

DUPLICATE

R. G. BOWEN

VOLUME I

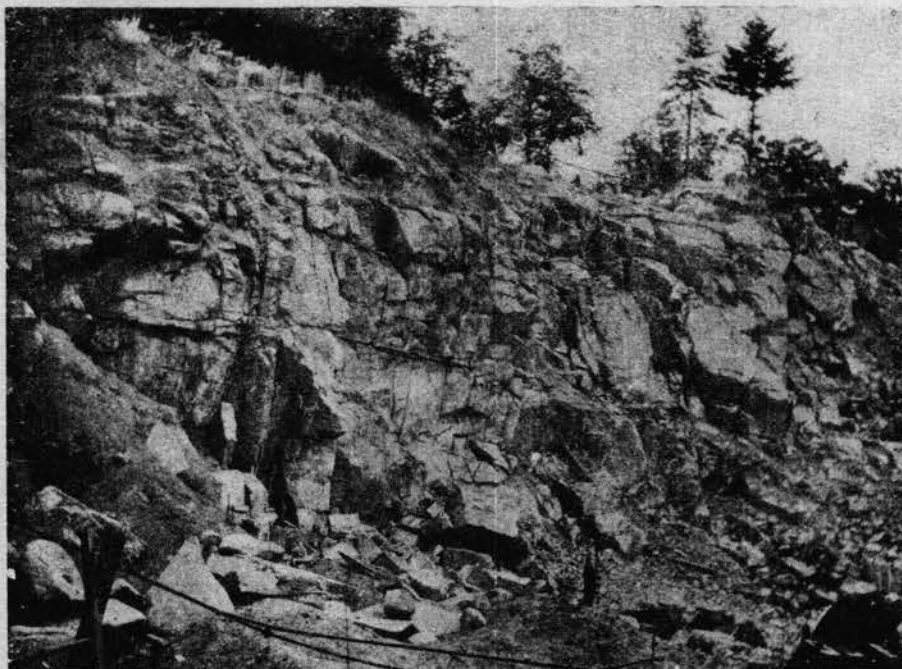
NUMBER 2

FEBRUARY, 1914

THE MINERAL RESOURCES OF OREGON

Published Monthly By

The Oregon Bureau of Mines and Geology



Gold Ray Granite Quarry, Jackson County.

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VOLUME I

NUMBER 2

FEBRUARY, 1914

THE MINERAL RESOURCES OF OREGON

*A Periodical Devoted to the Development
of all her Minerals*

PUBLISHED MONTHLY AT CORVALLIS BY
THE OREGON BUREAU OF MINES AND GEOLOGY
H. M. PARKS, Director

ESSENTIAL TO OREGON'S DEVELOPMENT.

By H. N. Lawrie.

Metal Mining: It is a matter worth emphasizing that the Oregon metal production for 1913 increased two hundred per cent over the yield for 1911. The analysis of the situation given by Director H. M. Parks, in the last issue of the Mineral Resources of Oregon, shows that this increase is due to the successful operation of hard rock mining in Eastern Oregon. The steady production year after year of such mines as the Columbia, together with the favorable geologic conditions, induced several good operators to enter that field and after years of the most intelligent application of labor to development the day has come for the reward of patience coupled with the investment of large capital. This success would not have come, it is believed, had mills been installed in the too early stages of underground development.

Sufficient ore was first put in sight to warrant extensive milling operations and careful mill tests were performed prior to the selection of mill equipment, so as to insure an efficient treatment when the mill was built. To these old and new companies and their managers is due much credit for thus adding to the wealth of Oregon. They have set an example in the business management of metal min-

ing which will serve as a guide to future development. Their success will stimulate the opening up of other meritorious prospects throughout the state.

Quarry Industry: The quarry industry of Oregon was given much publicity early in the past summer, in an attempt to locate satisfactory stone for use in the construction of the new Portland post office. At its inception a public meeting was called at which representatives of the Oregon Manufacturers' Association, Portland Chamber of Commerce, Portland Commercial Club, Stone Cutters' Union and the Oregon Bureau of Mines and Geology were present. Resolutions were adopted, but the most important fact brought out was the absence of information concerning the building stone of Oregon. The need for a systematic investigation of the quarries already opened up, to determine the fitness of their product to enter into the construction of state or federal buildings was thoroughly realized and the Bureau of Mines and Geology Commission was requested to make such an investigation. This they gladly agreed to do and immediately assigned this important work to H. M. Parks. In this number of *The Mineral Resources of Oregon* is the report of his findings both in laboratory and field. The report considers all present quarry locations but by no means does it cover the possibilities of future development of the stone industry in Oregon.

Cement: So much Portland cement has been sold and is still being imported into Oregon that much interest has been manifested by private and corporate capital in locating deposits of limestone and shale for use in its manufacture.

Competition with the California manufacturers has been, up to this last year, the controlling feature in estimating local conditions. Washington, however, with a point of manufacture at Bellingham, last year successfully entered the Portland market. This may change to some degree the basis of competition for the Oregon manufacturer. The search for suitable raw materials for Portland cement is so important that the Bureau of Mines and Geology decided to devote considerable time to this problem. Considerable information has already been secured and much time will be devoted to investigation during 1914. Samples will be taken from promising deposits and analyses and tests made of them; and an effort put forth to assist in every possible way those desiring to engage in the industry.

Road Metal: At the first meeting of this commission in June,

1913, stress was laid on the importance of classifying the road metal quarries or rock outcrops suitable for road materials. In many sections of Oregon roads have been built with a foundation of inferior rock. This entails a very high maintenance cost and in some cases such roads have proved impossible of repair. In order that we might without delay come in touch with the road building agencies of the state, the County Courts were advised that the commission was ready and willing to cooperate with them in every way possible in the search for and tests of the road materials of the state. The policy of the Bureau has been further extended by the records of our field parties who have during the past field season won valuable data concerning the road metal possibilities in the course of their work in different parts of the state. An issue of the Mineral Resources of Oregon will be dedicated to this all important problem of road making material, in which every tax payer is so vitally interested.

The Drainage Problem: During the past August the writer made a trip throughout Southern Oregon and the Willamette Valley. In an address at Albany the subject of land drainage was taken up and its importance urged at that time, on which the following comments were made in the Albany Democrat of August 16:—"This section is in need of a comprehensive drainage system, both for the protection of wagon roads and to increase the agricultural yield. Pursuant to assisting in this development the Bureau proposes to test the available clays to ascertain their qualifications for the manufacture of tile at points well located for distribution. With this information won on first hand and presented from the authoritative source of the Bureau of Mines, eastern manufacturers might be encouraged to investigate conditions, which would lead to cooperation to install such a system." Since that time, encouraged by employes of the Bureau, the Oregon Agricultural College specialists in drainage and the public press, the progressive land owners in Benton county on the Little Muddy between Corvallis and Monroe are establishing a drainage district there. The land owners in other areas in the valley, due to the activities on the Little Muddy, are also taking steps toward the formation of such districts.

The drainage of the Willamette Valley lands is essential to an increased population for several reasons, chief among which may be mentioned:

At present there is too short a crop season to permit the practice of proper methods for keeping the soil in its most highly producing condition.

At present the soil and subsoil layers are so saturated with water for so large a proportion of each year that they warm up slowly in the spring and growing crops can neither extend their roots to the proper depth nor does the necessary amount of air get into the soil for the promotion of the growth of crops.

Thorough drainage will largely correct these great drawbacks.

Comprehensive drainage systems organized under the drainage laws of the state should be installed without further loss of time.

The sooner comprehensive drainage systems are installed the less opportunity there will be for friction and opposition from people who have already drained their land individually. The longer individual drainage is allowed to continue the higher will be the ultimate cost of organizing drainage districts and of installing drainage systems.

It will always be impossible to build permanent roads and to maintain them at a reasonable cost where the bottom lands through which they pass lie undrained.

Up to the present time, there has been expended in the State of Iowa, over 200,000,000 dollars in draining land. Extensions in drainage contemplated in that state will amount approximately to 250,000,000 dollars more. When completed this total of 450,000,000 dollars will represent an investment equal in amount to the cost of the Panama Canal. These facts are mentioned to indicate that the problem of drainage is a large one and that it will challenge all the forces in the state to work out the necessary details. But large as the total cost of completed drainage in Iowa is shown to be, and however large the total cost of complete drainage of the floor of the Willamette Valley would be in the aggregate, the increased annual returns to landowners in Iowa are and in Oregon will be so tremendous that they cannot afford to do without it.

The state schools of higher education have already lent their assistance in the solution of many phases of this problem and always manifest a readiness to extend their aid in this same direction.

That portion of the work of drainage which comes especially within the province of the Bureau of Mines and Geology pertains to the raw materials for and the manufacture of the different kinds

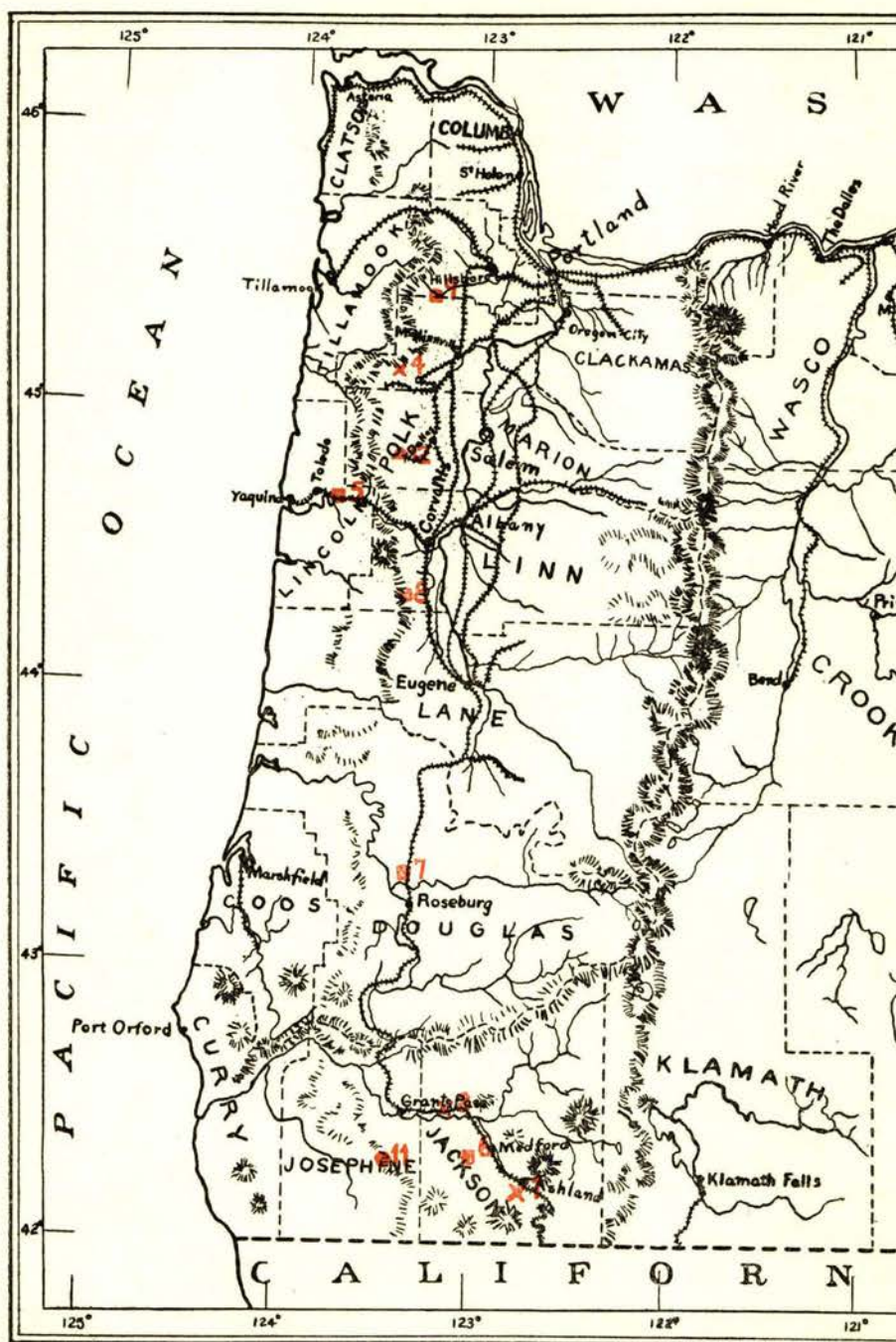
of drain tile, and their qualifications for accomplishing the work in wet soils that they are designed to do. The cost of the tile comprises around one third of the total for the average drainage installation. It is safe to say that the Willamette Valley is particularly well supplied with clays suitable for the manufacture of clay tile and that, for many localities in the valley, the concrete tile can be made to successfully compete with the clay made article.

Mr. Ira A. Williams, who has charge of the Bureau work in the interests of the clay and cement industries of the state has had the advantage of being closely connected with the drainage development that has taken place in the state of Iowa and other middle states. He is a man who is familiar with the practical details of the business as well as the theory upon which the ceramic industries are based.

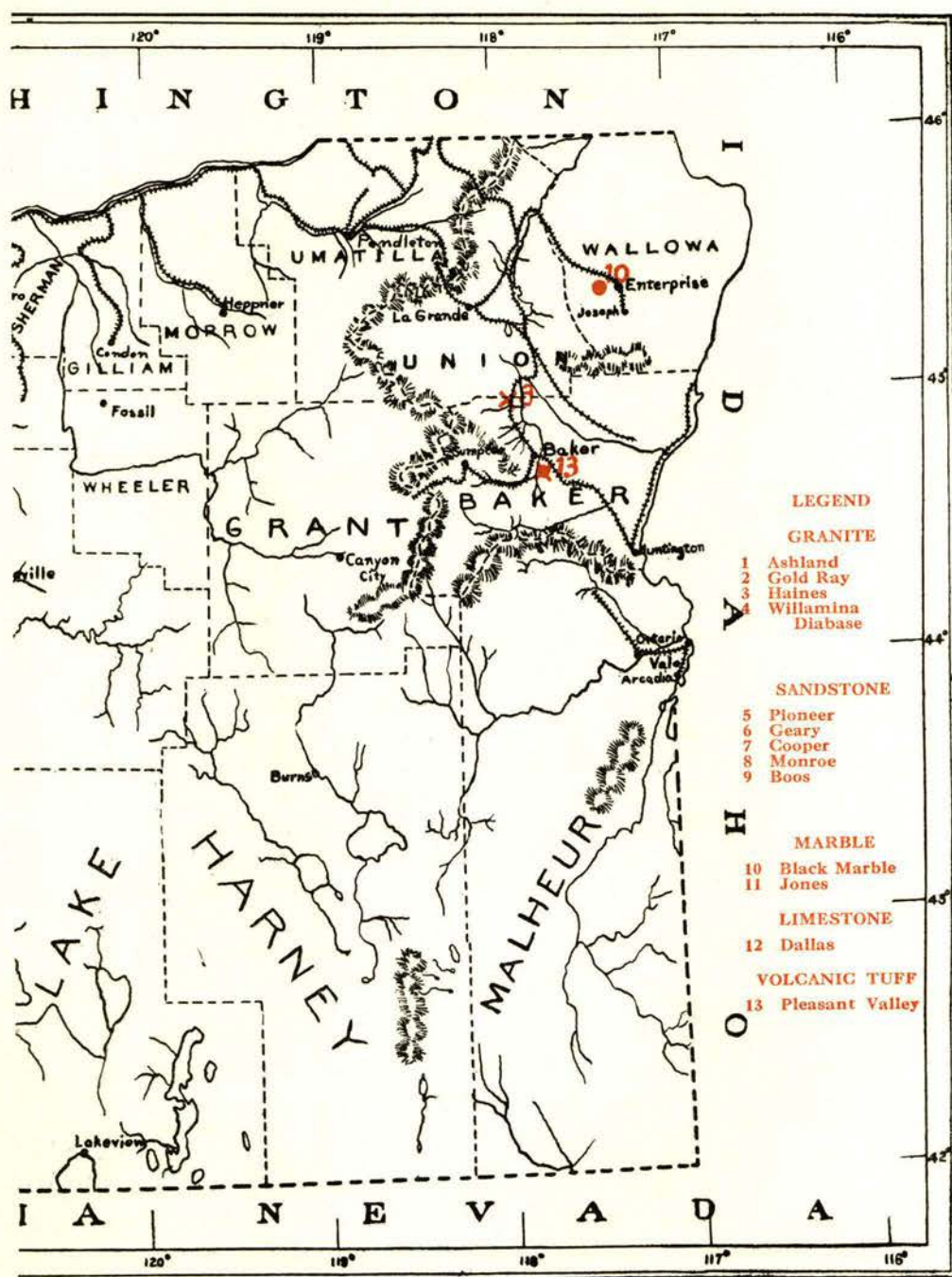
The Bureau of Mines and Geology stands ready to assist in every possible way the landowners of the Willamette Valley in solving this constructive problem.

As will be seen, the activities of the Bureau encompass a wide range, a number of which have been discussed above. It is being realized by many authorities that the law creating the Oregon Bureau of Mines and Geology, enacted by the last legislative assembly, is one of the best of its kind and the most progressive of the laws governing geological surveys and mineral resource development in the states.

It is apparent now and will become more so as we approach the end of the present year that the employes of the Bureau are furnishing information which is indispensable to the development of the mining industry of Oregon.



Outline Map Showing Quarries



Described in this Report.

PRELIMINARY REPORT ON BUILDING STONE IN OREGON.

By H. M. Parks.

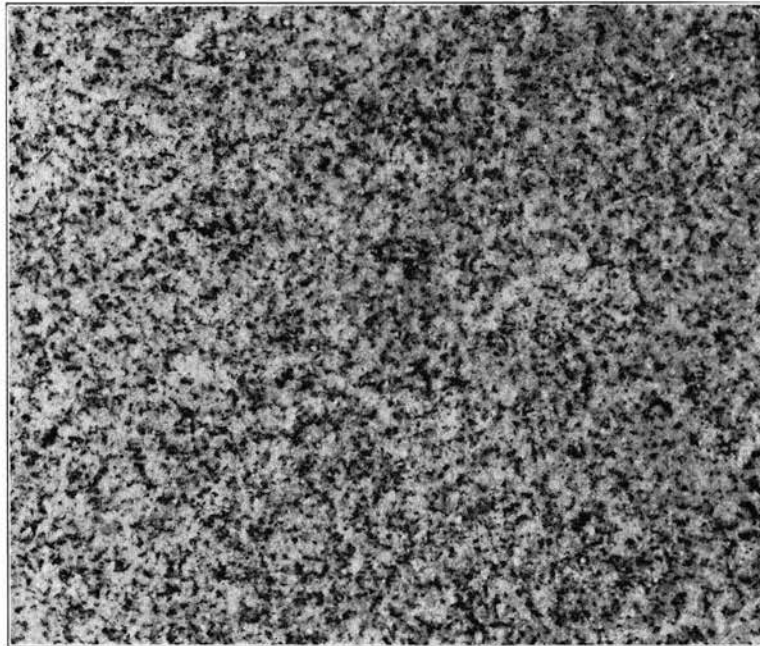
There has been considerable publicity in the past few months concerning Oregon stone for Oregon buildings, a number of individuals in the state even going so far as to take the matter up with our senators and representatives at Washington to bring influence to bear with the Supervising Architect of the Treasury Department to give more attention to Oregon stone. In this way it very soon developed that there was little information available concerning the quality and location of Oregon building stone. Numerous requests were made that the Oregon Bureau of Mines and Geology secure this information.

The Bureau decided to undertake the task and the writer devoted such time as he could spare from other duties to the examination of the different quarries and outcrops. Representative samples were taken from each quarry, together with notes on the general conditions surrounding them. The data obtained in this way take into consideration the general building stone qualities which can be observed in a quarry such as color, effect of weathering, jointing and bedding, as well as economic problems to be anticipated in quarrying, such as overburden, situation as to transportation, etc.

Lest this report be mistaken for a complete treatise upon the building stone resources of the state, the writer wishes to say at the outset that only those quarries are described here which are within a reasonable distance from transportation and which had sufficient development work done upon them to warrant the conclusion that there is a considerable quantity of stone available. In a few cases outcrops with little or no quarry development are included which are favorably situated.

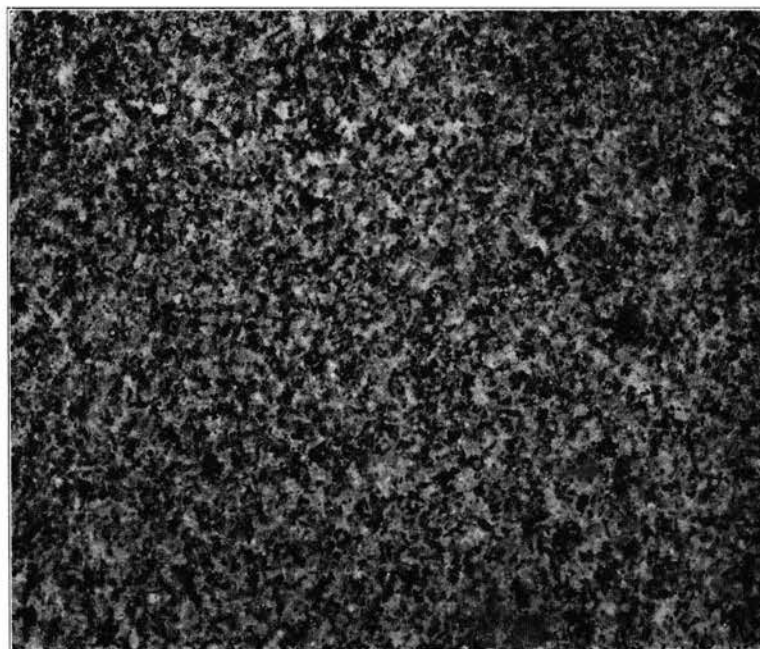
From the samples taken at each quarry test pieces were prepared in the form of cubes varying from two and one-half to four inches in each dimension. Nine of these pieces were tested by the Bureau of Standards, Department of Commerce, Washington, D. C. In

Fig. I.



Polished Section Ashland Granite, Jackson Co.

Fig. II.



Polished Section Haines Granite, Baker Co.

estimating the amount of stone necessary to make the test pieces it was not understood that the government required so large a number of cubes for the standard physical tests. As a consequence the number of pieces it was possible to make of each sample was somewhat less than was expected. The specifications of the Bureau of Standards requires the use of nine cubical blocks of the dimensions given above. It was found that some of the samples collected furnished twelve test cubes and others only eleven. There remained therefore in some cases three, and, in other instances but two of the cubes over those required for the government tests.

It was originally intended to provide two sets of test pieces, one for the government tests and a second to be tested in the laboratories of the Experimental Engineering Department at the Oregon Agricultural College. The few remaining cubes of each stone were submitted to Professor S. H. Graf and the tests of them were made. These results checked in the main with those of the Bureau of Standards but because of certain unavoidable disparities arising naturally from averaging the results on so small a number of test pieces, it seems scarcely fair to Professor Graf to separately quote his results in comparison with the government standard test which requires the use of the much larger number of pieces. The results from the government tests are given in tables found on pages 30 and 40.

GENERAL CONSIDERATIONS IN SELECTING A BUILDING STONE.

The most important considerations in the selection of a building stone are its architectural adaptability; its durability in use; and cost.

Architectural Adaptability. Of the qualities which determine architectural adaptability, to the individual who has a discriminating taste, color is the most important property of a building stone. The predominating colors are white, gray, brown, red, yellow, buff, green and black. The importance of color is largely a matter of individual taste or opinion and is often determined largely by the character and purpose of the structure in which the stone is to be used. Of late years the lighter colors are by far the more popular. This is especially true in the Oregon climate where we have many cloudy days.

The color of any rock is mainly a composite one which results from the blending of the separate colors of the constituent minerals. Uniformity of color is, of course, greatly to be desired in the stone from a certain locality or quarry. It is oftentimes a matter of

great difficulty in erecting a large building to secure uniformity of shade throughout the building for the reason that rocks rarely persist in exactly the same color over a considerable area. Not only are different beds in the same quarry often markedly different in shade but different portions of the same bed are apt to vary to some extent in this respect.

The quality of a building stone is sometimes impaired by the change in color which results from the alteration of certain minerals due to exposure to the weather conditions. For example, the sulphide (pyrite) or carbonate of iron (siderite) although themselves rather light colored, change on weathering into limonite, which is a dark brown mineral. Hence even a small crystal of either of these minerals produces a brown spot, or if the crystal is exposed at the surface, a blotch or streak of rusty iron stain across the face of the stone. Other easily weathered minerals may produce a pitted or roughened surface.

When used for inside ornamental purposes a stone does not suffer materially from weathering and the natural color will ordinarily remain permanent. The selection of the stone in such a case becomes merely a question of personal taste or judgment. A color will be chosen which harmonizes with the surroundings and other interior finish in the building. In flooring or steps the color should not be the controlling factor, but rather the capacity of the stone to withstand or resist abrasion.

For monumental purposes the particular inclinations of the purchaser is again the controlling factor, although durability should be first. Marble and granite are the commonest stones used for this purpose. Marble is very common because less expensive and easily worked and polished, but granite is replacing it for monuments because of its greater durability.

The texture of a rock is also an important factor in its appearance. By texture is meant comparative size, shape, manner of contact and arrangement of the mineral particles of which it is composed. It is a property so closely allied to color that it is doubtful if these two properties are ever observed singly. For example, a granite or crystalline limestone is usually more pleasing in appearance than a sandstone or massive limestone though the two may be identical in shade when viewed from some distance. Even in a single rock such as a sandstone the size, shape, and arrangement of the particles

have much to do with its appearance. Some of the coarser particles in such a rock may possess a color in marked contrast with the groundmass and produce a mottled effect which may or may not be pleasing. In general, texture is a property which the individual more or less unconsciously uses along with color in determining the architectural adaptability of a building stone. The finer and more uniform textures, other things being equal, are the more popular.

Durability. The inherent qualities of a rock by which it is able to withstand the attack of the different agencies of weathering and to endure the conditions it meets in use are termed its durability. The durability of a rock may be studied from the standpoint of its mineral composition, its texture, hardness, strength and structure.

The methods of determining the value of a stone for building purposes, therefore, are: The observation of the stone as found in the quarry and adjacent natural exposures; the examination of the stone where it has been used in buildings, monuments, etc.; laboratory tests. No one of these should be considered sufficient in itself but whenever possible all three should be applied.

Many very important observations can be made at and in the neighborhood of the quarry. For example, it is not only the best place to ascertain the uniformity in color and texture of the rock, but, as has been pointed out, it is also the most favorable place to note its durability and the permanence of its color. The value of the deductions from these observations depends of course very largely upon the accuracy of them and the experience of the observer.

No better idea of the durability of building stones can be had than by the careful examination of buildings which have been erected for a number of years. Such inspection is especially useful in ascertaining the permanence of the color and the presence of deleterious minerals which will usually show on the surface within a very few years. It is not uncommon that certain building stones shell off on the sides of the building that are exposed to the most severe weather conditions. A poor quality in the stone may thus be detected.

Laboratory tests for determining the qualities of building stones are of three kinds: chemical, microscopic and physical. Chemical analysis for example determines the presence and amount of certain deleterious substances in the stone, such as ferrous iron in distinction

to ferric iron, the former, on account of its lower state of oxidation, being much more susceptible to alteration than the latter. The presence of argillaceous or clayey material and proportion which it bears to the total mass may also best be determined by this method.

Very much may be learned of the structure, mineralogical composition and general character of most rocks by a careful microscopic examination. Oftentimes important rock structures are brought out by such examination that would otherwise pass unobserved. The accurate determination of the mineral composition is of greater value than the chemical analysis. It is also much less expensive. By means of the microscope and a thin section of the rock one can recognize both the component minerals and their state of aggregation, two exceedingly important items in the consideration of a building stone. This is the most practical way which has yet been found to ascertain the reasons why certain rocks flake, crumble, or scale off when exposed to the weather.

Of the physical tests the most common are: absorption, or the capacity to take up moisture, strength, or resistance to crushing with the stone in both the wet and the dry conditions, also crushing tests after repeated freezing and thawing.

By far too much emphasis is usually placed upon the crushing strength of a rock. Most all rocks are many hundred if not thousands of times stronger than is ever required of them in a building. When it is considered that the mortar which is used in laying building stone will usually stand a weight of about 1200 to 1500 pounds to the square inch, it will easily be seen that there is no particular advantage in having the rock in the same column capable of sustaining a pressure ten or more times as much as the strength of the mortar. In all of our sky scrapers the load is carried upon the steel structure. To show that even the weaker rocks are strong enough for extremely high buildings it may be stated that the pressure on the stone in the base of the Washington monument, which is 555 feet in height, is but 315 pounds to the square inch.

The results of the absorption test are used as a basis for estimating the danger from frost and from ordinary weathering. It is a common error to assume that danger from freezing is directly proportional to the absorption of a stone or its porosity. No doubt there is some relation between the two but it has recently been shown that the

size and the way the pore spaces in a rock are related to or connected with each other has more to do with its resistance to frost action than has the total amount of pore space. Often a rock which has very high absorption shows no ill effects from continued freezing and thawing. The freezing and thawing tests of the volcanic tuffs of Eastern Oregon given in table on page 40, typically illustrate this fact.

The freezing and thawing test is very useful in determining the behavior of a rock under frost conditions. The rock is first saturated with water then repeatedly frozen and thawed. Its crushing strength is then compared with that of the same rock crushed wet. The laboratory test of this kind more nearly duplicates the actual conditions to which building stones are subjected in use in regions of freezing temperatures than is probably the case in any other test.

Cost. The three main factors which determine the cost of a building stone are the quarry conditions, its workability, and situation with reference to transportation. Two of the most important quarry conditions to be considered are the amount of overburden, that is the quantity of waste rock and soil which must be removed in order to get at and to quarry the rock which is desired; and secondly, the spacing of the joints and bedding planes. This last is especially important as joints and bedding largely determine the size and to a considerable extent the shape of the blocks which may be obtained.

Uniformity of color, freedom from objectionable minerals and waste rock or overburden, advantageously developed joint systems and bedding, will evidently reduce the cost of quarrying per cubic foot.

The workability of the rock includes the comparative ease with which it can be tooled, sawed, planed or polished. There are no satisfactory methods known outside of practical experience for determining the comparative workability of building stones. On this account I am depending upon the consensus of opinion of the older stone workers of the state who have worked all of the different stones which come into the Portland market. Since at the present time the Tenino stone from Washington is used a great deal in Oregon and since, also, it is a stone which works as easily as any other stone in the Oregon market, we may arbitrarily select Tenino stone as a standard of workability. On account of the wide use and popularity of Tenino stone we may also refer to it in comparison

with other stones in the matter of color and other physical properties.

From the standpoint of cost alone, Tenino sandstone is probably the most favorable of any stone which comes into the Portland market. The most popular criticism directed against it is its dark color. As noted above the tendency in our Oregon climate, which is rather somber in winter yet free from the glaring summer sun, is to select the lighter shades. So, if a lighter colored sandstone or limestone could be had in the Willamette or Columbia Valley territory, or contiguous to water transportation, it would, other factors being equal, doubtless be able to compete very successfully with Tenino stone.

OREGON GRANITES.

ASHLAND GRANITE, JACKSON COUNTY.

One of the most promising outcrops of granite which the Bureau has had the opportunity to examine is found in the southern part of Jackson county about seven miles southeast of Ashland on Neil creek and about one and one half miles west of the Southern Pacific railway. Granite outcrops occur over many square miles in this section but it is probable that the most promising locations for quarry sites are to be found on one side or the other of the canon of Neil creek. The Penniston Granite Company of Ashland has had certain options on some of the most favorable outcrops in this region. Their options have, however, been recently taken over by W. M. Blair of the firm Schanen-Blair Company of Portland. Mr. Blair has purchased 120 acres, forty acres in section one of township forty, and the south half of the southeast quarter of section thirty-six in township thirty-nine south, range one east, known as the Ross tract, and is preparing to open up a quarry for handling granite on a large scale.

There has not been sufficient excavation work done to constitute a quarry in this granite. However, the Penniston Granite Company has worked up a considerable amount of the large boulders of weathering which are found on the surface, and the monumental granite obtained from these blocks is giving excellent satisfaction. (Fig. III.)

The rock is a rather fine-grained bluish gray granite. The prin-

cipal minerals are feldspar (both orthoclase and plagioclase), biotite, magnetite and zircon. With a more accurate classification petrographically, the rock might prove to be more nearly a granodiorite in mineral composition but for the purpose of this report it is a granite.

The granite is quite similar in color and texture to the "Barre" granite of Vermont. A polished section of the rock is shown in Fig. It is remarkably uniform in its texture and color, works well, breaks with equal ease in all directions, is hard and tough when fresh but slightly less so when weathered. It fractures very smoothly for granite. The weathering of the outcrops in this section varies somewhat in different places but in general the exposures show fresh, unaltered rock. The large, loose boulders already mentioned often show little or no weathering at a depth of four to six inches from their surfaces. The effect of slight weathering is to lighten the color, due probably to the beginning kaolinization of the feldspars. Where considerably weathered, biotite has stained the rock slightly yellow or brown, but even in this condition no deterioration or crumbling is in evidence. The process of weathering is so slow, however, that any discoloration would not appear except after long periods of time.

The joints vary in spacing on the surface from six feet apart in some of the best places to only a few inches in the less favorable. A quarry site could easily be found where joints are measurable in feet. There are no sulphides in the rock itself but the joints are sometimes filled with quartz and occasional grains of pyrite, the weathering of which in places produces an unimportant amount of iron stain on the surface of the stone.

The Neil creek granites are a part of a very large granite intrusion in the neighborhood of Mt. Ashland. In fact, Mt. Ashland is almost entirely a granite mountain. The geologic relations of this granite will be treated in greater detail in Dr. A. N. Winchell's report on this region which will be published later in the year by the Oregon Bureau of Mines and Geology. The streams in this section have cut deep canons with precipitous walls of which Neil creek canon is a type. On the canon sides the rock outcrops sometimes almost bare and in no place requiring much stripping of soil. The question of locating a quarry site, therefore, is one

of selecting an area in which the spacing of the joints of the rock gives promise of good quarry conditions.

The Ashland granite is pleasing in color and texture, is durable and so far as we can now judge, compares favorably in all the desirable qualities such a stone should possess, with the best commercial gray granites. See Fig. I.

GOLD RAY QUARRY, JACKSON COUNTY.

The Gold Ray Granite Company's quarry is located in Jackson county near Tolo station on the Southern Pacific railroad, the quarry being sufficiently above the track as to permit of economic handling of the material directly into cars. The rock is a coarse-grained gray granite, which resembles to some extent the granite in the neighborhood of Ashland. The latter is described in detail in another part of this report. The Gold Ray granite has a darker color, however, and is not so fine grained as the Ashland stone. The important minerals are quartz, orthoclase and plagioclase feldspar, black mica and hornblende. The black minerals are not uniformly distributed, the hornblende particularly occurring in rather large grains. This lack of uniformity is noticeable in only certain portions of the quarry.

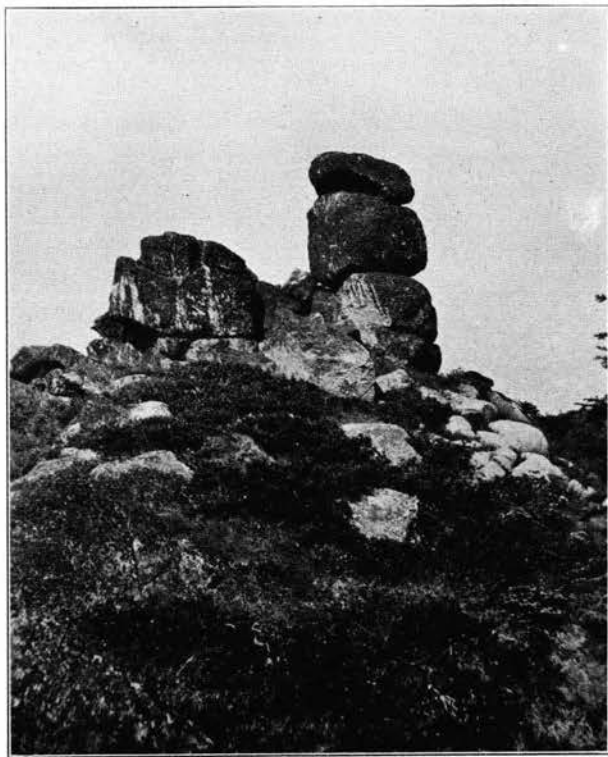
The jointing in this quarry is not especially well developed or regular and quarry operations are thereby considerably handicapped. The quarry has been idle for some time, but has been recently leased to the County of Jackson and will probably be operated extensively for road materials in the near future on account of the extensive hard surface roads which are to be built in that county.

The location of this granite deposit is so favorable with reference to transportation that there appears no good reason why the better blocks should not prove suitable for building and monumental purposes, while the balance of the stone may continue serviceable as road metal and ballast.

HAINES QUARRY, BAKER COUNTY.

The Haines quarry is situated near the center of section twenty-seven, township seven south range thirty-nine east in Baker county. The nearest railway station is Haines which is on the Oregon-Washington railway about two miles west of the quarry. The quarry is reached by a good wagon road. It is owned and operated by the Northwestern Granite Company of Baker, Oregon, and

Fig. III.



Granite Outcrops Near the Top of Mt. Ashland, Jackson Co.

Fig. IV.



Haines Quarry, Baker County Granite.

furnishes practically all the granite rock used in the neighborhood of this city.

The rock is a medium-grained, rather dark gray granite, the dark color being due to a considerable proportion of black minerals such as biotite and hornblende. There are a number of xenoliths or knots, that is, small segregations largely composed of black minerals, in different parts of the quarry face. For instance, there were observed in a single block twenty feet by four feet by three feet six dark colored knots, one about a foot in diameter, the others from two to six inches. The granite in the quarry as far as opened shows characteristic spheroidal weathering. This is a structure often found near the surface in various kinds of rocks. Such weathering produces more or less rounded boulders or spheroidal masses by the rounding off of the corners and edges of the original angular joint blocks. A good impression of this type of weathering can be had by noting Fig. IV.

Jointing in this granite is fairly well developed, and the planes are so spaced that single blocks can be had as large as twenty by four by three feet and cubes as large as six feet in each dimension could doubtless be readily obtained. Three openings are now being worked. The largest is about fifty feet in diameter and is worked back to a depth of twenty feet.

A cut of a polished section of the Haines granite will be found in Fig. II. The most important uses of the stone are for monumental purposes and foundation work. Baker county is fortunate in being well supplied with building stones. The volcanic tuffs described in another part of this report, have, because of the lower cost of quarrying and working, limited the extensive use of granite as a general building stone in this section. The Haines granite possesses properties which should render it serviceable for interior use as well as for a more extended application for general construction. As the city of Baker progresses and still more pretentious buildings are erected, there will be an increasing demand for granite for both the above purposes.

WILLAMINA DIABASE, YAMHILL COUNTY.

An outcrop of igneous rock supposed to be granite, situated about six miles north of Willamina in Yamhill county and owned by J. F. Sale of Astoria was examined by the writer in company with the owner.

This rock is a considerably altered medium grained diabase. Some samples of the stone were cut and polished. The polished section has a dull grayish green color, and a somewhat mottled appearance, due to the peculiar arrangement of the constituent minerals. The rock is composed chiefly of pyroxene, about forty-eight per cent, plagioclase feldspar, about forty per cent, and about twelve per cent of magnetite. Both the pyroxene and plagioclase have suffered considerable alteration, which gives rise to the dull greenish gray color.

On account of the unattractive appearance of the rock when polished, the writer believes that an extended description of this deposit is not warranted. Such a rock could be used locally to good advantage in foundations, piers, etc., but it is not probable that it would meet the market requirements as a building stone.

GRANITE TESTS.

Samples were taken and physical tests made of the different granites examined. The results, however, give so little usable information that they are not thought worth space in this report. This will be evident when it is considered that no sample of granite tested showed as much as one quarter of one per cent of absorption, the crushing strengths were all above 13,000 pounds per square inch and no deterioration was evident after repeated freezing and thawing.

OREGON SANDSTONES.

PIONEER SANDSTONE, LINCOLN COUNTY.

The most noted quarry in Oregon is the Pioneer quarry near Pioneer post office, railway station Morrison, on the Corvallis and Eastern railway, twenty miles east of Yaquina, Lincoln county.

The quarry has not been in operation for about sixteen years. The time of its greatest activity was from 1894 to 1898. During this period the Pioneer Sandstone Company sold more than 300,000 cubic feet of dimension stone and mill blocks at an average price of about fifty cents per cubic foot. They also sold rubble for the jetty work on Yaquina Bay. 8,000 tons (thirteen cubic feet per ton) were used by the United States government for this purpose at fifty cents per ton.

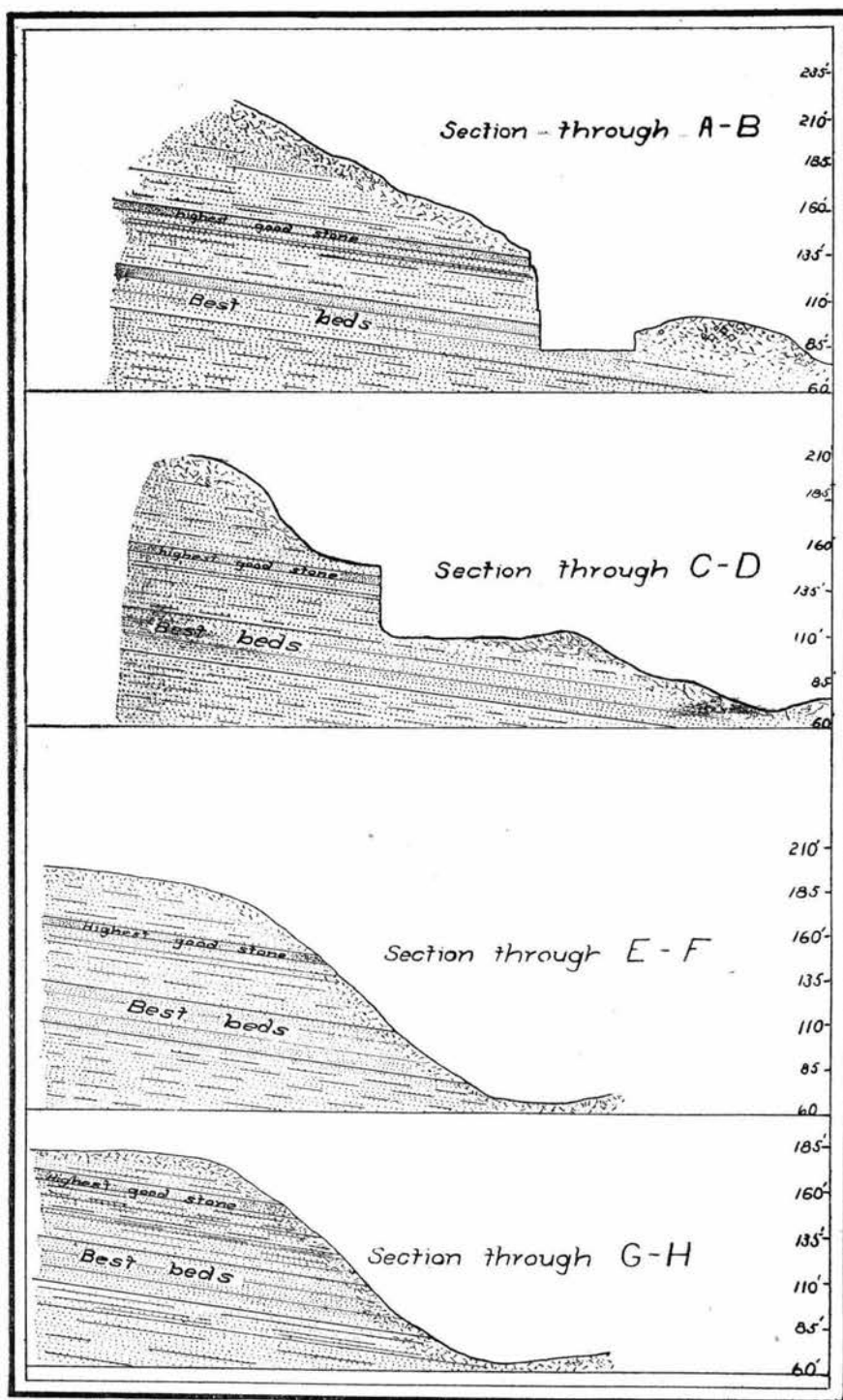
A considerable portion of the output reached a market as far away as San Francisco, California. The Call Building and the Emporium of that city were built of this stone. Numerous buildings in different parts of the Willamette Valley were built of Pioneer sandstone, notably two college buildings on the campus of the Oregon Agricultural College, Corvallis, a bank in Eugene, the City Hall and other buildings at Salem and a bank in Woodburn.

The quarry is located 1,500 feet north from Morrison station. A spur from the railroad ran to the quarry when it was in operation. About 1,000 feet of the spur is still in fair condition. The stone which was used in San Francisco was hauled to Yaquina by rail and thence to San Francisco by boat. The railway freight charges were five dollars per car of fifteen tons.

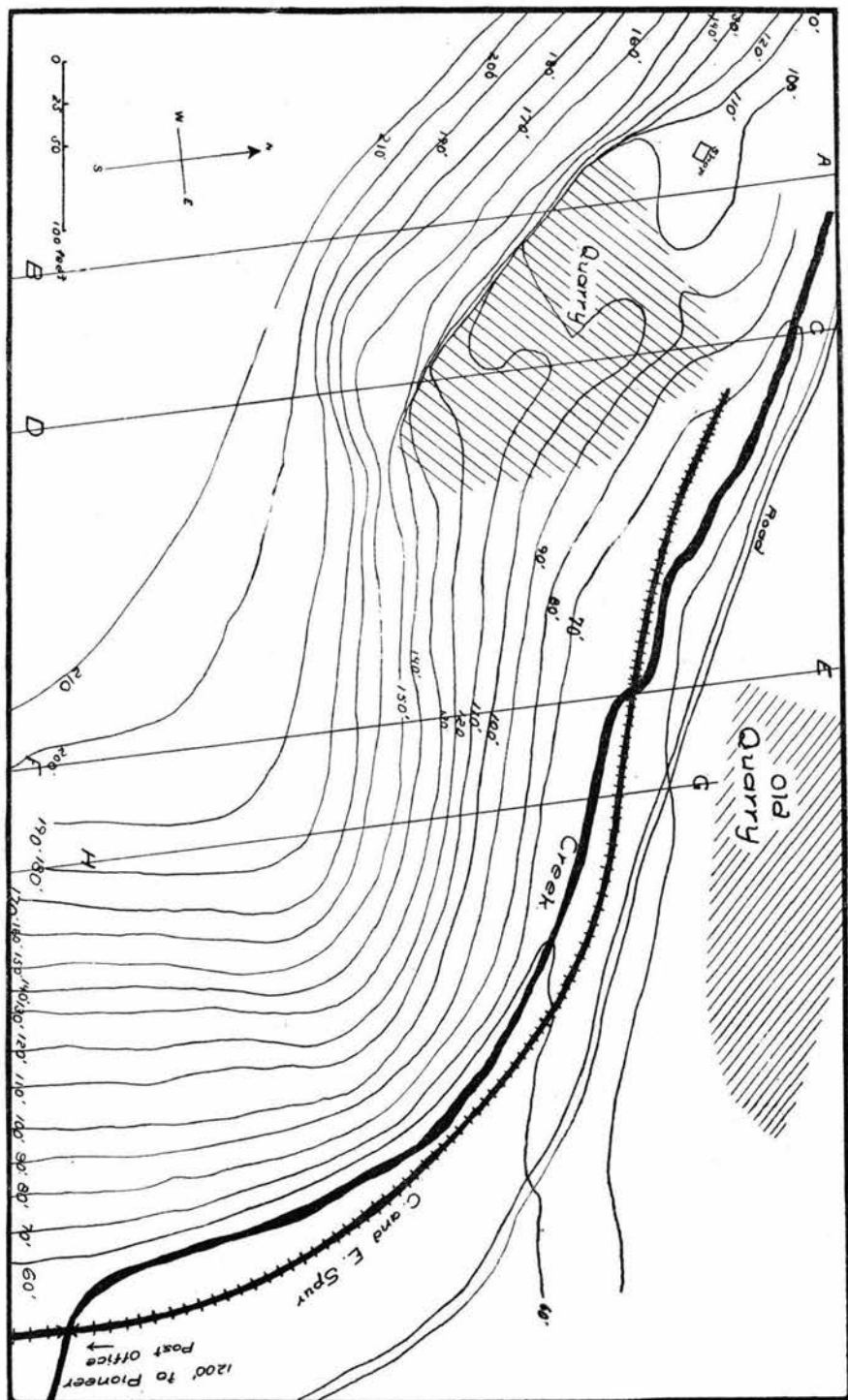
This sandstone covers a large area and its thickness is unknown. A hurried reconnaissance of the region, however, shows the presence of over 2,000 feet of it. The attitude of the beds is quite uniform over a considerable area. In a distance of a mile and a half at right angles to the strike the measured dip was found to vary between six and ten degrees. The strike at the quarry is nearly east and west and the dip about eight degrees to the north. The topography of the country is one of ruggedness with steep canons and sharp hilltops having differences in elevation of from 500 to 1,000 feet.

The color of the Pioneer sandstone varies from light gray to gray-buff and the rock has a fine even granular texture. It is composed chiefly of minute grains of quartz sand with occasional particles of feldspar, biotite and hornblende. The cementing material for the most part is argillaceous although a small amount of lime carbonate is present.

The quarry was first opened on the north side of the canon, as indicated on accompanying contour map. Although a considerable amount of excellent stone was taken out at this point the operators were soon forced to abandon the quarry on account of heavy overburden. It is not surprising that abandonment of this first quarry site was found necessary for the rock beds here dip at about eight degrees directly against a slope of the canon wall of about thirty-five degrees, the overburden increasing in the ratio of the tangent of the sum of the two angles or forty-three degrees, which is .932. That is to say, that every one hundred feet of advance into the hill



Vertical sections showing relations between surface of hill and beds of sandstone. Compare with contour map, page 23.



Contour Map of area in vicinity of Pioneer Quarry, Lincoln County.

following the beds would make 93.2 feet increase in overburden. These difficulties led to the opening of the main quarry on the south side of the canon in 1896 from which the greater portion of the Pioneer stone was taken. A view of this quarry in its most active days is shown in Fig. VIII. It should be noted here that the same beds in each of these quarries were found to be quite superior to the others.

By examination of the contour map and sections on pages 22 and 23 it will be seen that the second quarry site was not chosen in the best available location. Had a site been selected about 300 feet to the east of the present quarry on the south side of the canon, very much less stripping would have been required to obtain an equal volume of stone from these same beds. This is for the reason that the hill slopes toward the east while the attitude of the beds in relation to the surface carries the outcrops to the eastward higher and higher on the hillside. Moreover, the dip of the beds lies with the slope of the hill instead of against it as in the case of the first quarry.

The contour map and sections were made by S. W. French from field notes taken by him and a survey made with the use of a Brunton pocket transit and the aneroid.

By a study of these sections and the map the approximate amount of rock and soil to be removed in stripping and opening up a quarry face in the neighborhood of sections E-F and G-H can be readily computed by anyone. The beds which are labeled "best beds" in the sections were found both in the north and south quarries to be about twenty feet thick. It is from them that the larger quantities of the best rock were obtained. The lower limit of the "best beds" in each quarry corresponds to the bottom of the excavation.

From both quarries a great deal of building stone has been obtained between "best beds" and "highest good stone." It seems probable, however, that a greater amount of refuse rock had to be handled and sorted out from these beds than in the lower one. The inferior stone, which is found to a greater or less extent in all of the main strata is due largely to shaly partings between beds and occasional concretionary boulders known as "nigger heads" by the quarrymen.

As stated before, since the outcrops of the beds rise materially as one goes east from the south quarry, there will be some twenty feet of thickness available below those labelled "best beds" which were not available in either of the earlier quarries, should a quarry be opened at the section G-H. It is believed also to be a safe assumption

that the stone below the "best beds" will be of as good a quality and possibly better than the latter.

Of all Oregon sandstones examined by the writer the Pioneer stone has probably the best qualifications when viewed from the standpoint of the architect. One of the prominent architects of Portland made the statement recently that the Pioneer sandstone is very pleasing from the architect's standpoint and that if a feasible quarry site could be found for handling it in large quantities it would soon become one of the most popular sandstones on the Pacific coast. He also stated that, in his opinion, all of the Oregon architects would be glad to encourage further development of this stone.

As the table of sandstone tests on page 30 will show the Pioneer stone has a normal percentage of absorption, and an ample crushing strength for all building purposes, and that it shows no deterioration in the freezing and thawing test. All of the older stoneworkers of Oregon are agreed that it can be worked as easily and cheaply as Tenino stone.

The Pioneer stone is quite fortunately situated with reference to transportation, being immediately adjacent to the Corvallis and Eastern railway and only twenty miles from the harbor at Yaquina. It is thus but about seventy miles from the heart of the Willamette Valley, while by water a wide coastwise distribution is possible.

It will be seen from a study of the contour map and sections accompanying this report that the quarry conditions present no very difficult obstacles to overcome. It is the opinion of the writer that not only can a quarry be opened and economically operated in this section but also that such a quarry might easily develop into an important industry. The general qualifications of the Pioneer stone are such that it can doubtless enter the market in successful competition with the best grades of building stone now imported into Oregon besides possibly itself supplying a demand in neighboring states.

GEARY QUARRY, JACKSON COUNTY.

The Geary quarry is located on the ranch of Dr. E. P. Geary of Portland five and one half miles southwest of Medford on Griffin creek. The quarry has not been worked for several years. The beds are very much obscured by talus and waste stone which had been loosened with powder and not removed.

The rock is a massive sandstone. When fresh, it is of a bluish gray shade changing to brown by weathering as shown along the joint planes. The stone is composed largely of quartz grains with occasional scales of black mica. The cementing material seems to be very largely calcium carbonate. The beds lie flat with no indication of folding or faulting.

Scattered promiscuously through the beds are nodules and nodular masses having a concentric structure ordinarily known to quarrymen as "nigger heads." These "boulders" vary in size but the larger ones observed are from six to eight inches in diameter. They stand out on the exposed faces and the rock frequently breaks around them in quarrying. The material of these nodules seems to be of finer texture than the mass of the rock. There occur also some irregular and non-persistent bands or partings, parallel to the bedding, of similar texture and apparently made up of the same material as the nodules.

The quarry is located on the steep hill slope 150 feet above the present wagon road. The overburden of soil at the face is not over two to four feet. To this should be added two or three feet of weathered rock in the upper part of the section which would have to be removed by stripping in order to expose the workable beds. The best bed exposed is about five feet in thickness, of solid gray stone, which is as before stated, separated in places by nodular partings.

On account of the waste stone in the quarry it was impossible to examine the face to the full depth as it had formerly been opened. Possibly fifteen feet of workable stone have been exposed. The planes of separation are spaced so that dimension blocks of considerable size are available. It was not possible to secure information as to the workability of this stone but from appearances it would probably saw and tool satisfactorily. The same rock outcrops over considerable area on the east side of Griffin creek and in contiguous hills. There is very little question, therefore, but that a large quantity of stone would be available in this locality.

The rock has been used to some extent in buildings in the City of Medford and has been hauled by wagon from the quarry to that city. Fig. X shows the best exposure and quarry face as it appears at present.

By referring to the table of tests a comparison can be made of some of the physical properties of the Geary stone with those of other

Fig. V.



Call Building, San Francisco, built of Pioneer Sandstone, Lincoln County, Ore.

Fig. VI.



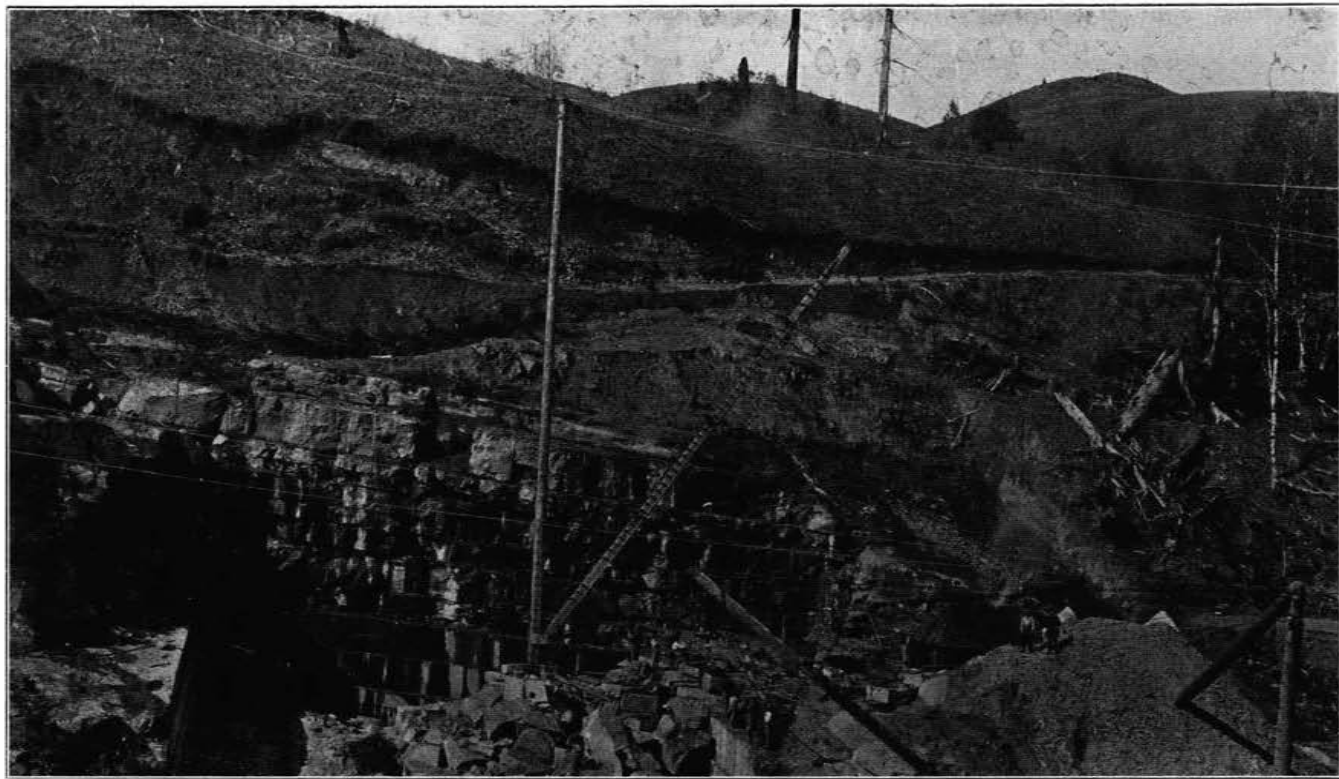
Old Pioneer Quarry, Lincoln County, first opening.

Fig. VII.



Bank Building, Sutherlin, Ore., built of Cooper Sandstone.

Fig. VIII.



Pioneer Quarry, Lincoln County, as it looked in 1896. Second opening on south side of canon.

Fig. IX.



Boos Quarry, Yamhill County, Sandstone.

Fig. X.



Geary Quarry, Jackson County, Sandstone.

sandstones. It has the highest crushing strength of any sandstone tested but, as stated under the discussion of essential considerations in selecting a building stone, this can easily be too high. It is frequently the case that stones which have a very high crushing strength are hard to work with tools. This stone has an absorption of only 2.64 per cent which shows that the spaces between the grains are nearly filled with the cementing material. It shows no deterioration in the freezing and thawing test.

COOPER SANDSTONE, DOUGLAS COUNTY.

There are two quarries in this stone situated four miles southeast of Sutherlin in Douglas county about one mile east of Deady switch, a point on the Southern Pacific railway some three miles south of Sutherlin. A spur runs to each opening. The quarry farthest west, known as the Cooper quarry, is now owned and operated by J. W. Matthes and Robert J. Snow of Portland. The other, a few hundred yards east and formerly known as the Pheonix quarry, is owned by Hegele and Riedle of Portland. A considerable quantity of stone has been taken out of both quarries. Considerable good equipment is found at each quarry, the Phoenix having a donkey engine of about fifty horsepower, an air compressor and one drill outfit, a fifty ton derrick and blacksmith shop.

Since these quarries are located so close together and in them the same beds are present, and since the qualities of the stone are identical, they will both be discussed together under Cooper Sandstone.

The rock is a firmly cemented sandstone of a rather dark gray color. It is remarkably heavily bedded. The beds in the vicinity of the quarries have approximately an east and west strike and dip about fifteen degrees to the south. Their attitude conforms very closely to the slope of the hillside. This is an advantage since the overburden would probably increase but little with the advance of the quarry face. About ten to twelve feet of stripping is required to expose the best beds. The bedding planes are not very evident and neither folding nor faulting is apparent in the vicinity of the quarries. The spacing of the joints varies from five to ten feet which permits large blocks to be obtained when desired. Both quarries are the side-hill type.

The absorption test on this sandstone shows a very small amount of pore space. This means that the original openings between the

sand grains have been almost entirely filled with natural cementing substance. A very dense hard sandstone has been thus produced. The table on page shows an average crushing strength per square inch of 8,875 pounds for the Phoenix quarry stone and of 9,788 pounds for the stone from the Cooper quarry.

One of the principal criticisms that have been applied to the sandstone from these quarries is that the rock is so hard it is very difficult to work with tools. In the opinion of a large number of stonecutters it will cost as much as thirty per cent more to work Cooper sandstone than Tenino on this account. On the other hand, it has been stated that this stone works quite easily when green. As the table will show the Cooper sandstone suffers some slight deterioration from repeated freezing and thawing, a fact, however, of little importance in western Oregon climate.

Cooper sandstone has been used in the following buildings:

Sunnyside Congregational Church, 32nd & Taylor Sts., Portland.

Sunnyside M. E. Church. 35th and Yamhill Sts., Portland.

Electric Building, (base courses and entrance steps) Portland.

Bank Building, Sutherlin, Oregon. (Fig. VII.)

Mount Tabor Presbyterian Church, 55th & Belmont Sts., Portland.

Church in Albany, Oregon.

MONROE QUARRY, BENTON COUNTY.

The Monroe quarry is situated on the east slope of a hill a little less than a quarter of a mile west from the town of Monroe, in southern Benton County, on the Portland-Eugene and Eastern railway. It is about midway between Corvallis and Eugene.

The rock is a fine-grained sandstone. Only a very small amount of stone has been taken out and the quarry has not been operated for a number of years. The quarry consists of two small openings each about thirty feet in length, fifteen feet in depth and in either a thickness of not more than six feet of beds is exposed.

The sandstone beds lie flat and no evidence of folding is to be seen in the exposures. The planes of bedding and of jointing are in such relation that blocks with a maximum dimension of three feet can be taken out. The extent to which the stone has been opened up is so limited that it is impossible to make any satisfactory estimate of the quantity available at this place.

The rock is of even texture, grayish green in color and consists

chiefly of quartz grains with occasional particles of feldspar, olivine, flakes of muscovite and films of secondary calcite. A few calcite veins also cut through the rock at varying angles. These mineral particles are cemented together largely by argillaceous matter and a small proportion of lime carbonate.

On an average six to eight feet of soil and waste rock would have to be stripped off in order to expose beds of usable quality. This amount of stripping would not become appreciably deeper for some distance. The stone is said to be easily worked but such a small amount has been used that it is difficult to get any very definite information on this point. The only place in which, to the writer's knowledge, the Monroe sandstone has been used is in the steps, water table and trimmings of the County Court House in Corvallis. On the whole, the apparent quality of the stone is favorable and since it is convenient to transportation a quarry could, no doubt, be opened up in this location to furnish considerable stone locally in the Willamette Valley.

BOOS QUARRY, YAMHILL COUNTY.

The J. G. Boos quarry is located in section twenty-two of township one south, range four west, two and one half miles northwest of Gaston, on the west side division of the Southern Pacific railway, between McMinnville and Forest Grove. It is about one and one half miles west of Scoggins station. The quarry is situated on the ridge which forms the northern boundary of Wapato lake. A railroad spur has been surveyed to the quarry having a maximum grade of three and three-fourths per cent.

The rock is a fine-grained sandstone of a dark bluish gray color when fresh which becomes a somewhat lighter shade when the stone is seasoned. The grains are chiefly quartz with some feldspar, muscovite and olivine. The cementing material is argillaceous. The rock strata in the neighborhood of the quarry have a strike north thirty degrees west and a dip of forty degrees to the eastward. The beds dip directly against the slope of the hill. Some signs of movement are in evidence in the quarry, one fault showing a displacement of about ten feet.

Quarry excavations have been made in two different places along the outcrop. The lower opening is about 200 feet in length along the strike of the beds and has been worked into the hill horizontally

for about fifty feet. The upper excavation which is some eighty feet above the lower, is about seventy-five feet long and twenty-five feet wide. Fifty feet of sandstone are exposed in the lower quarry opening and about twenty-five feet in the upper, each face being cut by more or less regular systems of joint planes. The overburden to be removed in either exposure, consisting of soil and waste rock, is from three to six feet deep.

According to the reports of stonecutters the Boos stone works easily. The greatest objection to it has been its rather dark color. To the writer's knowledge the rock has been used in the following buildings: Marsh Hall of Pacific University, Forest Grove, basement and trimmings; Court House at Hillsboro, foundation; Government Hospital at Ft. Stevens, steps and trimmings; steps of all University buildings at Eugene; steps of Mechanical Hall, Oregon Agricultural College, Corvallis; steps of Drain Normal School building.

TESTS OF OREGON SANDSTONES.

Name and location of quarry.	Percentage of absorption.	Crushing strength in pounds per square inch.			Specific Gravity
		Specimen tested dry.	Specimen tested saturated with water.	Specimen tested after freezing and thawing 10 times	
Boos Quarry	6.59	6617	4764	3968	2.33
Gaston, Ore.					
Phoenix Quarry ...	2.61	8875	6665	4695	
Sutherlin, Ore. ...					
Cooper Quarry	2.36	9788	6756	5493	
Sutherlin, Ore. ...					
Pioneer Quarry	5.74	7425	3522	3405	2.29
Morrison, Ore. ...					
Geary Quarry	2.64	10515	7492	7883	2.49
Griffin Creek					
Medford, Ore. ...					

OREGON LIMESTONES AND MARBLES.

BLACK MARBLE, WALLOWA COUNTY.

A deposit of crystalline limestone, or marble, has recently been discovered near Enterprise, in Wallowa county, which gives promise

of being suitable to furnish material for a considerable industry. This deposit is situated about five miles southwest from the town of Enterprise and is reached by a fairly good wagon road. As will appear later in this report, the quality of this stone is such that portions of it should prove suitable for interior finish and decoration in our best structures, other portions as a building stone; and its chemical composition shows that it should make a good grade of lime.

In but few other places in the world is fault structure so well exhibited in the present land forms as in certain parts of eastern Oregon. Stein Mountain, in Harney county, is a notable example of this structure, since the mountain range itself was formed by the tilting of a long narrow block of the earth's crust. The Wallowa Mountains in Wallowa county, where this marble occurs, also furnishes another illustration of this kind. Some general statements as to the geologic history of this range of mountains and the way in which it was formed may therefore be of interest.

The crust of the earth is constantly subjected to very heavy pressure on account of the cooling and consequent shrinkage of the interior. If these forces are greater than the crust can withstand a break is caused. When breaks occur the rocks which compose the crust are often fractured into large blocks. Portions of the crust then assume new positions. As these blocks settle into stable positions when the region becomes quiet again, we always find that some blocks have been lifted and somewhat tilted.

When these movements occur in a very large way a single block may be many miles in length. If the slipping of one block with reference to its neighbor has been considerable there will be exposed, before the wearing away effects of rains and floods have changed its appearance very much, a precipitous rocky wall as the plane or surface along which the slipping has taken place. If tilting has accompanied the slipping, and it usually does, the top of such a block is apt to be a gently sloping area which dips away from this wall or fault plane. Of course these conditions disappear with the passing of the centuries and, should no new movement occur, the region would eventually be graded down to a plain again. The erosive action of water rapidly cuts steep gulches at intervals in the precipitous wall and, in times of storm, raging mountain torrents rush downward and carry with them to the plain below large quantities of materials worn from the rocky wall. On the top of the tilted block where

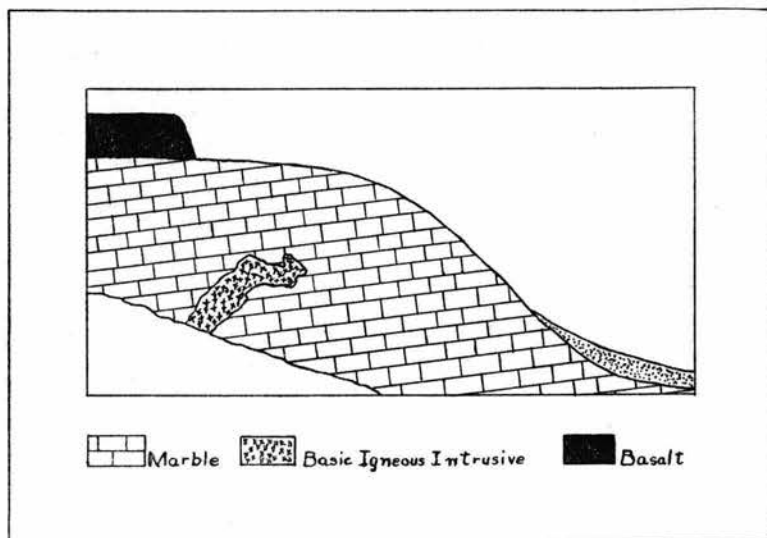
the gentle slope exists, the same storms occur, but the waters run more slowly. But since this was once a plain, on which weathering and soil formation to some depth had taken place, the waters even here will carve the slope into separate watersheds.

A precipitous wall on one side of a line of break and rock movement cut by sharp gulches, and on the other side a gentle slope partly worn away by the formation of low watersheds, is a set of conditions such as we have in the Wallowa Mountain range. Here the precipitous wall cut by steep gulches extends for a long distance and forms the southwestern limits of Wallowa Valley. This valley is reached by a branch of the Oregon-Washington railway, which has its junction with the main line at La Grande, and its terminus at Joseph, near the upper end of the valley. The traveler on this line rides along on top of the block which has slipped down. To his right as he goes up the valley is the precipitous wall which was tilted upwards now cut by streams and gulches. The block over which he passes and which extends far to the northwest has been shaped by the forces of nature into rolling hills.

Before the movement referred to occurred beds of limestone, as well as other sedimentary rocks, were present beneath the surface of the earth. When the movement was taking place the mighty forces which produced it subjected the limestone to conditions which largely altered it into a marble, while the downslip of the one block and the uptilting of the other have exposed this marble to our view in the face of the precipitous wall. It now outcrops about 2,000 feet above the level of the valley.

The property upon which the marble outcrop was examined belongs to the Oregon Black Marble Company, of which Dr. J. D. Fleenor, of Joseph, Oregon, is secretary and treasurer. It extends in an east-west direction for more than a thousand feet, and follows approximately the contours of the hillside. The width of this most easily examined and well-exposed outcrop varies from fifty to 500 feet. The thickness of the bed is known to be more than 500 feet in some of the more favorable exposures. Its strike is approximately east and west, with a gentle dip against the slope of the hill of approximately fifteen degrees south. Considerable folding is apparent in certain parts of the outcrop, indicating that the entire deposit, so far as has been observed, is the north limb of a synclinal or trough fold. Near the most eastern portion a small

stream has cut a gorge straight across the beds, thus permitting the observation of a good cross-section of a large body of the stone. An ideal vertical section as represented in this canon is shown in sketch below. (See also Fig. XIV.)



Ideal section showing relation between black marble and associated rocks.

The striking feature of the marble is that the color of a large portion of it is almost jet black. It is, at least, as black as the blackest of slates. The black color is due to the presence of carbonaceous matter in the original limestone, which was altered to graphite when the limestone was metamorphosed to marble. The blackest portion seems to be confined to the east 500 feet of the 1000 foot outcrop described above, and from that point west it grades off gradually into the dark grays and mottled marbles so common in many deposits. In the black area there are a few narrow white calcite veins running through the mass with more or less circular spots of white calcite. Figs. XI and XV.

Only a small amount of work has been done to make a quarry opening. Something more than 5000 cubic feet of excavation has been made in the hillside close to the gorge of the stream mentioned. This excavation is shown in Fig. XIII.

The separate beds examined in the different parts of the exposure

vary from two feet to six feet in thickness, and usually show the characteristic jointing of limestone. These joints are also from two to six feet apart. At a depth of sixteen feet from the surface, as exposed in the excavation, blocks of sixty to seventy-five cubic feet can be obtained without difficulty. Fig. XV.

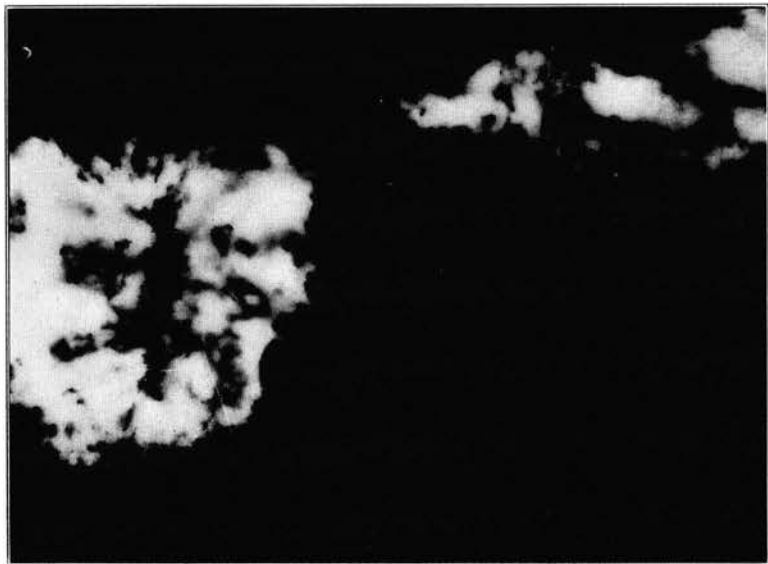
In the stream gorge, some 250 feet above the excavation, there is exposed a small amount of basic igneous intrusive rock which would indicate that these limestone beds are more or less involved with intrusives of this nature. It seems probable that the face of this limestone outcrop is itself a minor fault escarpment produced by a local movement within the main fault block. It has a very steep slope to the northeast and very little or no soil covering except in a few places where the slope is quite gentle. Stripping, therefore, would be a minimum consideration.

The chemical composition shows the rock to be a fairly pure limestone. From the color, one would naturally infer the presence of a considerable amount of impurities, but among a number of samples analyzed there is less than five per cent of insoluble matter present. The products which could be made from this deposit of limestone are lime, marble and building stone. Its chemical composition would indicate that this rock would produce a good grade of lime. This last conclusion is borne out by the fact that a considerable amount of lime has already been manufactured here, and it is said to be of an excellent quality. Such a limestone would also, so far as its composition is concerned, furnish the lime for a Portland cement mixture. The transportation charges on fuel, oil or coal, to this region, and on the cement out to the markets, would be so large a cost item in the production of Portland cement here, however, as to discourage its manufacture for some time to come.

There is considerable demand for a good black marble that will take a high polish. It is a well known fact that the Belgian black marble brings top prices in the market. Such marble is used mostly for interior decoration, for baseboards, electric switchboards, and to some extent for monumental purposes. Figs. XI and XII show the effect of polishing the Wallowa County Marble.

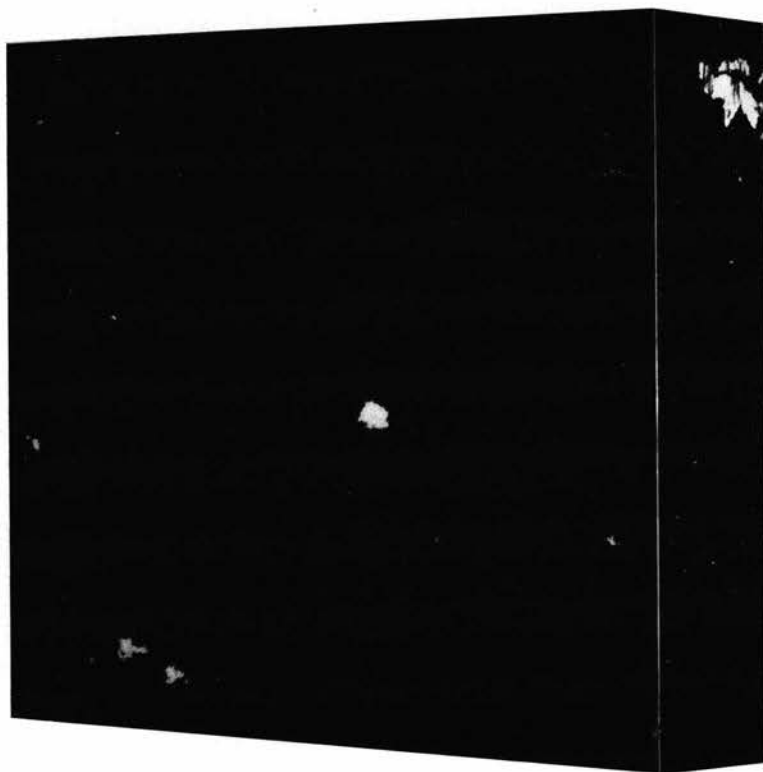
It seems highly probable that a considerable amount of building stone might easily be made available from the lighter colored portions of the deposit towards the west end of the outcrop. On the whole, the stone appears to be a very valuable one from the stand-

Fig. XI.



Polished section of Black Marble, Wallowa County.

Fig. XII.



Block of Polished Black Marble, Wallowa County.

Fig. XIII.



Quarry opening. Black Marble, Wallowa County.

Fig. XIV.



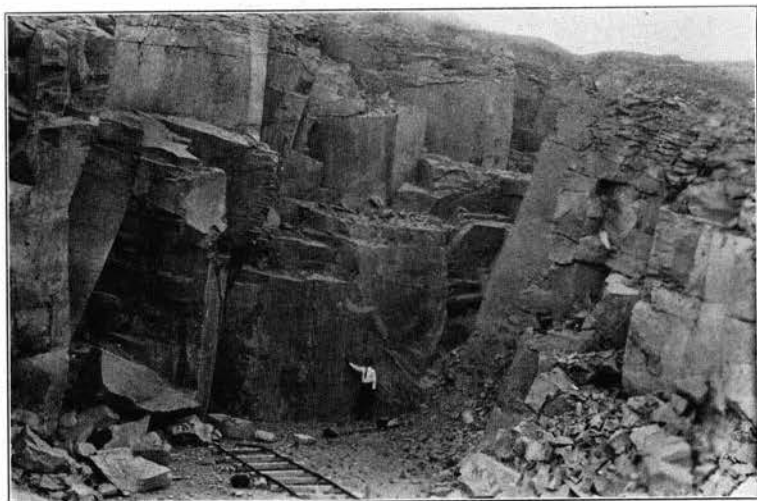
Stream Canon. Black Marble, Wallowa County.

Fig. XV.



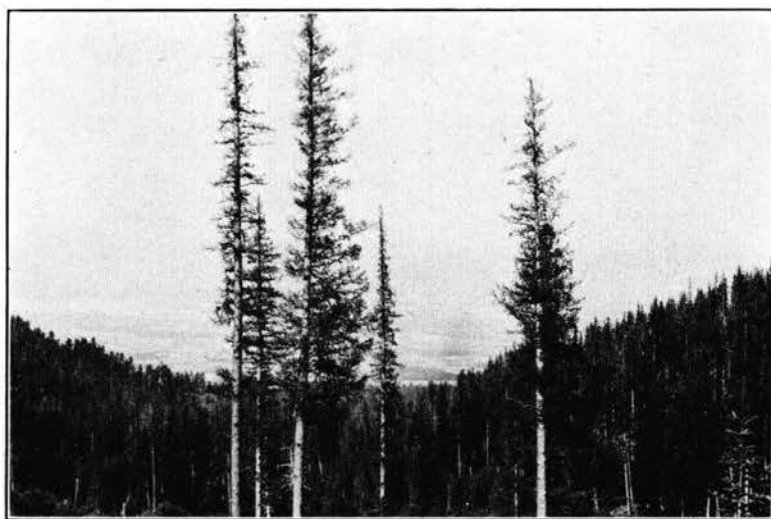
Black Marble Quarry, Wallowa County, showing jointing and size of blocks.

Fig. XVI.



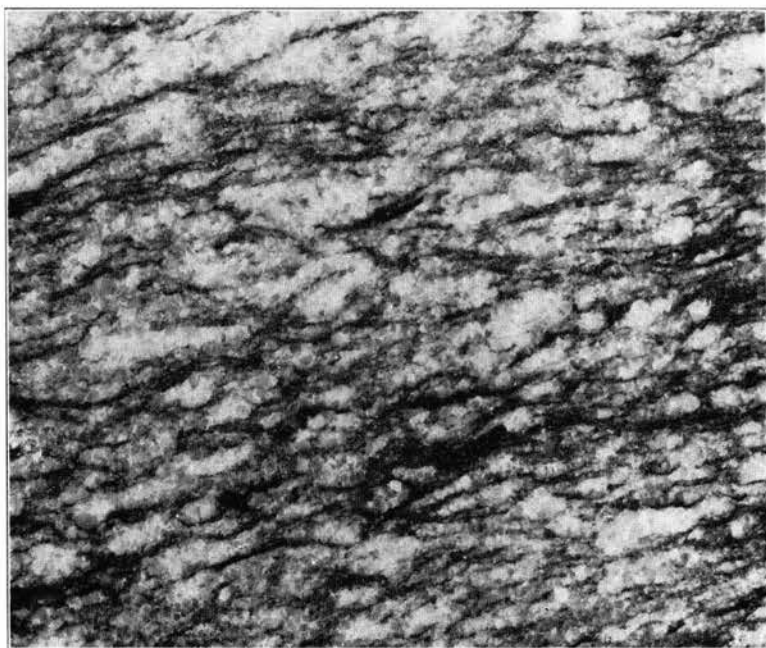
Volcanic Tuff, Oregon Lava Co.'s Quarry, Baker County.

Fig. XVII.



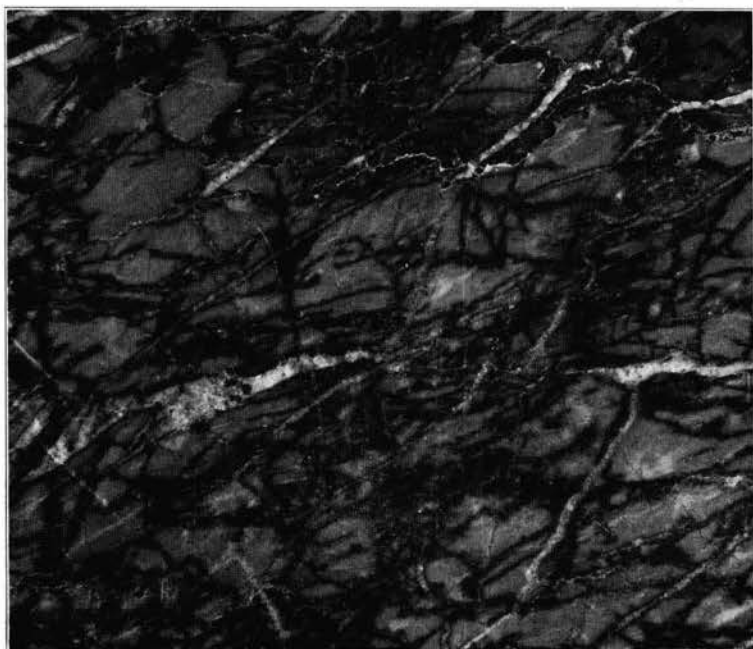
View from Black Marble Quarry, Wallowa Valley and Enterprise in background.

XVIII.



Polished Marble, Williams Creek, Josephine County.

XIX.



Polished Marble, Deer Creek, Josephine County.

point of quarrying. Best results financially would probably be yielded by combining a plant which would turn out more than one of the above suggested commercial products.

The climatic conditions in Wallowa valley are favorable to the operation of any one of these industries for nearly the entire year. There is a medium snowfall in the valley, coming usually in December, which does not go off until about the first of April. There is seldom enough snow to interfere with traffic to any extent. The extreme winter temperature is about ten degrees below zero.

JONES QUARRY, JOSEPHINE COUNTY.

The Jones quarry is situated on Williams creek in Josephine county, about twenty-five miles south of Grants Pass, the nearest railroad point. It is owned by C. B. Perkins of Portland.

The following data relating to this marble deposit have been furnished by Dr. A. N. Winchell, who visited the locality for the Bureau the past summer. Further consideration will be given this stone in a more complete report by Dr. Winchell on this region, to appear in a later issue of this publication.

This deposit contains an abundant supply of limestone and some coarse-grained variegated marble. It is in the form of a lens, very blunt at one end, more than 1,000 feet in length and its maximum width is about 300 feet. Much of it is stained by iron oxide and penetrated by veinlets of calcite, which impair somewhat its use as marble. It contains occasional seams and nodules of shale or argillite. A considerable portion of the deposit could be used as ordinary building stone, if it were more accessible to transportation. It was formerly about one-eighth of a mile from the wagon road, but at present the road is about a mile distant.

Mr. Jones, who has been operating the quarry, has a stonecutters' outfit about six miles from the quarry, near Powell creek. Up to date he has rolled the blocks of marble down the hill about one-eighth of a mile and hauled them by wagon to his works. The dressed stone then has to be hauled about twenty miles to Grants Pass.

A cut of a polished section of the variegated marble from this quarry is shown in Fig. XVIII.

By the courtesy of Mr. Perkins another cut of polished marble is also given (Fig. XIX) which is said to be representative of a deposit

on Deer creek, about fifteen miles west of the Williams creek stone, and also owned by him. This will serve to further illustrate the great variety of marble which will be more available in Josephine county as transportation facilities are improved.

ARGILLACEOUS LIMESTONE NEAR DALLAS, POLK COUNTY.

The quarries in this stone are situated in sections eleven and twelve, township eight south, range six west, about four miles southwest of Dallas. The Falls City branch of the Salem, Falls City and Western railroad runs about one mile south of the quarries. A railroad grade has been built to them.

The geology of the region is very simple. The stone consists of a series of flat lying beds. In one of the pits the observed strike was due north and south and the dip seven degrees east. The beds average about ten feet in thickness and are separated by thin strata of shaly material. The characteristic jointing and weathering of limestone can be seen in some of the quarry openings.

In color, the rock varies from a brownish green to a dark grayish green, and from a rather coarsely granular to a very fine-grained texture. The rock consists of irregular fragments of calcareous material, some of which are probably of organic origin. There are a very few grains of olivine, quartz and feldspar present. The cementing material is argillaceous and calcareous.

This rock has been used to some extent as a building stone. The Court House at Dallas is made of it. It has in general many of the good qualities of a building stone, except color, which is somewhat against it for this purpose.

The property is at present owned by the Portland Cement Company of Oswego, who expect to use the material as an ingredient for making Portland cement. From a few analyses available it would appear that the lime content of the rock is insufficient to permit of its use as the sole source of lime for a Portland cement mixture.

There is an abundance of this rock and the joint spacing is such that blocks of large size can be obtained. No great amount of striping would be necessary to secure a reasonable quantity, and this deposit can, therefore, doubtless furnish considerable stone locally for some time to come.

OREGON VOLCANIC TUFFS.

VOLCANIC TUFF, BAKER COUNTY.

Volcanic tuff, a rather unique building material which gives much promise, occurs over a wide area in eastern Oregon, and is found also in some parts of western Oregon. The body of this rock is made up of volcanic ash particles, through which are scattered darker fragments of volcanic glass, broken pieces of feldspar crystals and occasional masses of pumice. These particles vary from the size of fine-grained sand to that of the gravel pebble. The tuffs are probably formed by the accumulation of ash and other volcanic materials which were ejected from some prehistoric volcano of the explosive type. It is likely that in most instances the deposition took place in much the same manner as the recent accumulation of volcanic ash over large areas in Alaska during the eruption of Katmai volcano. Whatever its exact origin this deposit of fragmental materials was later buried by lava flows and sedimentary rocks, which consolidated it into a firm rock. At times the lava particles which were by the eruption explosively projected into the atmosphere, may have fallen into bodies of water where they would become sorted to some extent into layers of coarse and fine.

Volcanic tuff has been quarried and used in many places in the John Day Valley, Wallowa, Baker and other eastern Oregon counties. Very similar rock is also found in two or three localities in Marion county. In different places it varies materially in color, texture and general qualities.

The tuffs are very light in weight, being only about two-thirds as heavy as ordinary sandstone. The color is usually light, which gives a pleasing appearance for many purposes from an architectural standpoint. They can be worked very easily, sawed or carved into all kinds of shapes and possess sufficient compressive strength to safely meet any proper conditions that will be imposed upon them even in our largest public buildings.

Its uses in many places has demonstrated the adaptability of the stone to the climate of eastern Oregon. It is considerably less costly than some of the harder building stones, such as granite, sandstone and limestone. In this report space will not be taken to describe all of the different quarries and localities where this material has been used. Since this type of building stone has been most largely developed and more generally used in Baker county, only that gen-

eral region will be discussed. Figures XX are views of a number of buildings in Baker, Oregon, which are built of this stone.

The two quarries from which the bulk of the Baker county stone is obtained are about thirteen miles southeast of the City of Baker, on the Oregon-Washington railway, near the station of Pleasant Valley. One of these, known as the Ideal Quarry, is less than one-half mile north of the station, and is owned and operated by James Grant of Baker. The other quarry is about 1,000 feet south of the station and is the property of the Oregon Lava Stone Company of Baker.

The rocks in the general region of Pleasant Valley are chiefly a series of lava flows, tuffs and lake-bed deposits overlying the older greenstones. These rhyolitic flows and the deposition of the volcanic tuffs and lake sediments in this region seem to have taken place during about the same period of time. That is to say, volcanic eruptions of varying nature accompanied or succeeded each other, thus giving at times both solid and glassy rocks, and the loose-textured fragmental materials, which are now consolidated into tuffs; while sediments were at the same time accumulating in the bottom of lakes that covered portions of that region.

In very few of the quarries examined are any indications of bedding found. This shows that water probably had in most cases very little to do with the deposition of the rock strata. One exception to this rule is observed at the Ideal quarry, where the true lake beds are apparently overlain by volcanic tuff which later also seems to show some bedding. These beds have a strike of north seventy degrees west and a dip to the northward of thirty-five degrees.

The Ideal quarry is opened on the south slope of the hill, the beds dipping directly against the slope. On account of this relation between the attitude of the beds and the slope of the land surface greater difficulties have to be met in quarrying, on account of the increasing overburden, than if the quarry could be located at a point where the dip and the surface slope are more nearly in the same direction. It seems probable that a more favorable site in this respect could be selected within a few hundred feet.

The joints in this quarry are parallel to and at right angles to the bedding direction. (Fig. XXI.) More or less faulting and other evidences of movement since the rocks were consolidated are apparent in most exposures of the volcanic tuff and old lake bed deposits.

The Oregon Lava Stone Company's quarry on the south side of the railroad has a more favorable location with reference to the slope of the hill. As Fig. XVI will show, the rocks in this quarry are broken by a series of vertical joints and a second set of joint planes which are approximately parallel to the surface. These last occur much more plentifully and closer together within a few feet of the surface. The explanation seems to be that this series of shallow joints is entirely due to weathering agencies. It will be noted that some of the joint planes are smooth curves instead of plane surfaces. No bedding, whatever, is evident in the Oregon Lava Stone Company's quarry.

In both of the Pleasant Valley quarries stone can be gotten out in very large blocks if desired on account of the wide spacing between joints. Cubes as large as eight feet in each dimension can be easily obtained. The rock in each of the quarries varies to some extent in different parts of the face, but is usually a light gray in color, and for the most part quite fine-grained in texture. The stone from the Ideal quarry is a shade darker than that in the quarry of the Oregon Lava Stone Company. In some parts of the exposures, and especially in the lighter gray stone, scattered irregular fragments of glass and pumice occur. But few of the glass fragments are ever over a quarter of an inch in diameter while the inclusions of pumice are found at times to measure as high as an inch across. These larger fragments are often of a different color than the finer ground mass, sometimes lighter and sometimes darker. The glass particles are usually colored, sometimes black, while the pumice is more nearly the color of the ground mass.

In the table giving the results of tests made by the United States Bureau of Standards found on page 40 it will be found that these tuffs have an absorption of something more than twenty-five per cent and an average crushing strength of nearly 2,000 pounds to the square inch, which last is amply sufficient for building purposes. It should be noted also that the strength of the volcanic tuffs shows no deterioration due to repeated freezing and thawing.

The available supply of volcanic tuff in the Pleasant Valley area appears to be inexhaustible. The rock can be seen at the surface over an area of about 200 acres. The maximum depth is not known but a thickness of over 100 feet can be observed in places.

The amount of overburden encountered in quarrying will vary.

In some places there is not more than two or three feet of waste rock while in others as much as ten or fifteen feet of soil and weathered rock is present.

On the whole, volcanic tuff as a building stone has many features in its favor. Its conspicuous advantages are its light gray color, its light weight and the ease with which it can be worked and handled. Because of its porosity and darker color when wet it has been questioned by some whether such stone can be used to advantage as a building material in a climate similar to the Willamette Valley where the winter rainfall is heavy. On drying, it of course resumes its original characteristic color. Whether its high porosity would be found objectionable in a climate so damp as this for several months of the year is a question on which sufficient data are not at hand to definitely answer. Many common brick used in building walls everywhere are, however, fully as porous and as absorbent as the tests show this type of stone to be.

TESTS OF OREGON VOLCANIC TUFFS.

Name and location of quarry.	Percent- age of Absorp- tion	Crushing strength in pounds per square inch			Specific Gravity
		Speci- men tested dry	Speci- men tested saturat- ed with water	Tested after freezing and thawing 10 times	
Grant Quarry Pleasant Valley, Ore.	22.68	2916	2861	2816	1.81
Oregon Lava Stone Co., Pleasant Valley, Ore.	28.96	.....	1212	.....	1.64
" "	29.29	1724	1160	1261	1.33

BUILDING STONE PRICES.

Actual commercial conditions relating to the building stone industry which prevail in the United States and, what is more important, those nearer home, it is almost impossible to secure without extended travel and personal interview with both producer and

consumer. The writer was unable to do this but submits the data which follow for whatever they may be worth.

Marble. Some of the more important marbles that have been used in the construction of buildings in Portland and other Oregon towns, together with their prices, are mentioned below.

Alaska marble is one of the commonest used in Portland for interior decoration. The Alaska quarries are said to be owned by the Vermont Marble Company. It is reported that the quarries are situated on the coast so that the product can be quarried and placed immediately on board sea-going vessels. This company has a large plant at tidewater, Tacoma, Washington, where they completely prepare the stone for use in filling building orders. In this way they have materially reduced the cost of handling. This Alaska marble can be seen in the corridors of the Yeon building, the Pittock Block, the Northwestern Bank Building, the Stevens Building and various others. It is a light gray marble and costs the consumer when rough sawed about forty cents per square foot; when polished and in place from eighty cents to one dollar per square foot.

Another of the common marbles which is competing with the Pacific Coast marble is the Colorado Yule. Some statements taken from the "Mineral Resources of the United States for 1912" are as follows:

"The most extensively developed deposits of marble in Colorado are on Yule Creek, in northern Gunnison County. The deposits that are quarried here are high on the left bank of the creek and dip westward at an angle of about 52 degrees. The marble bed is reported to be about 240 feet thick, and to contain four bands of chert, each 2 to 4 feet thick. The underlying rock is cherty blue dolomite, and overlying the marble is a sill of igneous rock which is, in turn, overlain by 500 to 800 feet of blue cherty limestone. The marble itself is for the most part white and of medium grain, but there are bands of handsome greenstained material within the mass. This quarry has a complete equipment and has maintained a large output of marble for several years. The rock is carried to the mill at Marble, about 3½ miles distant by an electric tramway. At the marble mill, which is electrically driven and is one of the most completely equipped in the United States, the product is sawed, planed, turned, polished, carved, and otherwise prepared for all kinds of interior and exterior construction work. This white marble

has been used for interior decoration in the Cuyahoga County courthouse at Cleveland, Ohio, in the Cheesman Park shelter house, Denver, Colorado, and in office buildings in Salt Lake City and elsewhere."

This Colorado Yule has been employed, together with several other kinds, in the Northwestern Bank building. It is said to have cost fifty cents rough sawed and one dollar polished and in place. In the rough it costs about three dollars and fifty cents per cubic foot, f. o. b. Portland.

Belgian black marble, which has a variety of uses, costs ninety cents per square foot rough sawed and the usual additional expense of polishing and shaping and placing. Belgian blue marble, the body of which is black marble with many calcite seams across it, costs seventy cents per square foot rough sawed and when polished and placed one dollar and sixty cents per square foot. "Belgian Blue" can be seen in the Congress Hotel, Portland, and "Belgian Black" in Northwestern Bank as floor border. Both these marbles cost about four dollars per cubic foot in Portland.

Higher priced Italian marbles are often seen in Portland's more pretentious structures and the cost of these runs up to three dollars per square foot and in some cases more when polished and placed. Pavonazzo (Italian) marble is found in the entrance to Yeon Building and in certain exterior parts of Multnomah Hotel, and costs in the rough in Portland, about four dollars per cubic foot.

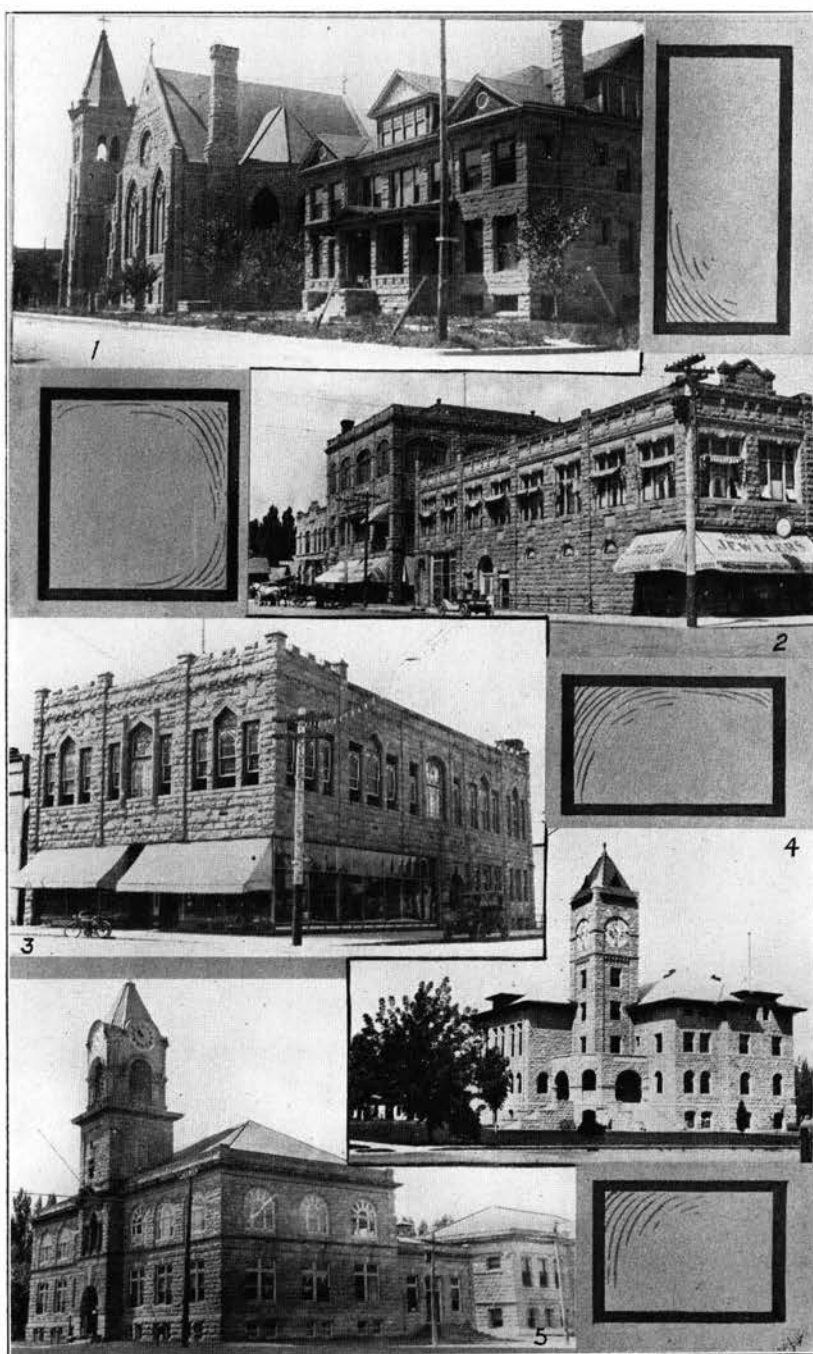
Silver gray Sienna (Italian) marble, in Benson Hotel, costs about seven dollars per cubic foot in the rough. California light gray marble, such as is used in the Merchants National Bank and in floor of Northwestern Bank costs about two dollars and seventy-five cents per cubic foot in Portland.

To show something of the growing importance of the marble consumption in Portland the following item concerning the nearly completed Northwestern Bank building is quoted. The Oregonian of February 1, 1914:

"Alaska, Colorado, California, Tennessee and even Belgium and Italy were called on to furnish marble for the interior of the new Northwestern Bank building. The marble cost about \$75,000.

The Bottisino marble in the main entrance was imported from the Italian quarries. It is said to be the least absorbent marble known.

Fig. XX.



Typical Buildings, Baker, Ore., built of Volcanic Tuff.

Fig. XXI.



Ideal Quarry, Baker County, showing jointing and size of blocks. Volcanic Tuff.

The floors and treads in the main entrance are gray Tennessee marble.

The entrance to the rooms of the Northwestern National Bank and the Portland Trust & Savings Bank are finished in Blanco Italian trimming, with Bresche violet marble panels and wainscoting. The marble for the banking rooms, with the exception of the floor, is specially selected, imported Italian Pavanazzo. The floors are Columbia marble, from California, with a Belgian black marble border.

The wainscoting in all the corridors above the first floor came from Marble, Colo., and is known as the Colorado Yule Pavanazzo. The treads for the stairways above the mezzanine floor were cut from blocks of Columbia marble in California. The basement stairway and the safe deposit department are finished in Colorado Yule Pavanazzo marble. The lavatories are finished in Alaskan marble, with wainscoting six feet high."

It will be seen in the descriptions of marble quarries that there are important deposits in southwestern Oregon and in northeastern Oregon, in almost extreme corners of the state, each approximately a full dimension of the state away from the principal market, Portland. Any quarryman in order to compete in this market with those that now supply it must not only pay the cost of informing the consumer as to the quality of his marble, but the transportation charges as well. Transportation charges from each of these localities would probably be about the same. No commodity rate exists at present but such a rate would doubtless be established at from fifteen to sixteen cents per hundred pounds to Portland should shipments be large enough to warrant it. This rate would amount to about twenty-seven cents per cubic foot in carload lots.

The Oregon quarryman would not be at a disadvantage in competing with Colorado marble under these conditions but transportation to Portland by water costs the Alaska quarryman less than the assumed rate of twenty-seven cents, by rail.

The above statement is made on the assumption that the Oregon product is only on a quality par with Alaska or Colorado marble. If the Oregon quarries can produce higher grades than these, for example, equal to the Belgian black or blue marble, and the highly prized marbles from the quarries of Italy, our stone producers will of course be in a position to control at least the northwestern market.

In order that those interested may have a more comprehensive

statement of the total sales of marble, together with the average prices up to 1912, for which accurate statistics have been compiled, the statement following is abstracted from the "Mineral Resources of the United States" by Ernest F. Burchard.

The value of the marble output of the United States in 1912 was \$7,786,458, as shown in the following table taken from the "Mineral Resources of the United States" for that year. This represents about ten per cent of the total stone industry.

	1910	1911	1912
Sold by producers in rough state.	\$2,098,480	\$3,182,620	\$3,358,536
Dressed for			
Building	1,463,749	1,220,635	1,396,254
Ornamental purposes	37,950	71,000	134,826
Monumental work	1,279,985	1,368,430	720,464
Interior decoration	2,001,646	1,545,963	1,944,161
Other uses	100,969	158,070	232,217
Total.....	\$6,992,729	\$7,546,718	\$7,786,458

Building Stone. The value of marble produced in 1912 for exterior building purposes (including rough and dressed stone) and either sold or used by producer, was \$2,771,645. This total includes \$1,375,391 for rough and \$1,396,254 for the dressed stone. The quantity of marble sold in 1912 for rough building stone was 945,728 cubic feet valued at \$1,369,213 or \$1.45 per cubic foot; 5,009 square feet valued at \$4828 and 450 tons valued at \$1,350. There were 478,361 cubic feet of dressed building stone marble quarried with an average price of \$2.91 per foot.

Monumental Marble, including rough and dressed stone, was valued at \$2,115,200 in 1912. The rough stone was valued at \$1,394,736 and the dressed monumental at \$720,464.

The total quantity of marble sold in 1912 rough for monumental work was 867,716 cubic feet at \$1.61 per cubic foot and for dressed monumental work was 214,326 cubic feet at \$3.36 per cubic foot.

Interior Work. The total value of marble for interior work for building in 1912 was \$1,944,161. The stone sold for this work was 364,769 cubic feet valued at \$1,863,561, or \$5.11 per cubic foot and 110,009 square feet valued at \$80,600 or 73 cents per square foot. Considerable marble was sold for other minor uses such as, sold to lime burners, to carbonic-acid factories, to paper mills, smelters

for flux, road making materials, mosaics, electrical work, etc., but the above include the major portion of the production.

Granites. The total sale of granite in 1912 for building and monumental purposes was \$10,770,873. Granite in the rough sold for building purposes amounted to \$1,255,800, and for dressed building purposes, \$4,870,954. The remainder, something over four and one-half millions, was about equally divided between rough and dressed monumental stone.

Average prices of granite for the United States are not obtainable but the following table giving the prices for 1911 and 1912 in the states of Vermont and Maine may be helpful:

		1911	1912
Vermont			
Building stone			
Rough	\$.52	\$.70	
Dressed	4.13	3.39	
Monumental			
Rough .....	.91	.97	
Dressed	3.47	2.72	
Maine			
Building stone			
Rough .....	.22	.33	
Dressed	2.09	2.61	
Monumental			
Rough .....	.67	.56	
Dressed	3.03	2.61	

In Oregon, some Portland prices on granites are as follows: British Columbia dark gray granite, about \$1.55 per cubic foot; California light gray granite, \$1.50; and such well-known stones as the Barre, Vermont, the Norwegian emerald pearl and Scotch red granites cost approximately \$3.80 per cubic foot.

Sandstone. The price of the Tenino sandstone in the rough at the quarry in Washington is thirty cents per cubic foot, sawed forty-five cents, and the sawed stone costs in Portland sixty cents per cubic foot. The Boise, Idaho, sandstone is priced at fifty-five cents sawed at the quarry and eighty-five cents in Portland.

Government statistics of sandstone are much less satisfactory than those which are given for limestone and marble. The total value of rough building sandstone sold in 1912 was \$860,263 and for the dressed building stone \$1,403,026.

The price at the quarry of the Bedford oolitic limestone in Indiana is about thirty cents per cubic foot in the rough. The cost of sawed slabs of Bedford in Portland is \$1.37 per cubic foot. More than 150,000 cubic feet of Bedford stone have been used in the city of Portland in such buildings as Wells Fargo building, Spalding building, Multnomah county court house, City library and Reed Institute. The cost of Bedford stone finished, f. o. b. Portland is \$2.70 per cubic foot. The freight charges amount to about one dollar per cubic foot. It will be seen, therefore, that something over \$200,000 have been invested in labor outside of the state in the stone for these buildings. It is evident that since so much of this stone has been purchased at so high a price not all the consumers are satisfied with the local stones now on the market. When the Oregon quarryman satisfies the purchasers of Bedford limestone and of Tenino sandstone with local sandstone he will have gained a very considerable market for his product.