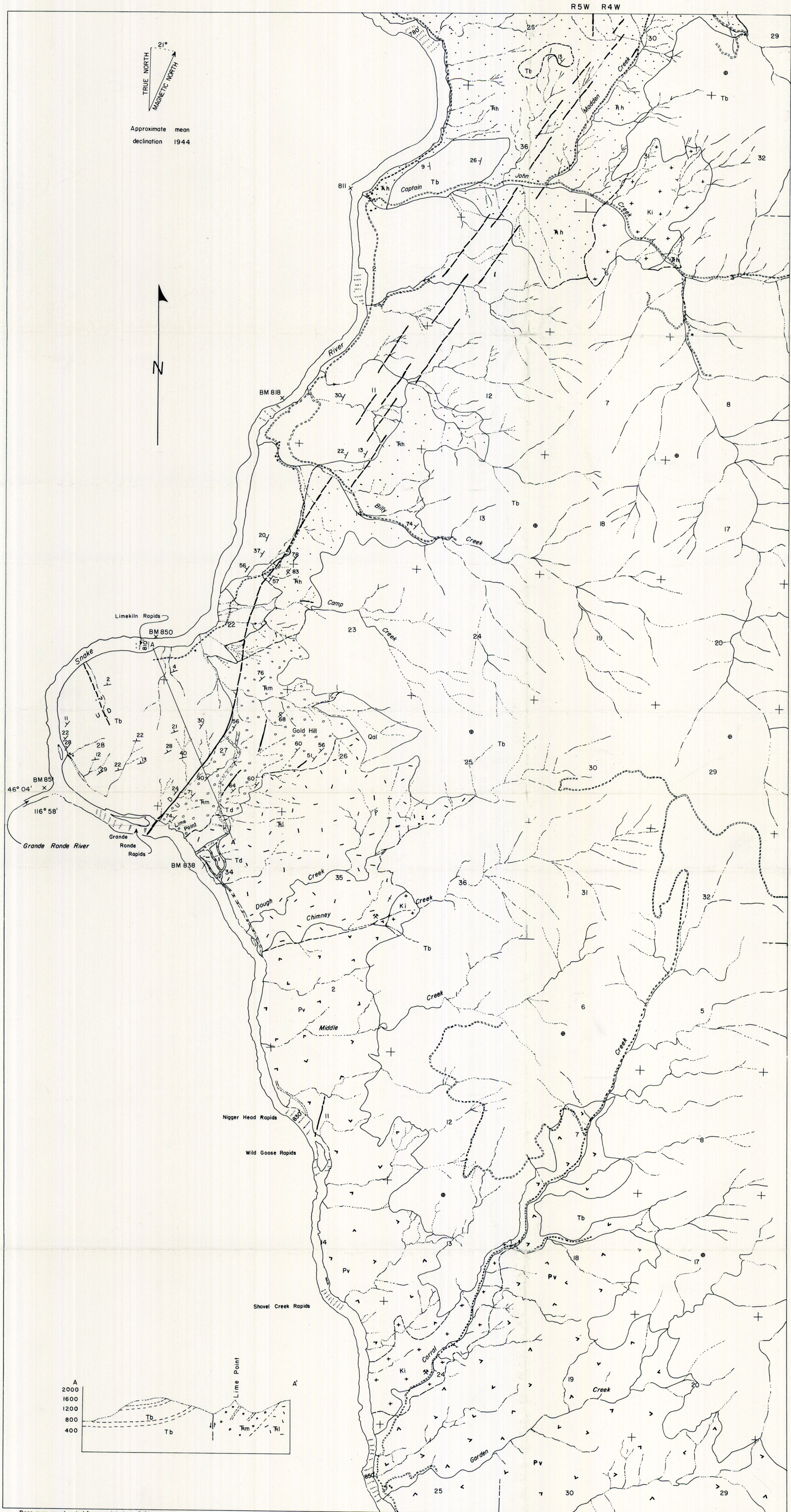


EXPLANATION

SEDIMENTARY ROCKS
(In part metamorphosed)

QUATERNARY
- Qal — Alluvial deposits

UNCONFORMITY(?)

TRIASSIC
- Ћh — Hurwal Formation
- Ћm — Martin Bridge Formation
- Ћl — Lower Sedimentary Series

UNCONFORMITY(?)

PERMIAN
- Pv — Seven Devils Volcanics

IGNEOUS AND PLUTONIC ROCKS

TERTIARY
- Tb — Columbia River Basalt
- Td — Basalt dike

CRETACEOUS
- Ki — Idaho batholith

20 — Overturned beds

20 — Strike and dip

Horizontal strata

90 — Vertical strata

Adit

Prospect pit — Quarry

Spring

BM × 248 — Bench mark; Triangulation point

Definite contact

Approximate contact

Fault

Approximate location of fault

Jeep trail

Large rapids

Approximate section corner

Base map constructed from aerial photos (USDA-1946) 1/20,000
Horizontal control from Corps of Engineers SN-148-1&2, 1951 (1/24,000)

PLATE I

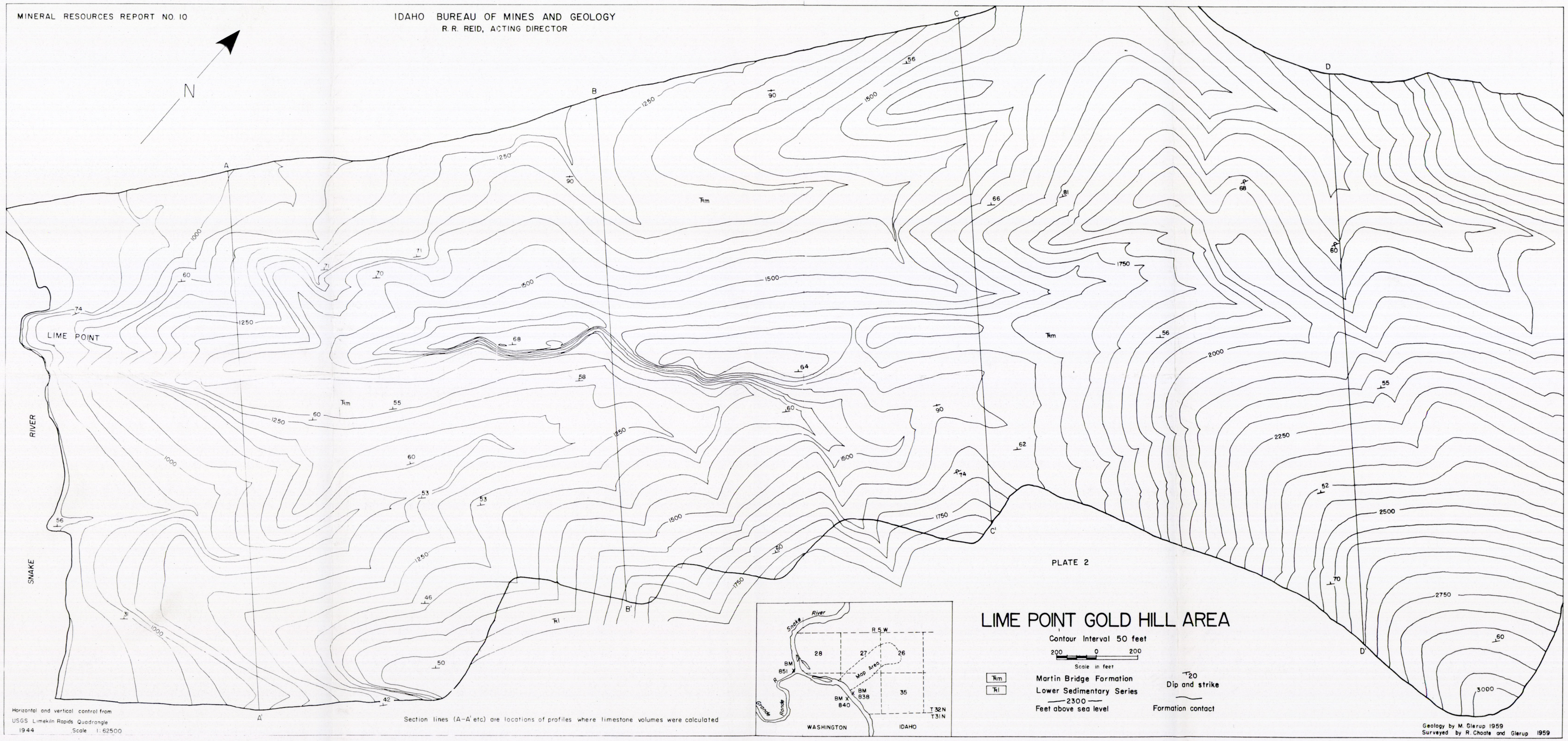
R5W R4W

Geology by M.O. Glerup 1959
Revisions by C.N. Savage 1964

GEOLOGIC MAP OF LIME POINT AREA

NEZ PERCE COUNTY, IDAHO

0
SCALE IN MILES



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N
A
B
C
D
LIME POINT
SNAKE
RIVER
A'
B'
C'
D'
PLATE 2
LIME POINT GOLD HILL AREA
Contour Interval 50 feet
Scale in feet
Martin Bridge Formation
Lower Sedimentary Series
Feet above sea level
Dip and strike
Formation contact
Snake River
R 5 W
Map Area
Grande Ronde
T32N
T31N
WASHINGTON
IDAHO
Horizontal and vertical control from
USGS Limekiln Rapids Quadrangle
1944 Scale 1:62500
Section lines (A-A' etc) are locations of profiles where limestone volumes were calculated
Geology by M. Glerup 1959
Surveyed by R. Choate and Glerup 1959