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PORTLAND CEMENT MATERIALS
NEAR POCATELLO, IDAHO

by
Alfred L. Anderson

University of Idaho
Moscow, Idaho

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PORTLAND CEMENT MATERIALS NEAR POCATELLO, IDAHO

INTRODUCTION

Deposits of limestone near Pocatello in Bannock County, Idaho, suitable for Portland cement manufacture have been known for several years. These deposits have been sampled by several interested parties and have been found low in magnesia and apparently satisfactory as an ingredient in Portland cement. The interest in their exploitation has been sporadic, and no plants have been constructed for the manufacture of cement. As a result of awakened interest in these deposits during the early part of 1928, the writer was assigned to make a reconnaissance examination of the geologic features of the deposits. Seven days were spent in the district from April 27 to May 30, 1928, during which the outcrops were studied and the age and stratigraphic position determined. A geologic sketch map was also prepared on which are shown the location of the limestone and also the beds of shale which are equally essential in the manufacture of cement. Two limestone series which are separated by several thousand feet of sandstone, shale and quartzite probably have commercial value. These lie near the main line of the Oregon Short Line railway. The limestone beds are extensive and may be traced for long distances from the railroad, but only those deposits adjacent to the railroad were visited and mapped. Fortunately the two widely separated series of limestones are each underlain by a series of shales which can probably furnish the silica, alumina, and iron also needed in cement manufacture.

In this report only the geologic factors are considered and for those who are interested in the technology of cement making or in a brief sketch of the general status of the Portland cement industry the writer wishes to refer them to Bulletin 243, U. S. Geological Survey, "Cement Materials and Cement Industries of the United States", by Edwin C. Eckel, 1905, and to Bulletin 522, U. S. Geological Survey "Portland Cement Materials in the United States", also by Edwin C. Eckel, 1913. The region near Pocatello wherein the limestone deposits occur has been briefly described by E. B. Weeks and V. C. Heikes in Bulletin 340, U. S. Geological Survey, "Notes on the Fort Hall Mining district, Idaho", 1907. The writer found it necessary to revise somewhat the stratigraphy and structure as described by Weeks and Heikes, particularly the age of the formations, largely because of the finding of index fossils, and also because they may be correlated stratigraphically with some of the formations in neighboring areas that have been studied more recently in detail by G. R. Mansfield and made available in "Geography, geology, and mineral resources of the Fort Hall Indian Reservation, Idaho," U. S. Geological Survey Bulletin 713, 1920, and in "Geography, geology, and mineral resources of part of Southeastern Idaho," U. S. Geological Survey, Professional Paper 152, 1927. Some of the formations studied by the writer apparently underly the oldest formation, the Brigham quartzite, described by Mansfield and are hence new to the geology of southeastern Idaho.

LOCATION AND ACCESS

The limestone and shale deposits lie along the sides of the Portneuf valley between Portneuf and Inkom. Portneuf is a siding on the Oregon Short line (Union Pacific System) and is about six miles southeast of Pocatello.

Pocatello the county seat of Bannock County and the second largest city in the state has a population of about 20,000. The town on Inkom is about six miles east of Portneuf.
SKETCH MAP ALONG THE PORTNEUF RIVER FROM PORTNEUF TO INKOM

LEGEND

SEDIMENTARY ROCKS

Aluvium
stream deposits

Middle Cambrian
undifferentiated limestones
and shales (including Long-ecott[?], Uter, Blacksmith[?],
Bloomer[?], and koumns [?] Formations)

Brigham Quartzite
reddish and grayish sandstones
and quartzites with
shale (broken lines)

Black Rock Limestone

Bannock Formation
lava flows, quartzites,
agglomerates, shales, and
impure limestones
(Shale - broken lines)

IGNEOUS ROCK

Valley Basalt

Fault

Dip & Strike

Based on U.S. Dept of
Agriculture soil survey map, 1921.

Geology by
Alfred E. Anderson, 1928
The limestone formations also continue south of Inkom for several miles along both sides of the valley of Portneuf River and Marsh Creek. The two deposits that are most easily available lie, one about two miles northeast of Portneuf Siding or little more than half a mile north of the railroad, and the other about one quarter mile south of the railroad station at Inkom. The area examined lies along both sides of the Portneuf River from where it makes the turn to the west near Inkom to where it assumes a northwesterly course at Portneuf Siding. Mapping covered from one to two miles on both sides of the valley.

**TOPOGRAPHY**

The deposits outcrop in the Bannock Range, a northerly trending mountainous ridge, which is bounded on the north by the Valley of Ross Fork and extends southward to the headwaters of Malade Creek. The Portneuf Range lies to the east and the Pocatello Range to the west. These are separated by wide northerly trending valleys. Southward the boundary between the Bannock Range and Pocatello Range is not so well defined. The Portneuf River crosses the Portneuf Range in a narrow valley and enters the wide valley which separates this range from the Bannock Range near McCammon. It flows northward to Inkom along the east side of the valley where it has been straitened by a flow of basalt and is joined near Inkom by Marsh Creek, a stream that, held from entering the Portneuf by the lava flow, flows along the west side of the same valley. The Portneuf then cuts across the Bannock Range in a westerly direction between Inkom and Portneuf Siding and enters the wide valley between the Bannock Range and the Pocatello Range where it flows to the Northwest through Pocatello. Its valley across the Bannock Range is relatively narrow and the slopes especially near Portneuf Siding are nearly precipitous. Eastward the valley widens so that the valley floor is nearly a mile wide, but the sides rise steeply, especially in the south, and the crest in a number of places is more than a thousand feet above the river. Numerous intermittent streams join the valley from the north and south, and the range is maturely dissected. Black Rock Creek is the most notable one north of the valley, and it follows approximately the strike of the limestone beds northeast of Portneuf Siding and has aided in bringing the bedrock to view. Indian Creek is the only stream in the South that bears a name, and this enters the Portneuf Valley a short distance west of Inkom. A large important intermittent tributary south of Portneuf Siding needs naming. Mink creek lies just to the west of the area mapped and enters the Portneuf River from the south about a half mile west of Portneuf Siding. This stream is permanent. Rabbit Creek is likewise permanent and enters the Portneuf River from the north at Inkom.

**GENERAL GEOLOGY**

Rocks of widely different ages both sedimentary and igneous outcrop in the district, but the limestones belong to the Cambrian system, one series of limestones to the Lower Cambrian and a second series to the Middle Cambrian. These two lie adjacent to the railroad and are probably suitable for cement manufacture. Younger limestone formations of Ordovician age outcrop outside of the district, but these are too distant from transportation lines to have present economic value. Beds of Devonian and Carboniferous age also occur in the county. Patches of Pliocene (?) Salt Lake formation cover parts of the limestone along Marsh Creek, and late Tertiary alluvial fan deposits cover part of the limestone and shale south of Inkom along the wide sloping bench that flanks the Bannock Range on the east. Basalt of Quaternary (?) age lies in the valley and also alluvium of the same age, and of recent date.
CAMBRIAN SYSTEM

The Cambrian rocks cover the greater part of the district. These are mainly quartzite, conglomerate, and shale with a series of limestones and shales lying both above and below. The total thickness is more than 14,000 feet. The quartzite and interbedded shale are readily recognized as the Brigham quartzite formation of middle and lower Cambrian age because of lithologic similarities to the Brigham quartzite described by Mansfield in adjoining areas, and also because the formation underlies limestone on which Middle Cambrian trilobites have been found by the writer. Beneath the Brigham quartzite is a series of limestones and shales which are new to the stratigraphy of southeast Idaho, for heretofore the base of the Brigham quartzite has not been found. Beneath the limestone of presumably Lower Cambrian age, as no definite fossils were found, is a series of ancient volcanic rocks comprising lava flows and tuff beds with intercalated shale, sandstone and conglomerate, all highly sheared, mashed, and altered that may be older than Cambrian, but which the writer has left tentatively at the base of the Cambrian because of lack of detailed study. This formation the writer will name the Bannock Volcanic formation because its only known occurrence is in the Bannock Range. The limestone which underlies the Brigham quartzite and apparently overlies the Bannock Volcanic formation will be designated as the Black Rock limestone because of its occurrence along Black Rock Creek.

Bannock Volcanic Formation

This formation has been mentioned by Weeks and Helkes who assigned an Ordovician age to it, and who considered the lavas the original source of the copper deposits in the Fort Hall Mining district. The formation includes not only several flows of lava of probable andesitic composition, tuff beds, and breccias, but also thin beds of impure limestone, calcareous shales, sandstone, quartzite, and conglomerate, measuring more than 1200 feet thick. The base of the series is here unexposed, and the top has been taken to include the shale beneath the Black Rock limestone.

The formation trends slightly east and north and may be traced for many miles along the west flank of the Bannock Range. Its southern extension is not known, but the writer has traced it from east of Scout Mountain, over Chinks Peak and across Pocatello Creek to its disappearance beneath Salt Lake formation and the Snake River, Plains. It probably outcrops for at least 20 miles along the Bannock Range. The series crosses the area mapped by the writer at Portneuf Siding and forms bold precipitous outcrops along the river.

The lavas are purplish, reddish, and greenish in color, but because of their alteration are best described as greenstones. Vesicles or amydules are preserved in some places, and the lavas, both reddish and greenish, have numerous quartzite boulders and pebbles as inclusions. The lavas are platy and are usually sheared and mashed. The tuff beds are particularly mashed and sheared and altered to a greenish mass that is difficult to recognize as tuff. A section across the high ridge south of Portneuf Siding has about 300 feet of purplish, greenish and reddish lavas, with some agglomerates along the west side with the base unexposed. These are overlain by a series of yellowish and buff thinbedded calcareous sandstone and shale, but in massive beds near the top. Near the top are also some thin beds of greenish and purplish sandstone and shale which weather brownish. Most of these beds are highly fractured. The shale and sandstone series are capped by a massive bed of
conglomerate about 15 feet thick which forms a particularly bold outcrop near the top of the ridge. The boulders are several inches in diameter and are held in a siliceous matrix. The conglomerate is in turn overlain by about 100 feet of reddish and purplish lava. Above this is grayish and pinkish sandstone which forms the dip slope on the east side of the ridge. Impure limestone and thin bedded shale outcrop on the next ridge to the east and apparently overlie the main volcanic series conformably. The base of the second ridge has thin bedded limestone in part arenaceous and in part argillaceous, but the upper part of the ridge is grayish, laminated shale. The east slope of the ridge is obscured by overburden but is probably composed of limestone. On the ridge north of Portneuf Siding erosion has made a structure section more difficult to obtain. The reddish and greenish lava forms the west slope of the ridge. The same assemblage of calcareous sandstone and sandstone underlie the beds of conglomerate and upper lava member. Tuff beds are also exposed in the south and east draws of the ridge. The shale and lava are apparently more highly sheared than south of the river. On the east side of the ridge near Black Rock Creek is a series of thin bedded grayish laminated shales probably tuffaceous, generally contorted by drag folding, and fissile. This series is probably several hundred feet thick and underlies the Black Rock limestone, probably conformably. This shale is probably valuable to a cement plant, for it lies immediately adjacent to the limestone.

Although this formation is considered tentatively as Lower Cambrian the metamorphism which the series shows might suggest that the rocks are pre-Cambrian or Algonkian in age. The formation, however, apparently underlies the known Cambrian conformably, and it may represent the lowest part of the Cambrian, the mashing and shearing being accounted for by reason that the rocks are along the axis of an anticlinal fold. No fossils were found.

Black Rock Limestone

The Black Rock limestone is so named because of its occurrence along Black Rock Creek about two miles northeast of Portneuf Siding. The formation also outcrops south of the river, but the best exposure is on the north side where it may be traced up Black Rock Creek for several miles. The limestone is well exposed on the ridge east of Black Rock Creek Valley and on the Portneuf Valley side where the tilted massive beds form particularly pronounced ledges or outcrops.

The limestone is for the most part thick-bedded, massive, and relatively pure. Some sandy limestone members outcrop near the top of the ridge, and minor amounts of calcareous shale occurs in some parts. The formation is grayish and weathers gray. The limestone is more than 800 feet thick. It is in turn overlain by about 150 feet of calcareous shale, sandy shale, sandstone, and quartzite, with the shale near the base and the quartzite near the top where the formation merges with the Brigham quartzite. Some of the limestone beds contain small rounded concretions and other more irregular forms that may be traces of fossils, but they could not be clearly recognized. Inasmuch as the formation clearly underlies the Brigham quartzite conformably, for the two formations including the contact are shown in cross-section on a ridge to the east, the age from its stratigraphic position must be Lower Cambrian. The shale series beneath the limestone is also probably conformable though the relationship is not clearly shown north of the river, but is borne out on the south side.
The Brigham quartzite was named by Walcott from its occurrence in the west front of the Wasatch Range, northeast of Brigham, Box Elder County, Utah. The formation consists of massive, more or less vitreous quartzite or quartzitic sandstone, generally of purplish or reddish tinge, together with conglomeratic layers, and some beds of hard, sandy, and more or less micaceous shale. The formation has similar characteristics in the areas described by Mansfield in the Fort Hall Indian reservation and in other parts of Southeastern Idaho and shows little or no change in the district studied by the writer.

The Brigham quartzite covers the greater part of the district and outcrops on both sides of the Portneuf River between Portneuf Siding and Inkom. The section south of the river is probably complete, but that on the north has been interrupted and duplicated by faulting. The beds on the opposite sides of the river do not match well because of faulting along the Portneuf valley, especially near Inkom. This formation extends many miles to the south and north and also comprises the greater part of the Pocatello Range on the west. The formation has no value as a basis of a cement industry unless some of the shales can be utilized. The quartzite series is underlain by the Black Rock limestone on the west and is bounded on the east by the limestone of Middle Cambrian age.

The formation is mainly a quartzite of prevailingly purplish or reddish tinge, but both texture and color are somewhat variable. The texture is locally sandy or even sugary rather than quartzitic, and there are numerous gritty and pebbly or conglomeratic layers. The pebbles, composed chiefly of quartzite, are generally less than an inch in diameter and well rounded. The lower part of the formation, however, is a white, more or less sugary quartzite in rather marked contrast with the upper reddish beds. The light colored beds are well shown along the north edge of the valley, but the outcroppings are generally concealed on the south side. A section on the south side of the valley gives a thickness of more than 10,000 feet. Whether there has been duplication due to faulting could not be definitely determined along the parts of the ridges examined. The lower part of the formation on this side is the white to gray vitreous quartzite, in massive beds giving a thickness of more than 500 feet and overlying the limestones and shales of the Black Rock formation. These quartzites are in turn overlain by about 3500 feet of the reddish and purplish quartzite and conglomerate. The colored quartzite is in turn overlain by about 2000 feet of greenish, thin bedded, mucaceous shale. This shale forms an immense talus slope along the steep south side of the valley. The shale is in turn overlain by more than four thousand feet of reddish to white quartzite, sandstone, with intercalated, reddish and greenish shale. The upper hundred feet or more is composed of thin bedded greenish, fissile shales, in part sandy and possibly in the uppermost beds in part calcareous. These outcrop along the east side of the Valley of Indian Creek near where it enters the main Portneuf Valley. Southward the formation is concealed beneath a fine silt overburden. This shale is immediately overlain by the limestone of Middle Cambrian age. Faulting has interrupted the sequence on the north, but about 150 feet of greenish and reddish shale outcrops on the hill about a quarter of a mile northeast of Inkom.

Few fossils occur in the quartzite. What may be annelid trails or borings were seen by the writer near the base of the formation, but no collections were made. Walcott considers that most of the Brigham quartzite is of Middle Cambrian age but that it also includes several hundred feet of Lower Cambrian beds.
The Langston limestone so-called by Mansfield in designating the limestone above the Brigham quartzite was originally named by Walcott from Langston Creek, Utah, for some massively bedded bluish gray limestone with many round concretions. The probable equivalent of this formation extends south of Inkom along the west side of Marsh Creek Valley for several miles, though southward it is obscured in many places by patches of Salt Lake formation. The limestone overlies conformably the greenish, thin-bedded shale of the top of the Brigham quartzite formation. It is found south of Inkom only, for its northerly trend has been interrupted by faulting.

The limestone is thin to massively bedded, light gray with some members somewhat coarsely crystalline. The top of the ridge south of Inkom is composed of the massive beds of this formation which form nearly a dip slope on the east side. On the west side of the ridge near the base, the beds are much thinner. In some places the beds are dark gray, but all show little staining as a result of weathering. Mansfield describes the limestone as somewhat dolomitic in St. Charles Canyon, and for this reason the formation should be very carefully sampled before considering it of value for cement making. The thickness of the formation is probably about 800 feet.

The formation is not very fossiliferous and no good examples could be found by the writer. According to Walcott the Langston limestone is of early Middle Cambrian age.

Ute (?) Limestone

The Ute limestone was named by Walcott from the Ute Peak, Cache County, Utah. At the base of the formation lies a well-defined shale with an abundant fauna which he has named the Spence shale member. Mansfield has used the same terminology for a similar formation in southeast Idaho that overlies the Langston limestone. What is probably the equivalent of this formation forms a bold outcrop along the road about one mile southeast of Inkom on the west side of Marsh Creek. Only the lower part of the formation is exposed, for the top has been eroded and is concealed beneath the alluvium and basalt in Marsh Creek Valley.

As described by Walcott, the formation is composed of blue to bluish gray, thin bedded fine grained limestone and shale, together with some oolitic concretionary and intraformational conglomerate. The Spence shale member represents the lower 30 feet of the formation and consists of a fine argillaceous papery shale that weathers readily and is well exposed in but few places. It usually forms depressions in the ridges. South of Inkom a distinct depression follows the ridge along the strike of the limestone and occurs at the top of the Langston (?) limestone. This may represent the easily weathered Spence shale member. Above this are fairly massive beds of dark-gray limestone, some members, especially near the base, abundantly fossiliferous with numerous remains of trilobites, including fragments and complete specimens. Some of the trilobites are recognized in Neolinus inflatus and are of Middle Cambrian age. Many members of this formation are locally oolitic and crowded with minute indistinct traces of fossils. Higher in the series the formation is composed mainly of thin bedded bluish-gray limestone. What is probably the same formation outcrops along the east side of the valley of Mink Creek about two miles to the west of the mapped area. In this place the formation which is here better exposed contains thin-bedded clayey limestone as well as numerous oolitic members above massive beds of limestone, probably the Langston. Middle Cambrian trilobites are also numerous in some members, also a few brachiopods.
The thickness of this formation is undetermined, but south of Inkom at least 150 feet of beds are exposed.

Walcott considers the age of the Spence shale member as early Middle Cambrian, and that of the main body of the formation as Middle Cambrian.

Blacksmith (?) Limestone

What may be the Blacksmith limestone outcrops along the lower west side of Steamboat Rock, a high elliptical hill between Portneuf River and Marsh Creek just above where they join about a mile and a quarter southeast of Inkom. This formation forms a low line of cliffs a little to the side of the main hill and is separated from it by a strike saddle or depression. The base of this formation as well as the top of the Ute (?) is concealed by the wide marshy floor of Marsh Creek. The beds that are exposed are bluish-gray limestone, rather massive and with a few yellow sandy members as well as a few oolitic beds. No fossils were clearly recognized. About 50 feet of this formation is exposed.

Bloomington (?) Formation

The remainder of Steamboat Rock which rises about 150 feet above the Valley and is about one fourth of a mile long and one sixth of a mile wide is probably the Bloomington formation. A shale member between 50 feet and 100 feet thick consisting of yellowish and yellowish green thin-bedded shale in part calcareous and including some impure thinbedded limestone lies at the base of the formation and forms the well defined strike depression above the Blacksmith (?) limestone. This may correspond to the Hodges shale member which lies at the base of the Bloomington formation in Bloomington Canyon and in the Bear River Range, Idaho. Above the shale member are a series of bluish-gray, including both thin-bedded and massive, limestones. Some beds contain small concretions and probably oolites. Some of the members are in part sandy. Thin-bedded shales crop out along the main highway between Inkom and McCammon on the east side of the Portneuf River about one quarter of a mile southeast of Steamboat Rock. This bed is probably not over 25 feet thick. It probably represents the top part of the Bloomington (?) formation. In all, more than 500 feet of the formation is exposed. Indistinct traces of fossils are numerous in many beds, but the character of none of them was recognized. The Bloomington formation as assigned by Walcott to the Middle Cambrian.

Nounan (?) Limestone

Conformably above the uppermost shale member of the Bloomington formation is a series of light gray to dark bluish-gray limestones, in part cherty. These lie at the western base of the Portneuf Range and dip under the mountain. This series was not carefully studied but it probably is the equivalent of the Nounan limestone as described by Walcott west of Liberty, Idaho. Mansfield mentions that the lower part of the limestone series is dolomitic. The writer found no fossils in the exposure examined near the highway. Walcott has assigned the Nounan limestone to the Middle Cambrian.

Above this formation are higher members of the Cambrian system, probably limestones, and capping these are the limestone, dolomite, and quartzite of the Ordovician system which probably make up the greater part of the Portneuf Range. These are too distant from transportation lines to warrant present economic study.
TERTIARY SYSTEM

The Tertiary rocks comprise beds of volcanic ash, probably belonging to the Salt Lake formation of the Pliocene (?) series. Remnants of these beds cap the Langston and probably the Brigham quartzite series from a mile and a half to several miles south of Inkom. These occur as massive beds of pure white ash in part crossbedded on ridges between the valleys of intermittent streams which have cut through into the underlying limestones. Some of these beds are several hundred feet thick. This formation probably has no value to a cement industry, except that it covers parts of the limestone to such a depth as to make quarrying of the limestone unprofitable wherever it occurs. Some of the wide alluvial fans, cones and hill wash on the gently sloping east flank of the Bannock Range probably have a Late Tertiary Age. The Salt lake formation covers much of the country immediately adjacent to Pocatello on the east along the west flank of the Bannock Range.

QUATERNARY SYSTEM

Valley flows of olivine basalt of probable early Pleistocene (?) age lie along the Portneuf River and have been traced by the writer from the Bancroft Basin on the east side of the Portneuf Range to near the south limits of Pocatello. The river flows on top of the basalt for most of the distance in the narrow valley across the Portneuf Range, but on entering the wide valley between the Portneuf Range and Bannock Range at McCammon has but a channel along the east margin of the basalt to Inkom. The wide flat valley of Marsh Creek which formerly held the outflow of ancient Lake Bonneville is cut through the west margin of the basalt. Large remnants of the basalt remain in the valley between Inkom and Portneuf Siding. Two flows are shown. The present margins of these flows stand as nearly vertical walls where they represent the banks of the former great river of Lake Bonneville time. The basalt probably would form an excellent foundation or base for cement plant sites, especially near Inkom. Deposits of sand and gravels remain in many places along the valley, left by the ancient river. More recent deposits lie along the stream. Large alluvial cones extend from most of the tributaries, particularly the intermittent streams, into the main Portneuf Valley, deposited mainly since Pleistocene time.

STRUCTURE

The Bannock Range in part is formed by an anticlinal fold that follows its general trend but which has given way to overthrust faulting in the line of the canyon to the south of Portneuf Siding. This overthrust fault is to the west with plane dipping eastward and approximately marks the west border of the Bannock Range. The fault has brought the beds of the Bannock Volcanic formation of supposed Lower Cambrian age against the Middle Cambrian limestone that crop out along Mink Creek and which overlies the Brigham quartzite that makes up the greater part of the Pocatello Range. The fault involves a displacement of several thousand feet. West of the fault the strata have a northerly trend and a moderate dip to the east. In the area mapped, the Bannock Volcanic formation on the ridge north of Portneuf Siding is thrown into an anticline with axis near the center of the ridge. South of the siding the west part of the anticline has been entirely wiped out by erosion and faulting, and only the steeply dipping beds on the east flank remain. Eastward from the Volcanic series to the Portneuf Range and probably across the range the strata are tilted to the east. South of Portneuf Siding the dip is 52° which decreases more or less progressively to 35° in the limestone south of Inkom. The general trend of the
bedding is from N. 10° to N. 15° W. The beds north of the river between Portneuf Siding and Inkom show some differences, explained by a steep syncline along the river near Portneuf Siding which apparently passes into a fault at Inkom, and which has raised the beds on the north with respect to those on the south and has brought the limestone of Middle Cambrian Age against the quartzite of the Brigham formation. Some faulting is shown even on the tip of the ridge south of Portneuf Siding. The structure on the north of the river does not match the uniformly tilted beds on the south side, but is represented by a minor anticline about half way between Portneuf Siding and Inkom and by quartzite beds dipping steeply west at Inkom, apparently upturned against a thrust fault which has a steep dip to the east. On the other side the beds again dip to the east, and are members of the Brigham quartzite. The Middle Cambrian limestone beds do not crop north of the river in the area studied.

ECONOMIC FEATURES

FORMATIONS AVAILABLE AS CEMENT MATERIAL

Insofar as these studies have gone, the limestones in this area that are perhaps most suitable for cement materials are the Black Rock limestone and the Langston limestone. Mansfield* in discussing the cement materials of south-eastern Idaho mentions that these limestones of early Paleozoic Age are more or less magnesian and that the Carboniferous limestones are better adapted for general purposes than most of the others. Many limestones in the Mesozoic and even the Tertiary and Quaternary formations are in sufficient quantity for commercial production, and he concludes that cement materials of good quality are abundant in the region from Soda Springs to Bear Lake in the area covered by his report, but that distance from markets and transportation make them potential resources only. The Carboniferous formation crop out in parts of Bannock County, but, so far as known, only at considerable distance from railroads. Mesozoic formations are apparently wholly lacking in the area adjacent to Pocatello. This leaves as the only material available for a cement industry the limestones of Cambrian Age which crop out near Portneuf Siding and Inkom.

The Black Rock limestone near Portneuf Siding has been extensively sampled and tested by interested parties. Actual analyses are not available for publication, but the general results show a limestone with a very low magnesia content, less than two percent, and in every way suitable for a cement material. The Langston (?) limestone has also been sampled and analyzed and the results show a limestone in general with less than two percent magnesia but with at least one bed with somewhat more than that amount. As a whole the formation is probably suitable for cement material, though the formation should be carefully and systematically sampled before a plant is actually constructed. Analyses have been made of members higher in the series and these in general show a greater increase in magnesia so that the Ordovician beds are described in part as dolomite. Beds of relatively pure limestone may be found, however even in the dolomite. The beds east of the Portneuf River are probably not generally desirable. Whether the limestone on Steamboat Rock is suitable depends on the results of careful systematic sampling and analyses.

AVAILABLE QUARRY SITE ON BLACK ROCK LIMESTONE TWO MILES NORTHEAST OF FORTNEUF SIDING. MASSIVE BEDS OF LIMESTONE TILTED TO THE EAST ARE SHOWN NEAR CENTER OF PICTURE. WALL OF THE VALLEY BASALT IN FOREGROUND. NOTE SCARCITY OF OVERBURDEN. PICTURE TAKEN FROM HIGHWAY NEAR RAILROAD.

AVAILABLE QUARRY SITE AT LANGSTON (17) LIMESTONE ONE QUARTER OF A MILE SOUTH OF INKOM. NOTE DIP SLOPE OF LIMESTONE. UTE (17) LIMESTONE IN EXTREME LEFT. PICTURE TAKEN FROM TOP OF LAVA BENCH.

STEAMBOAT ROCK QUARRY SITE IN THE MIDDLE FOREGROUND. NOTE THE MASSIVE BEDS OF LIMESTONE NEAR TOP OF HILL AND LARGE TALUS SLIDE WHICH PARTIALLY FILLS THE DEPRESSION ALONG THE SHALE MEMBER AND THE BASE OF THE BLOOMINGTON (17) FORMATION. LOW CLIFFS OF BLACKSMITH (17) LIMESTONE IN FRONT. PORTNEUF RANGE IN BACKGROUND.
The shales that occur beneath the Black Rock limestone and beneath the Langston limestone are probably suitable for cement material, though analyses were not seen by the writer. Other beds of shale might also be utilized.

**AVAILABLE QUARRY SITES**

The quarry sites have been selected by the nearness of the limestone formations to the railroad and by the natural adaptation of the outcrop to quarry methods. Two exposures are admirably situated, one about two miles northeast of Portneuf Siding which the writer will designate the Black Rock Quarry Site and the other on the Langston limestone about one quarter of a mile south of Inkom station which the writer will designate the Inkom Quarry Site. The Steamboat Rock so named from the hill, will also be considered as a possible quarry site.

**Black Rock Quarry Site**

Although this site is about two miles from Portneuf Siding it is scarcely more than a half of a mile from the main line of the Oregon Short Line. The outcrop lies mainly in sections 13, 14, and 24 in T 7 S. R 35 E. A floor of basalt extends from the outcrop to near the highway and railroad, and a plant perhaps could be placed in front of the wall of lava that is shown in Plate II figure 1 which would involve a very short haul of the raw materials to the plant and railroad.

The Black Rock limestone forms in part massive cliffs that need no stripping of overburden. Most of the hill, however, has a thin veneer of talus and soil which would be only a very slight handicap to open-pit quarry methods. The beds strike N 5° E and dip 30° E. The dip of the massive beds may be seen in the illustration. The dip gradually flattens eastward, and the formation crops out along the base of the hill for some distance to the right of the picture, for the beds are folded into a small anticline. They are capped higher on the hill by the Brigham quartzite. The formation was traced up Black Rock Creek for several miles, always on the east side of the valley, and all available for quarrying. As the hill is nearly 200 feet high and as the working base shown in the picture is more than a quarter of a mile across, the reserves are practically unlimited. The same formation crops out on the south side of the Portneuf River and might also be utilized. The exposure on the south side does not present as bold aspect as that on the north side because perhaps of a greater quantity of overburden, but the reserves are as large, and a quarry site might be established without much greater expense.

Because only a small amount of shale occurs with the limestone, access must be had to other beds. The thin series of shales that overlie the limestone and crop out on the west side of the valley of Black Rock Creek offer unlimited reserves provided they have the desired composition. The limestone and shale are thus together and might be mined from the same quarry floor, though on opposite sides of the narrow valley. The shale is hard and does not slack readily which might add to the cost of treatment.

Both the shale and limestone have been prospected in numerous open cuts generally made along the strike of some particular number. An individual bed is not likely to show much change in composition along the strike over considerable distances, but as each bed may show marked differences from those that overlie or underlie, each should be tested individually and then collectively.
The Inkom quarry site is more advantageously situated than the Black Rock site, for it is scarcely more than a quarter of a mile from the railroad station at Inkom. The limestone and shale are mainly in sections 27 and 28 of T 7 S., R 36 E., but pass south into sections 33 and 34 and probably continue farther. A bench of basalt extends from the base of the limestone hill and ends abruptly near the river and railroad tracks with sufficient space, however, between the basalt and river for a plant site. The basalt bluff is about 50 feet high and would serve admirably as a working floor for the quarry and would permit the materials to be fed to the crusher plant at its base under gravity.

The ridge which is composed almost wholly of the Langston (?) limestone with some Ute (?) limestone shown in the extreme left of figure 2, Plate II rises about 250 feet above the basalt terrace and extends to the south for more than a mile before parts of the formation are hidden beneath volcanic ash of the Salt Lake formation. The bold steep northeasterly front of the ridge cuts diagonally across the formation, but the extreme north tip of the ridge offers a quarry face several hundred yards wide which increases southward to nearly half a mile across. The limestone is covered by more overburden than at the Black Rock quarry site, but the quantity is not serious to open quarry methods, once a working face is started. The steep slope shown in the picture is mainly a dip slope and the limestone beds are very near or at the surface, much of it with less than a foot of overburden. Some of the heavier overburden is talus, in particular soil,—that has come from the ledges above and even this can probably be utilized by a cement plant. On the more gently sloping west side of the hill the overburden in places is several feet deep, especially near the base of the ridge, but is composed mainly of a fine silt or possibly loess that is easily stripped. The Ute (?) limestone gives a bare massive outcrop. This does not show in the picture.

The limestone beds strike about N. 150° W. and dip about 35° to the northeast. The beds that crop out near the crest of the hill are fairly massive but those on the west side, and some of those near the top of the series, are more than bedded. The limestone contains no chert or other objectional impurities and is probably satisfactory as cement material. The hill has not been prospected by cuts or pits, and samples have been taken from the scattered surface exposures. The analyses show generally less than 2% magnesia. The formation can perhaps be most easily and cheaply as well as most satisfactorily sampled (except by diamond drilling) by trenching up the hill on the west side across the bedding thus exposing at the surface each bed from which samples may be taken. As the beds dip steeply into the hill on that side the analyses would give a reasonable reliable estimate of the quality of the limestone within the hill, for little change need be expected along the dip and strike of any particular member. In this way each member can be properly sampled and also the formation as a whole.

Shale may be mined from the same quarry face. Whether the Spence (?) shale at the base of the Ute (?) limestone shown by the saddle in the ridge at the left of the picture is sufficient can be determined only by trenching. The extent and quality of the shale could not be determined in the field because of heavy overburden. However, more than a hundred feet of thin-beded greenish fissile shale, the upper part calcareous (?) lie beneath the Langston (?) formation and are exposed in a small dry gulch at the west base of the limestone hill and also along the road which passes up Indian Creek. A small cut has been made in the shale at the road intersection. The shale apparently strikes N. 10° E. and dip 45° E., but the top of the member exposed in the small gulch on the
east about a hundred yards away conforms with the overlying limestone beds. The shale has not much overburden along Indian Creek or in the gulch, but the intervening ridge which is nearly a hundred feet high has a capping of at least 5 feet of fine soil. Southward the quantity of overburden increases. Analyses show that the shale is satisfactory as a cement material, but the whole formation should be systematically sampled and analyzed.

The same series of limestones crop out on Mink Creek about two to three miles above the mouth and from particularly massive ledges near the stream bottom. These are probably too far removed from the railroad to have present value unless a branch line be brought in. The shale was not exposed, because of heavy overburden.

Steamboat Rock Quarry Site

The Steamboat Rock quarry site lies wholly in section 27, T. 7 S., R. 36 E. It is flanked on the south by the valley basalt, but rises about 150 feet above Portneuf River on the east side and Marsh Creek on its west side. The main line of the Oregon Short Line cuts across the east base of the hill.

Figure 3 in Plate II shows the shape and size of the hill as well as the general lack of overburden and the massive nature of the limestone beds of the Bloomington (?) formation is well shown over much of the precipitous west slope of the hill and partially fills the depression carved in the soft thin-bedded, in part calcareous shale, and impure thin-bedded limestone that lie at the base of this formation. The top of the Blacksmith (?) limestone forms a low ledge or cliff that is set in front of the main hill and partially hides the lower part of the large talus slope. The bedding of all formations strikes about N. 15° W. and dips 40° E. though locally a strike of N. 5° E. was found.

The hill has not been properly sampled and nothing can be said as to the value of the limestone and shale as cement materials. The reserves as seen in the picture are reasonably large. The shale member is between 50 and 100 feet thick and may possibly be in part a natural cement rock. A small amount of shale also occurs near the top of the Bloomington (?) formation and crops along the highway across the Portneuf River. The quantity that is easily available is not large.

Limestone crops out along the main highway on the east side of the Portneuf River for more than a mile with but little overburden. These need to be sampled and analyzed to definitely prove their worth, but they are apt to carry considerable magnesia and to have considerable chert. These lie but a few hundred yards from the railroad.

FACTORS CONTROLLING LOCATION OF CEMENT PLANTS

Valuation of deposits of cement materials has been discussed by Eckel* from whose valuable work the following excerpts have been taken:

"Very erroneous ideas appear to be current concerning the value of deposits of cement materials. It should be clearly understood that in most parts of the

United States excellent cement materials are common, and that the commercial value of undeveloped deposits of such materials is necessarily slight.***** The value of the deposit depends less upon the character of the materials than upon other factors, prominent among which are the general scarcity of limestone and the demand for good limestone in each particular area.********

The determination of the possible value for Portland cement manufacture of a deposit of raw material is a complex problem, depending on a number of distinct factors, the more important of which are (1) chemical composition (2) physical character, (3) amount available, (4) location with respect to transportation routes, (5) location with respect to fuel supplies, (6) location with respect to markets. Ignorance of the respective importance of these factors frequently leads to an overestimate of the value of a deposit of raw material."

The factors listed above will be analyzed with special reference to the deposits in the Pocatello vicinity.

Chemical Composition

The raw material must be of correct chemical composition for use as a cement material. This factor must be settled before a plant is installed and is determined only by many chemical analyses of the limestone and shale. Insofar as the few chemical analyses have been made on the outcrops near Pocatello, both the limestone and shale seem suitable for cement manufacture, and this factor is therefore probably favorable, though many more analyses should be made on systematically collected samples from the outcrops.

The following are analyses of Portland cement mixtures ready for burning, as used at various large cement plants in the United States:

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<tr>
<th>Analyses of Portland Cement Mixtures</th>
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<tr>
<td>Silica (SiO₂)</td>
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<td>Alumina (Al₂O₃)</td>
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<td>Lime Carbonate (CaCO₃)</td>
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<td>Magnesium Carbonate (MgCO₃)</td>
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This implies that the material, if a limestone must contain as small a percentage as possible of magnesium carbonate, less than 3 to 4 percent as the maximum. Free silica in the form of chert, flint, or sand must be absent or present in very small quantity.

Physical Character

Economy in excavating and crushing requires that the raw materials should be as soft and dry as possible. On this account cherty limestones, very wet chalky limestones, and wet sticky clays are disadvantageous raw materials. The materials near Pocatello are exceedingly dry, but are relatively hard, though not cherty. They may be cheaply excavated, however, by blasting from a high
quarry face and loading into cars by a small electric or steam shovel. Crushing expense would probably be reasonably light because of the lack of chert, though the limestone is dense and massive.

Amount of Material Available.

There is little question of the abundance of any of the necessary rocks. Eckel states that each barrel of cement will require the use of approximately 450 pounds of limestone and 150 pounds of clay or shale. A plant making 5000 barrels a day will therefore use, in the course of an ordinary year about 66,000 tons of limestone and 22,000 tons of clay or shale; a 1,000 barrel plant will use up almost 1,000,000 cubic feet of limestone in a year, together with 250,000 cubic feet of shale. A plant of such capacity is probably not justified in the Pocatello region, but a plant of even a tenth of that capacity or less will use an immense amount of material over a period of years. As the investment in plant is heavy, it would be folly to locate a cement plant, under ordinary circumstances, with less than 20 years supply of raw materials in sight.

Location of Plant with Respect to Transportation Routes

Portland cement is bulky for its value, and the cement business is therefore much affected by transportation rates. Pocatello is strategically situated as a distributing point, and the cement could be sent in all directions practically from the plant. One line of transportation only is available, the Oregon Short Line, and the rate is a matter between a cement company and the railroad. But a cement plant near Pocatello would enjoy advantages over competitors from the outside, for the latter must ship their products over the same line for much greater distances.

Location of Plant with Respect to Fuel Supplies

There is no proper fuel for cement manufacture in the region itself, but all coal must be shipped in from the outside. According to Eckel every barrel (380 lbs.) of Portland cement marketed implies that at least 200 to 300 pounds of coal have been used in the power plant and kilns. In other words, each kiln in the plant will, with its corresponding crushing machinery use up from 6,000 to 9,000 tons of coal a year. The item of fuel cost is therefore highly important, for in the average plant about 30 to 40 per cent of the total cost of the cement will be chargeable to coal. A plant near Pocatello could probably use electric power to advantage for the crushing machinery etc., and thus probably save on the coal item, but coal must be used in the kilns. There is an abundance of coal in southwestern Wyoming that could be readily shipped in by rail and utilized. Coal can also be had from Utah, probably as cheaply. But the coal resources of Idaho are also available, and it is likely that coal could be shipped in to advantage from the mines near Driggs in Teton County, Idaho, and thus provide additional markets for an Idaho resource.

Location of Plant with Respect to Market

Eckel lists as the last factor but probably one of the most important—the location with respect to markets and states that in order to achieve an established position in the trade, a new cement plant should preferably have a local market area, within which it may sell practically on a noncompetitive basis, and easy access to a larger though competitive market area.
The plant nearest Pocatello is at Ogden, Utah, about 140 miles distant: a plant is also at Trident, Montana, but its products must be shipped through Butte to compete in the Pocatello district, involving a much greater haul than that between Ogden and Pocatello. Another plant is at Lime, Oregon, near the west margin of Idaho, south of Huntington, Oregon, along the Snake River. Thus Pocatello is in a district relatively remote from any other cement plant and is the distributing point for the whole of southeastern Idaho. The local market area can be considered to include not only the territory immediately adjacent to Pocatello, but the whole of the upper Snake River valley to the Montana and Wyoming line, the south central part of the state including the Burley, Twin Falls, and Buhl region and probably in part the Boise region and points between Boise and the region north of the Snake River Plains. The towns as far east as Montpelier, Idaho, can also be included. Nevertheless, strong competition would be offered by the Ogden plant even in Pocatello, and strong competition would also have to be met in the Boise district from the plant at Lime, Oregon. The quantity of cement used annually in this district is not known to the writer, but the statistics should be easily attainable by anyone interested.

CONCLUSIONS

Large bodies of limestone, and shale of Early and Middle Cambrian Age are available adjacent to Pocatello along the Oregon Short Line railroads, (Union Pacific System) near Portneuf Siding and Inkom. Analyses so far made, indicate that the limestone and shale are suitable as cement materials both from a chemical and physical basis. The deposits are well located with respect to transportation. Whether a cement plant is advisable near Pocatello depends wholly on the response of the local market which includes the greater part of Southeastern Idaho, and the ability of such a plant to compete with the strongly established plants in Northern Utah, Montana and Eastern Oregon.