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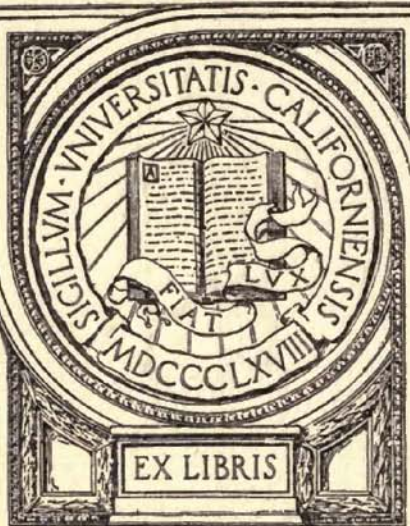
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PRELIMINARY REPORT

ON THE

BUILDING STONES OF NEVADA,

INCLUDING A BRIEF CHAPTER ON

ROAD METAL.

UNIV. OF
CALIFORNIA

Allen
JOHN A. REID.

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Table of Contents.

CHAPTER I.

Introduction: Need for knowledge and use of stone; uses of rocks; arrangement of context.

CHAPTER II.

Rocks: Their nature and classification. The igneous rocks; their occurrence and general classification:—plutonic, intermediate and volcanic; acid and basic. The tuffs; the atmospheric rocks, eolian and aqueous, including sedimentary, organic and chemical rocks. The metamorphic rocks with their divisions.

CHAPTER III.

Qualities of building stones. Changes in rocks: physical and chemical. Rock characteristics: color, hardness, strength, structure, texture, mineral content. Observations on rocks: quarry, buildings, chemical, physical.

CHAPTER IV.

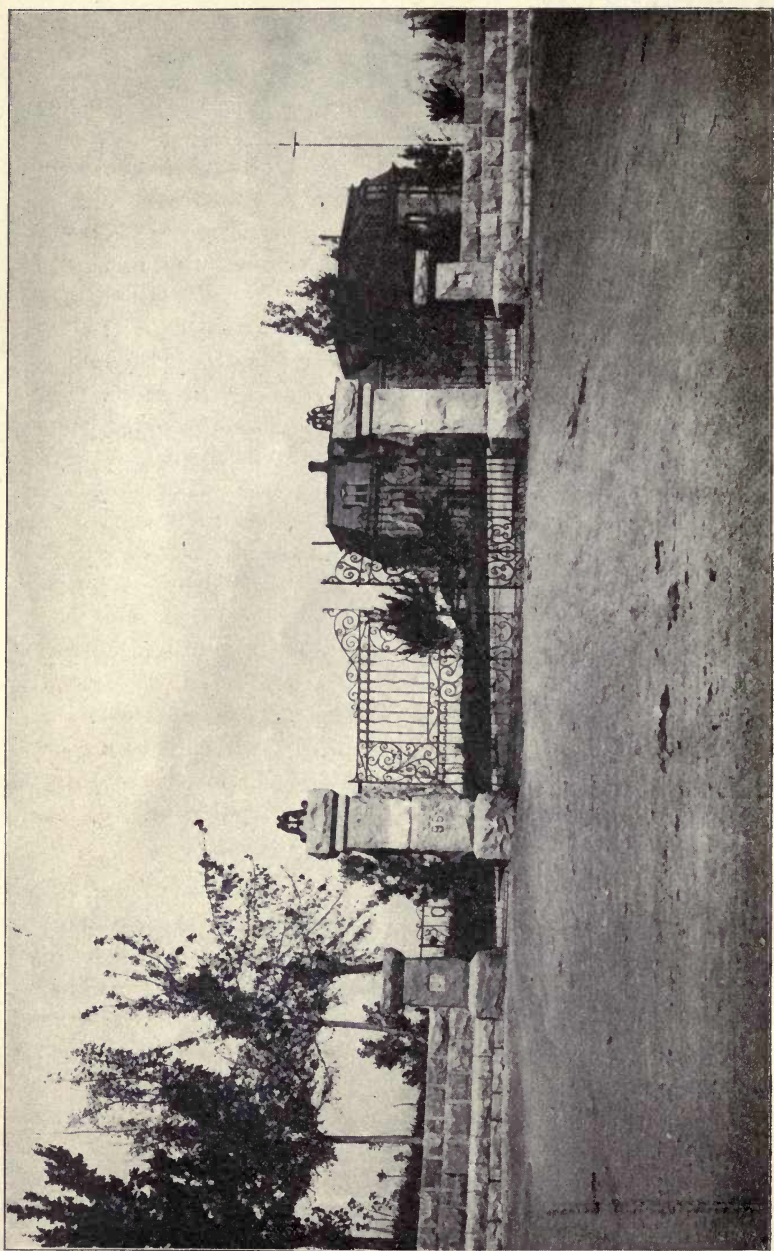
Building stones of Nevada: Granites, diorites, rhyolites, andesites, tuffs, sandstones, marbles, travertine. Characteristics, uses, location and availability of each.

CHAPTER V.

Road Metal and some General Principles of Road Making. Agents destructive of roads; selection of materials to withstand these; kinds of roads for different traffic requirements. Necessary qualities in road metal. Materials available in Nevada. List of references on the subject.

CHAPTER VI.

Conclusion: Need of more work on development of State and of more exact knowledge regarding the resources.



INTRODUCTION.

CHAPTER I.

The statement that the West is undeveloped is undeniably true. It is doubly true of the State of Nevada. Little has been done to develop her natural resources; little is known of the boundless wealth of her mountains and valleys. Yet Nevada is on the eve of a great awakening; with the advent of irrigation thousands of acres of fertile land, now desert like, will be made to yield an abundance of the fruits of the field, and will support a large population. As the community increases in numbers, a demand will arise for all modern improvements, among which two of the most important are, permanent buildings and good roads. It is needless to state that both of these are made possible by the use of stone; stone for erecting substantial, handsome structures, and stone for the betterment of the highways, which are so important to the healthy life of a growing community. It is not needless, however, to state that the principle underlying the choice and use of stone for the above purposes are little understood. Moreover, were these principles understood, little is known of the various rocks in the state available at present. The purpose of this preliminary report, then, is as follows: First, to present the main principles governing the selection and use of building stones and road metal; second, to describe briefly the stones now in use, or that can easily be used, in Nevada, with their location and availability; and third, to attempt to arouse a larger interest in a subject of such vast importance to a healthy commonwealth,

We in the West are prone to build for the day only; tomorrow is allowed to care for itself. This is undoubtedly cheaper at any particular time, but is far dearer in the end. The scale of any civilization may be told from its architecture; the stability of that civilization is shown by the materials used in the architecture. But we are learning to build, not for mere decades, but for centuries of use, and to do this we must use stone. The first cost may be high, but the ultimate expense is low. The result of this is to be seen now in many places. Not only are stone buildings more common, but also the use of stone is seen in bridges, culverts, roads, curbing, and in many other ways too numerous to mention. In a rapidly growing state like Nevada the importance of these considerations cannot easily be overestimated, yet that importance is little realized. The frontier town is one of tents

and temporary light wooden buildings. Everything is done with the greatest haste, and calculated to bring in the largest returns for the least expenditure. Every western town has gone through such a period in its growth. After this first newness has worn off a bit, more stable conditions obtain, and almost imperceptably more solid and substantial structures appear, to take the place of the first flimsy ones. In mountainous regions such as Nevada, men have turned instinctively to the rocks in the hills for building materials. As a consequence nearly all of the towns of the state show one or more stone buildings, while in the larger ones, as Reno and Virginia City, brick is common also as a material of construction. Yet even with brick structures, stone is required for cornices, arches, and similar uses. The people need to know something about the proper and improper use of these materials, which of course, is the reason for the writing of this report.

The nature of this subject is more complex than appears on casual inspection. Fundamental principles of three separate sciences all play an essential part; the subject is built upon geology, physics and chemistry. The practical man may believe that he has no time for such considerations, yet the simplest rule of thumb method, if it be right, is founded upon true scientific principles. No man in this advancing age of competition can afford to be ignorant of those things which vitally concern him and his business. Every citizen, directly or indirectly, is concerned with the erection of public buildings, private buildings, and county and city highways. Hampered by lack of facilities for detailed work, a full report on the subject is impossible for some time, yet the time is ripe for a little knowledge to be distributed about these matters.

The chief uses of rock are as follows, in order of their relative importance. First, the largest amount of stone is used in the construction of buildings, under conditions already mentioned. Second, much of the finest grade of stone is used for monumental and ornamental work. It is not right, nor is it necessary, that nearly all of our rocks for such uses come from outside localities. Third, the importance of crushed rock for the construction of roads is well known. Fourth, in the larger towns and cities, stone curbing is imperative on the graded streets. Fifth, the use of cut stone for bridges and culverts, especially by the railroads, is growing constantly. Sixth, much cut rock is used for sidewalks and by the railroads. Sixth, much cut rock is used for sidewalks and tiling in the most approved buildings. Besides these, there are many lesser uses, such as the construction of piers, break-waters, dams, retaining walls, with such small uses as hitching posts,

steps, mounting blocks, and the like. And it is worth noting that this list is constantly increasing.

The text will be divided into five succeeding chapters; a short chapter on the nature of the various rocks, with their classification; a second chapter devoted to the qualities of building stones, good and bad; a third devoted to an account and description of the building stones of Nevada; fourth, a brief chapter on road metal; and lastly a conclusion.

CHAPTER II.

ROCKS: THEIR NATURE AND CLASSIFICATION.

To the average man, any rock is either a granite, a porphyry, a sandstone, or a slate; these terms are all embracing. Were it not that this loose use of terms is productive of actual loss in construction, by causing a misunderstanding of the characteristics of a stone, with consequent misuse, this chapter would be superfluous. But when such a broad error is made as the use of a partially decomposed volcanic rock, an andesite, under the belief that it was a sandstone, which is a rock not often subject to decomposition, at least in the better grades, the writer feels it necessary to present in some detail the various types of rocks found in the earth.

The first question naturally arising is this: What is a rock? A proper definition is as follows: A rock is any material making up an integral part of the earth; that is, any substance which exists in large enough amount to be considered as constituting an essential portion of the globe. This definition, however, though a strictly scientific one, seems rather too broad for our present needs, for by it the soils, water, ice, and all the soft as well as hard materials, are classified under one great head. Here we are only to consider the hard rocks, or stones, and have use for no others. The definition should be kept in mind, nevertheless, for there is no well defined line between a sand and a sandstone, a clay and a shale, or a gravel and a conglomerate.

The rocks of the earth are divided into three grand classes, as follows:

- I. *The Igneous or Massive Rocks.*
- II. *The Atmospheric, or Stratified Rocks.*
- III. *The Metamorphic, or Changed Rocks.*

Let it be understood that in the following remarks under classification, the chief aim has been to present, to the general reader and practical worker, a mere outline showing how rocks are grouped. It is utterly impossible to describe a rock without some knowledge of minerals on the part of the reader, hence the following brief attempts at describing each rock must be understood as incomplete and greatly limited in scope. It is hoped the descriptions may convey some ideas to the practical man as an aid to his work, as well as act as references for the rocks to be later described.

THE IGNEOUS ROCKS.

The Igneous Rocks are those made by the agency of heat, that is, have cooled from a molten condition. They are also called the massive rocks, because of their structure, which is, broadly speaking, the same in all directions. Also the term eruptive is applied to them, because of their origin as eruptive molten masses. These rocks occur in several different ways, as follows:

1. *Batholites*, or those immense masses of igneous rocks, as granites, which form the axes of our greatest mountain ranges. They are characterized by their great size, their evident position beneath other rocks, and the fact that as far as is known they descend to the deep interior mass of the earth.

2. *Laccolites*, or those dome shaped rock masses which have been intruded between layers, or strata, of other rocks, lifting them up like immense blisters. They differ from batholites mainly in the fact that they rest upon other rocks and are smaller in size.

3. *Sheets or Sills*, or those occurrences of igneous rocks which lie between other rocks as mere sheets, or on top of them. They differ from laccolites in that they are everywhere of about the same thickness and have caused no doming of superincumbent rocks. They may have been intruded between other rocks, or poured out upon the surface as lava flows, and are usually more nearly horizontal than vertical.

4. *Dykes*, or intrusive masses filling fissures, much as do mineral veins. These dykes usually cut across other rocks, are of great length on the surface compared with their width, and descending to unknown depths. They are usually more nearly vertical than horizontal.

5. *Irregular Masses*, such as volcanic necks, which are merely the hardened lava in the throat or pipe of an extinct volcano, standing up as a more or less conical mass after the wearing away of the soft cone. Also, we have very irregular bodies of igneous rocks of various sizes and shapes which are intruded into overlying rocks. To these, for lack of a better name, the term "stock" is applied. As a grand division, the igneous rocks are those from which all others are derived.

CLASSIFICATION.

To handle this subject of rock classification from a popular

standpoint is a delicate task. The principles underlying it can only be partly stated, for obvious reasons. A knowledge of mineralogy cannot be expected, and all that will be done in what follows is to attempt to render intelligible in the simplest possible manner, the main features of the subject. A working knowledge of the simpler minerals, as quartz, feldspar and mica, will be assumed.

The igneous rocks are classified along two lines. First, chemically, they range from acid to basic, with all gradations between. This variation results in the formation of different minerals, so that the chemical rock types have different appearances. Secondly, these rocks are classified on a basis of what is called texture. Those which have cooled at great depths from a molten condition have done so slowly, with a result that they are thoroughly crystallized, often coarsely so. On the other hand, those which have cooled on the surface and hence quickly, are glassy, at times being a simple glass. The thoroughly crystalline, deep seated rocks are called *plutonic*, the glassy, surface ones are called *volcanic*. Those which have cooled and solidified a short way below the surface are often spoken of as dyke, trap, or intermediate rocks. In accordance with these two lines of difference, then all rocks which have solidified from a molten condition are classified. It will be noticed that there are, unfortunately, two kinds of intermediate rocks: those chemically intermediate and those occupying a middle position on the basis of crystalline texture. However, when an intermediate rock is mentioned, one of the latter kind will usually be meant, or a dyke rock. The meaning of the various textures may be looked at in this way. A granite, for instance, is the type of an acid plutonic rock. Melted and cooled rapidly it would form a glassy volcanic rock, and, of course, called a rhyolite. Melted and cooled more slowly, yet not so slowly as a deep seated rock loses its heat, an intermediate acid type, with some crystals showing, would result. This rock would be called a quartz-porphry. A more basic plutonic rock, as a diorite, when similarly treated would yield a volcanic *andesite* and a dyke phase *porphyrite*. These facts are embodied in the following table, in which only the few main types are mentioned. The many varieties and sub-types made by the petrographer are not necessary in such a report as this.

TABLE OF CLASSIFICATION.

COMPOSITION	TEXTURE		
	PLUTONIC	INTERMEDIATE	VOLCANIC
Acid	Granite	Quartz-Porphyry	Rhyolite
Intermediate	Syenite	Porphyry	Trachyte
	Diorite	Porphyrite	Andesite
Basic	Gabbro	Diabase	Basalt
Ultrabasic	Peridotite	LIMBURGITE	

A peculiar fact to be noted about these rocks is this: Of the plutonic rocks the acid ones, the granites, are most common throughout the earth, while of the volcanic rocks the basic, the basalts, are best developed. Another fact is to be noted regarding the different names. For reasons not necessary to state here the names of the intermediate rocks, quartz-porphyry, porphyry and porphyrite, are being dropped, and the volcanic terms used to cover them. For example, andesites and porphyrites are called merely andesites.

THE INDIVIDUAL ROCKS

PLUTONIC.

All wholly crystalline, often coarsely so.

1. *Granite*: The granite family consists of acid rocks, wholly crystalline with a coarse to medium fine grain, and of a grayish or reddish color. Free quartz, in colorless crystals, at times tinged bluish or reddish, is always present. Also a white or reddish feldspar, usually clouded with other whitish substances, and some dark mineral, as brown mica, are to be seen. In some rarer granites only a white mica, besides the quartz and feldspar, is present. The granites are the most easily determined of all the igneous rocks, and can be confused only with one other kind. The feldspar of a true granite contains potash, and is comparatively acid. A rock very similar to a granite, a diorite with free quartz, differs only in the nature of the feldspar, which contains, in place of potash, soda and lime, making it more basic. To the eye of any one but a trained observer, the two rocks appear precisely the same, showing colorless quartz, white feldspar and some dark mineral. This diorite with quartz is called a granite-diorite, grano-diorite, or quartz-diorite.

2. *Syenite*. The syenite family may be briefly character-

ized as granites without quartz. They are comparatively rare rocks, especially in the western part of the United States. In color they vary about as do the granites, from shades of gray to pinkish or reddish tints. The minerals are simply feldspar and some dark colored ones, as mica or hornblende.

3. *Diorite*. Of this family the quartz bearing variety, grano-diorite, has already been mentioned. The other varieties are without quartz and more basic than syenites, and have about the same grain as the granites and syenites, though averaging a little finer. The fresh rocks are gray in color typically, but darker than the above mentioned types, and show a white feldspar with some dark mineral, usually hornblende.

4. *Gabbro*. The gabbro family is the most basic of the normal plutonic rocks, which are of complex nature. These rocks are often coarser in grain than any yet mentioned, the individual crystals at times being an inch or so in diameter. In general their color is grayish, often with a dark olive green tinge. Other colors are black, brown, green and in some varieties white. The minerals present are a white feldspar, often with a greenish stain, and some dark mineral which may be dark green, brown or black. Some types are wholly feldspar, and white in color. The gabbros are rare rocks, particularly in this western region.

5. *Peridotites*. These rocks are a peculiar family composed entirely of dark minerals. The feldspars are typically absent, hence the rocks are called ultra-basic, for the dark minerals are usually black, with sometimes a tinge of green. They alter as a rule to the common mineral and rock known as serpentine.

· INTERMEDIATE ROCKS.

These rocks, with the exception of the diabases, show what is called porphyritic texture. As far as appearances are concerned, this texture causes the rocks to show well developed crystals of some mineral set in a paste of fine grained material which usually cannot be resolved into its component parts by the unaided eye. This fine grained paste is called the ground mass; the well formed crystals set therein are termed phenocrysts. To the naked eye the different kinds of these intermediate rocks are distinguished by the occurrence of certain minerals in well developed crystals and also by the color and general appearance of the ground mass.

They are as follows :

1. *Quartz-porphyry*. In this rock are seen crystals of clear colorless quartz, with sometimes feldspar and mica, all set in a ground mass of various shades, from almost black, but sub-transparent, through shades of red, pink and grayish. This ground mass varies in grain, from that which looks like an exceedingly fine grained granite to apparently almost glassy. However, as with the granites, free quartz is characteristic. Where the ground mass is noticeably granite-like though very fine in grain, the rock is called a granite porphyry.

2. *Porphyry*. Often this rock is called an orthoclase porphyry or syenite porphyry, depending upon coarseness of grain. The relations between this rock and syenite is precisely that existing between quartz porphyry and granite. Also porphyry and quartz porphyry are connected in the same way that syenite and granite are. Free quartz is absent, and the minerals appearing as phenocrysts are feldspar, typically the potash variety, orthoclase, with often mica or hornblende. When the ground mass appears fine crystalline to the unaided eye the rock may be called a syenite porphyry. As a rule the rock looks much the same as quartz porphyry, differing in that free quartz is absent and replaced by white or glassy feldspar.

3. *Porphyrite*. These rocks are the chemical equals of the diorites, but having cooled near the surface, lack their crystalline texture. They are usually much darker rocks than the preceding, showing well developed crystals—phenocrysts—of typically a dark mineral, but sometimes a white feldspar, in a dark gray, dark green, or even black, ground mass. As with the first two types of intermediate rocks, when the ground mass appears finely crystalline we may have a diorite porphyry. These rocks often assume a reddish hue when weathered.

4. *Diabases*. These rocks are the equivalent of the gabbros, occurring typically as dykes and laccolites. They constitute the greatest body of dyke forming rocks known. They are seldom porphyritic, differing from the preceding but are wholly crystalline, appearing on casual observation like fine grained diorites. There are, however, some differences of note. As with the diorites they are composed of a light mineral and a dark one, but the dark one usually has a dark green tinge and a greasy luster seldom present in the black mineral of the diorites. Also, the white feldspar in the true diabases is seen to

be in well formed crystals with the dark mineral crystallized around and between. The reverse is true with the other wholly crystalline rocks; the black mineral shows the best crystal form, with the white feldspar in the spaces between.

VOLCANIC ROCKS.

These rocks constitute the lavas, or surface flows of molten rock. In texture they range from porphyritic to glassy; chemically they cover the same range as the plutonic rocks, from acid to basic. The common term "obsidian" means a volcanic glass of any chemical constitution whatever. Being cooled lava flows they often show what are called flow or fluxion lines. Their varieties are below, and it is to be remembered that these names are now used to cover both volcanic and intermediate types of rocks.

1. *Rhyolite*. These rocks are the most acid of the lavas, corresponding chemically to the granites. In color they are usually various shades of white, gray, blue, pink or green, but are always of light tints except the obsidians, which may appear dark. When porphyritic, they look like quartz-porphyrries, into which they shade by insensible gradations, always showing free quartz. When no crystals of any kind are to be seen, yet if the rock is not all glass, their typical white or whitish color serves to distinguish them. The old term felsite is often given to these white varieties which are too fine grained to show any well formed crystals.

2. *Trachyte*. The trachytes are much like the rhyolites in appearance, but differ in showing no free quartz. The only minerals showing are typically white or glassy feldspar with sometimes a small amount of the darker varieties. They have usually a characteristic rough feel, hence the name *trachyte*, which means rough. Specifically, their color is often white, varying to shades of pinkish white or green. The whiteness is more pronounced than in the rhyolites because of the absence of glassy quartz. The trachyte obsidians, like the rhyolitic ones, are darker, often black in large fragments. The family as a whole is a rare one.

Andesite. This family of rocks is much darker than the two volcanic groups already mentioned. The color ranges from a fairly light gray to a black, a dark gray being an average hue. The well formed crystals—the phenocrysts—show both light and dark in color. Some andesites show black

crystals in a light gray ground mass, while others show white feldspars in a dark gray or black ground mass. In some varieties the feldspars are glassy, resembling quartz on cursory inspection. Quartz does occur in one variety, known as dacite. This rock bears the same relation to an andesite that a quartz-diorite does to a diorite. At times an andesite shows no crystals to the unaided eye, when its color is nearly black, much like a basalt. A noteworthy fact is that these rocks tend to weather a dark red color, due to the iron oxide formed by atmospheric agencies.

4. *Basalt*. These common volcanic rocks are prevailingly black or nearly so. They show discernable crystals less often than the above types, and are usually finer grained and more homogeneous in appearance. However, in some common varieties small grains of a light greenish mineral appear on close inspection—the mineral olivine—and again, at times crystals of black color are apparent in the dark ground mass. A feature of these rocks and of the andesites as well, is the weathering or splitting into so-called “basaltic columns.” The rock mass parts or cleaves into long prisms, roughly hexagonal in cross section, forming a cluster of natural columns.

5. *Limburgite*. This rare and unimportant family of volcanic and intermediate rocks is mentioned merely to complete the account of the massive igneous rocks. This family is composed entirely of dark minerals set in a paste of the same or of glass with identical chemical composition. The color therefore is black or greenish black when fresh, weathering to a dark red.

THE TUFFS AND AGGLOMERATES.

Thus far have been listed only the massive igneous rocks; there is a minor group of rocks formed by fire agencies, of much less geological importance, but of considerable value as building material. This group is constituted by the fragmental igneous rocks, or tuffs and agglomerates.

1. *Tuffs*. These rocks are volcanic ashes and cinders more or less consolidated into firm stone. They are composed of finely divided glassy substances, rock fragments of the various igneous rocks, and often with mineral grains and large pieces of stone. They are named in accordance with the chemical family to which they belong. Thus, there are (1) rhyolite tuffs; (2) trachyte tuffs; (3) andesite tuffs, and (4) basalt tuffs. The rhyolite tuffs are most common.

2. *Breccia*. This variety of fragmental rock is composed of pieces angular in shape and varied in size, usually of only one kind of rock. They differ from tuffs in that they are not ashes, but made up of rock fragments of some size, and have originated either by the explosive action of a volcano or the crushing effect of pressure exerted in the earth's crust. The fragments are usually cemented by a paste of the same material, finer in grain.

3. *Agglomerate*. This rock is most simply described as a mixture of various kinds of volcanic rocks in the form of semi-angular or rounded boulders, small pieces and even ashes. Many agglomerates are hardened volcanic mud containing stones like plums in a pudding. The term is *agglomerate*, to distinguish it from *conglomerate*, which latter term is applied to consolidated gravels deposited by water. Both names mean, however, a mixture of materials.

THE ATMOSPHERIC ROCKS.

This grand division of the rocks embraces those which owe their formation, directly or indirectly, to the decomposing action of atmospheric forces on previously existing rocks. Their structure is that called stratified, meaning in beds or layers. The whole division is often called the stratified rocks. But as all the varieties are not truly stratified, the term is not all embracing. In general there are two primary divisions of these rocks, of very unequal importance. They are as follows:

I. *Eolian or wind formed rocks*.

II. *Aqueous or water formed rocks*.

1. *Eolian rocks*. These rocks are of no importance in the present connection, and will be dismissed with a few words. They consist mainly of those materials piled up by the wind, such as the sand dunes of our coasts. Their recent deposition and geological youth prevent any great amount of consolidation, hence the group needs no further mention.

2. *Aqueous rocks*. This group is often called the sedimentary, because they are largely composed of sediments deposited by water action. The name is misleading, for they are not all sedimentary in origin. It can be stated, however, that they have been deposited in or by water. The materials composing them are (1) the residue from the waste of other rocks and derived directly from them; and (2) that material derived

from other rocks by their decomposition, held in solution in water, and deposited either by the action of living organisms or by chemical precipitation. Therefore under this head come two divisions:

a. *Sedimentary Rocks.*

b. *Organic and Chemical Rocks.*

Under the action of the atmosphere a rock breaks down into soft incoherent material by the leaching out and removal of its soluble parts, leaving an insoluble residue. Thus a granite disintegrates into a sandy soil, mostly quartz and feldspar, moistened with alkaline water. Ultimately nothing is left but quartz and clay, stained with iron oxide and containing water alkaline with potash, soda and lime. In general it may be stated that quartz and clay are the two least soluble minerals commonly encountered, and hence, singly or together, mark the end of the decomposition of any rock. It is to be noted that from all rocks except the most acid lime is washed out as well as potash and soda, and the more basic the rock usually the more lime. The alkalies play no particular part in rock building but the lime does. Hence in this brief and popular exposition it may be considered that a decomposed rock will yield quartz sand, clay and a solution of lime. The metallic oxides, such as iron and manganese, remain as coloring materials merely, and are of no essential importance. However, as few rocks break down into their ultimate products before being consolidated into new rocks, we may expect to find, and do find, nearly all aqueous rocks to be neither pure quartz, pure clay, nor pure lime. Keeping these few facts and causes in mind, the principle varieties will illustrate their results.

SEDIMENTARY ROCKS.

1. *Conglomerates.* These rocks are consolidated gravels, resulting from the wear and tear of waves and currents upon preexisting rocks. The material composing them consists of rounded fragments of various sizes, often cemented by finer material of like nature. These pebbles or boulders, as the case may be, are often of various kinds of rocks, while again they may be all of one sort.

2. *Sandstones.* The name of these rocks explains their nature; a stone built up of grains of sand. The ideal sandstone is composed of grains of pure quartz, representing the last stage

of decay of preexisting rocks. But as most sand is not pure quartz, neither is most sandstone of pure quartz grains. As a result, these rocks have a variety of colors, depending upon the materials present. The most common minerals are quartz, feldspar, mica flakes, garnet and many other dark kinds. There is also another important quality of sandstones. Such rocks are composed of a mass of grains of sand, set in and cemented by some other substance. The three important cementing materials are (1) silica or quartz; (2) lime, and (3) iron oxide. Combinations of these may occur. The first will give a more glassy appearance to the rock and the color will be nearest to that of the original sand grains. The second will give the rock a white color as a rule; the third will give the stone that red color so desired for architectural purposes.

3. *Clay Rocks.* The one rock name necessary to name under this head is *shale*. A clay or mud, when hardened by natural processes, becomes a shale. A pure clay makes a pure shale; a sandy clay a sandy shale, and so on, with all gradations into the sandstone. These rocks are of no value whatever for the purposes of this report, but the clay rocks mentioned under the last grand division of the metamorphic rocks, the well known slates, are very important.

ORGANIC AND CHEMICAL ROCKS.

There are only two varieties of these rocks of any particular value in this discussion. They are these:

I. *Siliceous Rocks.*

II. *Lime Rocks.*

Both owe their origin to the fact that certain minute animals secrete either lime or silica from the water, and on dying their remains accumulate in certain places to form rocks. Also chemical reactions play a part in accumulating both kinds of substances. The first, or siliceous rocks, are formed largely by the growth and death of certain low forms of life, as sponges; the second are due in large part to the well known coral polyp.

1. *Siliceous rocks or cherts.* These rocks are very fine grained, sometimes almost glassy in appearance, and of various colors from white to red, green and black. They are well known under the name flint or chert. The fact that they are seldom pure silica results in their various shades of color. They are of

no use as building stones, but some have achieved success as road metal.

2. *Lime rocks or limestones.* Under this head come the limestones, so well known to everyone. In color they vary from a pure white through the grays to a dead black, the black being due to carbonaceous material. The texture varies from a medium coarse grain to very fine or compact, that is, showing no crystal forms to the naked eye. The crystalline varieties are least common, and are not marbles, which are metamorphic rocks. The crystals of the limestone are due to simple solution and redeposition, while the marbles owe their crystalline texture to other causes. A drop of a weak acid will always serve to identify the lime rock, as a bubbling of gas is caused.

METAMORPHIC ROCKS.

In this division is treated those rocks which have been changed from their original condition by heat and pressure into new forms. They are derived from both the igneous and atmospheric rocks. Geologically they constitute an extremely important and interesting class; economically they are of little value. A few statements will serve to distinguish the main types. They will be taken up in the following order:

I. *Gneisses and Schists.*

II. *Slates and Quartzites.*

III. *Marbles and rocks altered chemically.*

GNEISSES AND SCHISTS.

The gneisses are usually rather coarsely crystalline rocks which show a laminated or banded structure due to a flowage under pressure. In mineral content they correspond in most cases with the plutonic rocks, differing from them in the evident structure. A few varieties are derived from the atmospheric rocks, as conglomerates and sandstones. The banded structure is made evident by the arrangement of minerals in more or less parallel planes. The colors vary precisely as do the colors in the rocks from which the gneisses have been derived. The different varieties are named in a general way from the rock from which the gneiss has originated or resembles most closely. For instance, there are granitic gneisses, syenitic gneisses, conglomerate gneisses and so on.

The schists are similar to the gneisses in that they are banded

or laminated, but differ in that these laminations are much finer, giving the rocks the power of splitting along fairly parallel planes. With an elimination of fine distinctions, then the schists are finely laminated or foliated rocks rather fine in grain, with mineral content roughly parallel to that of the gneisses and hence to the plutonic rocks. Their most obvious difference from the gneisses, into which they grade, is in their finer banding. In color they range from white, in the quartz schists to black in the basic varieties. They are named from the dominant mineral showing, which mineral is usually arranged in more or less parallel layers, and causing the rock to split readily along these planes. The schists are derived both from the igneous and the atmospheric rocks. The two chief varieties are the mica-schists, showing bands of brown, black or white mica, and the hornblende-schists, otherwise called amphibolite-schists or greenstones. None of these are of particular value in this paper.

SLATES AND QUARTZITES.

When an ordinary clay rock, or shale, is squeezed under pressure, as often happens in mountain regions, it is made to flow at right angles to this pressure. Certain molecular changes set up in the mass cause it to assume a structure which results in its splitting easily along parallel planes into thin slabs. This structure is called slaty structure, the cleavage is slaty cleavage, and the rocks themselves are slates. They are formed in similar manner from igneous rocks also. The typical slate is not crystalline; some varieties show incipient crystallization and shade by insensible gradations into the schists. Their economic importance is too well known to need discussion.

The quartzites are rocks composed chiefly of silica, or quartz. They have usually been derived from siliceous rocks, as quartzose sandstones, by the addition of more silica, binding the whole into a hard, compact mass. Geologically no, old sandstones frequently are converted into quartzites by long continued action of heat and moisture. Quartz schists and quartzite gneisses, and, in fact, all metamorphic rocks mainly silica, come under this head.

MARBLES AND CHEMICALLY ALTERED ROCKS.

The marbles, properly speaking, are those rocks which have been derived by the crystallization of the limestone by the action of heat and moisture with perhaps pressure. They are often of coarser grain than the crystalline limestones. The pure

varieties are white in color, composed entirely of lime, or lime and magnesia. When made from impure limestones the impurities crystallize out as other minerals, of varying shades from white through reds and greens to black. The purer varieties of marble, which are of value for ornamental stones, are of even grain, the crystals showing shining faces. The test with acid always serves to identify these rocks. It is to be noted that there are two kinds of limestones; (1) those composed entirely of lime, and (2) those composed of lime and magnesia. The second, or lime-magnesia rocks, are called dolomites, or dolomitic limestones, when only a small percentage of magnesia is present. In appearance there is usually no difference; the dolomites are less acted upon by a cold dilute acid.

The *serpentines* are a group of chemically altered rocks of light or dark green to greenish black color, and usually of very fine grain. Sometimes well formed crystals with shiny surfaces are seen set in the finer material. These rocks have resulted from the chemical addition of water to the peridotites, or ultrabasic plutonic rocks. They are of some value as ornamental stones.

Steatite, better known as talc and soapstone, is also a chemically altered rock, similar to serpentine. In color the pure varieties are greasy white, often with a light greenish tinge. They are best known by their greasy feel. Other types of these altered rocks exist, but none of importance in this place. Steatite is often used for furnace foundations and other places where a fire proof material is needed.

This subject of rock classification is one of great complexity and difficulty, particularly in regard to the grand division of the igneous. Necessarily the matter has been presented as one concerned with hard and fast rock varieties, with more or less fixed differences. This is not so, for there are no well defined lines separating any of the various rock types, yet after all, it is the *types* which are of particular value here, and not the finely drawn conditions and conclusions of petrography.

CHAPTER III.

QUALITIES OF BUILDING STONES.

This chapter is divisible, by reason of its nature, into three parts. One speaks of the qualities of a certain stone, with its consequent value for architectural purposes. These qualities are of value, first, because of the inherent power of the stone to resist those changes which tend to impair its usefulness, and second, because of the resultant appearance of the rock. These characteristics are estimated in a number of ways. Hence, the divisions of this chapter are as follows: First, an account of the many possible changes to which a building stone may be subjected; second, a description of the features which govern these changes; and third, a brief notice of the ways in which these these qualities are estimated. The treatment of all this will be brief, a full discussion being reserved for a detailed report to be issued at a later date.

CHANGES IN ROCKS.

These will be discussed under the following outline:

A—*Physical Changes*, due to

- I. Temperature changes.
- II. Mechanical wear and tear.
- III. Effect of pressure.

B—*Chemical Changes*, due to

- I. Atmospheric solution.
- II. Decomposition of certain minerals.

PHYSICAL CHANGES.

I. *Temperature*. The results under this division are of two sorts, and due to different qualities in any particular stone. The first are those results produced by the alternate expansion and contraction of a rock, and, of course, of its component minerals, due to heat and cold. This process is the most important method of rock disintegration in regions of little moisture, as in our typical deserts of the west. During the day the stone becomes warm, or even hot, and expands. At night the temperature lowers, the stone contracts, and the changes being usually rather sudden and of unequal amounts in all directions, chips of rock fly off. The Indians use this principle in manufacturing arrowheads. After heating a suitable fragment in a fire, by

touching any desired portion with a drop of cold water, unequal contraction is produced and a small piece chips off. In regions of equable temperature, as along the western coasts, little is to be feared from such action; in Nevada, where the daily changes are often pronounced, some importance is to be attached. The mineral composition and texture of a building stone largely determine how greatly it shall be so acted upon. The loose textured fragmental rocks suffer least, because of their ability to take up without rupture small inequalities of motion in their mass. The massive igneous rocks suffer most because of their internal rigidity and the fact that each one of the constituent minerals expands and contracts differently from the others. The volcanic or partly glassy igneous rocks are probably most liable to such disintegration, the plutonic, because of their interlocking grains, are less so.

The second result from temperature changes is due to the freezing of included water. All rocks are porous to a greater or less extent, the crystalline least of all and the fragmental most so. Also the tendency of all rocks to break into large fragments or masses, often rudely regular in shape, by means of parallel cracks, or joint planes, as they are called, allows water to act in this way. The massive rocks especially are subject to jointing action, which may be either on a large scale or a very minute one. In some instances these joints become apparent only on the weathering of the stone. Water, penetrating the free spaces and cracks in rocks on freezing expands, and exerts a tremendous force acting to disrupt the material.

2. *Mechanical wear and tear.* The conditions under which a stone is to be used determines very largely the changes coming under this head. Stones for paving, for tiling, for floors, and for walks, all must be chosen to resist the constant wear of pressing feet and vehicles. Rocks for curbing, subject to hard knocks and the rubbing of wagon tires, must be had resistant to such abrasion. Such stones should be homogeneous and without flaws, otherwise disastrous breakage may occur. Two less important considerations in this connection yet of too great value to omit, are (1) the action of wind, bearing sand and other particles, on the rock of a building; and (2) the erosive and wearing effects of water, particularly in a country of considerable rainfall. The hardness, toughness and texture of a building material govern its strength or weakness, of which more will be stated further on.

3. *Effects of pressure.* The most important consideration here is, obviously, the fact that a stone selected for purposes of construction must be sufficiently strong to withstand all the force applied to it. For buildings not of large size the average stone has strength far above that required; in large structures some attention must be paid this factor of utility. The effect of pressure or strain on a rock is that of crushing, each variety of building material having its own crushing strength, as it is called. These figures, expressed in pounds per square inch mean the force necessary to crush a cube one inch on an edge. Some average figures are as follows:

Granite—15,000 to 40,000 pounds per square inch.

Volcanics—10,000 to 30,000 pounds per square inch.

Marble—15,000 to 25,000 pounds per square inch.

Sandstone—4,000 to 8,000 pounds per square inch.

Tuffs—2,000 to 6,000 pounds per square inch.

Results both above and below these are often obtained, the hardest granite and rhyolite showing a strength of about 50,000 pounds per square inch of surface, while other varieties will crush at a pressure of 10,000 or 12,000 pounds, or even less. In use, a factor of safety, usually of from six to ten, is employed. But there is more to the crushing strength of stone, however. An important relation exists between the strength of a building material and its structure. A limestone or sandstone, for instance, is much more able of sustaining a given load when laid parallel to its bedding plane. It is a well known tenet of the masonry trade that a stone should never be laid on edge, particularly one of the sedimentary or laminated rocks. The same holds good in the other rocks, even seemingly structureless granite, for there is often some one direction in which such a rock will cleave or break most easily. This plane should always be laid at right angles to the direction of pressure. Lastly, there is a further consideration growing out of all these facts. All stones are brittle, hence must be handled carefully to avoid shattering. The most incipient fractures, of microscopic dimensions, will in time ruin even the hardest rock. Quarrying should be done by the most approved methods, so that this danger of ruining future buildings shall be reduced to a minimum.

CHEMICAL CHANGES

1. *Atmospheric Solution.* Under this head comes the mere dissolving out and carrying away of certain parts, or the whole, of a rock. The chief agent of atmospheric action is carbon dioxide or carbonic acid gas, which in time decomposes nearly every rock forming mineral. Marbles, limestones and such rocks dissolve completely. Other rocks, as granite, have certain elements leached out, causing a crumbling of the remainder. The alkali metals enter into minerals and compounds which are easily extracted by the water. The decomposition of granite into sand composed of quartz, feldspar and other mineral fragments has been mentioned under the atmospheric rocks. The densest and least porous of the rocks are obviously least liable to this action of solution, and a compact marble, if not broken or shattered in any way, resists for a long time the attack of the atmosphere. In the igneous rocks the iron bearing minerals are easily acted upon and partially leached out. Hence the mineralogical composition of a stone has an important bearing upon its commercial value.

2. *Decomposition of certain minerals.* Here will be briefly outlined some noteworthy results produced by the decomposition of certain minerals. The oxygen and water vapor of the air, combining with the sulphide minerals, such as ordinary pyrite, produce sulphuric acid and iron oxide. This strong acid rapidly attacks the minerals with which it comes in contact, while the iron oxide stains the rock a yellowish or reddish. Pyrite is common in all rocks, and lessens their value for structural purposes in proportion to its relative abundance. An abundance of iron in any rock will cause it in time to become stained a disagreeable yellow color. There are many other reactions of a similar nature, but of subordinate importance and do not need mentioning. The ultimate value of a stone is greatly influenced by these considerations.

II. ROCK CHARACTERISTICS

1. *Color.* This feature of a stone is governed by the colors and relative amounts of its component parts and minerals. For instance, a granite is gray because of the blending of the black mica, white feldspar and colorless quartz. The value of a stone is largely governed by its color, irrespective of other characteristics. Other things being equal a red sandstone will be more sought after than a dull gray one; a red granite will often com-

mand a higher price than one with a somber hue. The variation in tint of any particular rock also changes its commercial value, as uniformity in all things is desired. Many stones, otherwise first class, are denied a place in the market because of such a defect. Besides the variation in color of a stone from one point to another, it is also to be noted that on drying or mere exposure to the air, some change in the tint may occur. This may be a deepening of color due to partial oxidization or surface chemical change; again it may be a bleaching due to drying. Often a rock with an abundance of iron assumes a reddish or dark red hue, due to the deposition of iron oxide throughout. Many of the Nevada andesites now used in construction are thus altered. The color is pleasing to the eye, but the stone is weakened in the process. Sometimes it is less a change of color than a decrease in the luster of a rock surface. This effect is common on granites, whose materials become either slightly altered on thier exposed parts, or covered by a film of dust.

For ornamental work, as in cornices and monuments, the ability of a stone to show a contrast between the appearances of its polished and rough hewed surfaces is of great value. The crystalline rocks possess this power in the highest degree, because of the fine polish possible. When such materials are carved and their exteriors smoothed, the contrast lies in the fact that a broken surface reflects more white light, while the poushed surface, which exhibits the colors of the minerals, absorb more of the sun's rays. A certain granite, valuable as a building material and monumental stone, polishes a very dark gray, while roughing to a light or whitish gray tint.

The selection of color is mainly from two standpoints: taste or fashion, and utility. In regard to taste, there is nothing to state from the view point of this paper except that, other things being equal, a warm tint is preferable to a colder one. Concerning utility, it needs to be emphasized that certain colors are more suitable for particular localities, as, for instance, a gray sandstone should be selected for a building in a manufacturing center, where smoke, dust and grime are ever present. And on the other hand, white stones should be used only where least exposed to tarnish.

2. *Hardness.* The hardness of a stone is its resistance to abrasion, shown usually by resistance to rubbing. Necessarily, the most important characteristic of a rock underlying this is its mineralogical content, a rock containing an abundance of the

harder minerals, as quartz, being the hardest, and, as all minerals vary in hardness, their relative abundance, state of aggregation, and size of crystals, govern the resistance of a stone to abrasion. A sandstone composed of grains of hard quartz may be very soft because of the loose hold they have upon one another. The chief reason for the greater hardness of the plutonic rocks is because their component minerals mutually interlock and bind the whole firmly together. Also in the metamorphic quartzites, the little broken pieces of quartz have grown by the addition of more silica until a similar interlocking texture is produced. A sandstone cemented by lime or iron oxide is softer because the grains do not bind one another together. In all the sedimentary and laminated rocks variations in hardness may occur in the different layers or laminae caused by a change in any or all of the conditions of the minerals mentioned above. As a result, much care must be exercised in their use. In the crystalline and more brittle rocks it must be kept in mind that even the slightest shattering by improper handling lowers the hardness and hence the value.

3. *Strength.* The strength of a stone is its resistance to applied pressure, either compressive force or transverse strain. This quality is very closely allied to hardness and depends in general upon the same internal conditions: mineral content, state of aggregation, and size of grain. As has been pointed out under "effects of pressure," in large structures the power of a stone to sustain a load is of great moment, while in small buildings and other ordinary uses, it matters little. It is not an unusual sight to see in large stone structures that the material near the base shows undoubted signs of crumbling, due to an overload. Every edifice erected is constantly jarred, and this small inappreciable motion has its lasting effect upon a rock already taxed to sustain a weight too near the limit of safety. More facts pertinent to this matter have been mentioned under "effects of pressure."

Another characteristic of certain building stones has a direct bearing on both hardness and strength. It is the power of some rocks to harden, or temper, on exposure to the air. In particular, some of the tuffs show an ability to temper to considerable hardness, at times sufficient to turn the edge of an ordinary hammer. The last bit of interstitial water of the rock, on working its way out to the surface, deposits whatever it holds in solution in the outer parts of the mass, and at times a perceptible crust is formed,

which, when broken through, exposes the softer stone beneath. Hence a rock once laid and undergoing this process of tempering should not be disturbed.

4. *Structure.* Broadly speaking we have massive rocks, such as the igneous; stratified rocks, as the sedimentary; schistose rocks, and so on. These are, properly speaking, rock structures. There are, also, other structures of the utmost importance. Joints, which have already been mentioned, are common. Irregular cracks and openings of all sizes, down to microscopic joints produced by movement and pressure, come likewise under this head. All these determine very largely just how long a stone will last under given conditions. The massive rocks, those whose characteristics are constant in all directions, are best fitted for long life; the stratified or laminated ones are liable to allow rather free access of water, with resultant deleterious effect, especially if not laid properly.

5. *Texture.* The texture of a rock enters largely into the various factors which govern its strength and resistance to change. The different textures, or internal arrangements, have been stated under rock classification, so that but little in the way of reiteration is needed here. A knowledge of the size, arrangement, and mutual relations of the minerals or parts of a rock are of the utmost value in estimating the worth of such material for structural purposes. For reasons given, a porous sandstone is weaker than a more compact one of the same composition, and should not be used in work requiring any particular strength. In the fragmental rocks the value of the cementing substance is all important. As a general rule it may be stated that the hardest rock is that in which the binding material is of the same nature as the mass. The texture of the plutonic rocks is commonly spoken of as "granitic," because of the similarity with that of true granite; an interlocking mass of crystals.

6. *Mineral Content.* Very little can be written at this time about the various rock forming minerals, because no knowledge of the subject is assumed on the part of the reader. To enter upon a thorough outline of such a matter is beyond the scope of the present paper, and will be reserved for a later date. Quartz, feldspar, mica, and hornblende have been referred to, because they not only are commonly known, but also are among the most important. The importance of the mineral content has been conclusively shown already in the several connections, so that no new space need be devoted to the subject.

III. OBSERVATIONS ON ROCKS

1. *Quarry.* From the quarry one learns the color of a rock, or its colors, as the case may be, its hardness, structure, weight, and something about its texture. Also, the main minerals may be determined with the resistance they offer, severally and collectively, to the atmospheric agents of decomposition. The ability of a rock to temper well, the colors of the rough and polished surfaces, with much about the larger features, can be ascertained. The weathering effects often show important things. All incipient joint planes, all lines of weakness, all traces of lamination, which are not noticed in the fresh stone, are brought to light in the slightly altered portions. Changes in color are caused in like manner, due both to bleaching, and to staining by the decomposition of particular minerals. Lastly, the quarry shows unmistakably the average character of the rock and not alone its best specimens, and the amount possible to expect for commercial purposes. Quarrying in some of its details, is much like mining. The owner almost invariably selects the best piece of rock to be found to exhibit—and who can blame him—with the result that often totally erroneous ideas may be conceived and ultimate injury done to a good business proposition.

2. *Buildings.* This is an important means of determining the value of a given material. It is not, however, as some think, the best or only means. A stone which has proved a failure in one building may owe its poor showing not to inherent weakness, but to a number of various causes, of which the most common are the improper working of the rock preparatory to laying, and the lack of consideration regarding the qualities demanded by the structure. The permanence of color and temper, the power to withstand the attacks of the wind and dust, the effect of sustained load, in a word the *permanence* of the material, may be largely ascertained by these observations. In such estimations it is to be borne in mind that many things must be regarded as influencing deterioration. For instance, some buildings are more exposed than others to all sorts of active agents, as the acids in manufacturing districts. And in every case there are multitudinous little details which every fair minded observer should notice. No stone should be condemned because of one or two failures, as in this way a blow is dealt an important industry.

3. *Chemical.* Since the decomposition of any building material is strictly a chemical process, a knowledge of its chemical constituents, and hence properties, is necessary if we would thor-

oughly understand it's fitness for use. In investigating this quality of a stone we need simply to apply chemical principles to the determined composition in order to throw light on possible alteration. For a simple example, a sandstone ninety-six per cent. silica is obviously far more servicable than one containing fifteen per cent. of lime. A type analysis will be found under granites in chapter IV.

4. *Physical Tests.* These are of several kinds, all of fundamental importance, and serve to fill out the knowledge gained by the methods already mentiond.

a. The strength of a stone is measured directly in a testing machine by applying force to carefully cut blocks. Commonly two inch cubes are crushed, the figures obtained being corrected to ultimate crushing strength per square inch of surface. The machines used are those employed in the testing of strengths of materials in engineering laboratories. The Nevada State University is not yet equipped with such apparatus, which is one of the main reasons for the incompleteness of the report. Such a machine, with a limit of 200,000 pounds pressure costs in the neighborhood of \$10,000. The transverse strength is tested by using a suitable prism of stone, laid crosswise on supports.

b. The specific gravity of a stone is the ratio of its weight to the weight of an equal volume of water. The common term "weight" is used in practice, and is similar but not the same, as "specific gravity." For instance, a cubic foot of water weighs about 63 pounds, and its specific gravity is, of course, 1 (one) The specific gravity of a granite, let be assumed, is 2.65. Hence its weight per cubic foot, were it absolutely solid, would be 63×2.65 , or about 225 pounds. As a matter of fact, the porosity, or air space, reduces this figure, which would be about 175 pounds weight. To obtain this figure, a simple and fairly accurate method is as follows. A representative piece of the rock to be tested is obtained, say containing about four cubic inches. This is thoroughly cleaned of all loose particles, dried at 110 deg. Centigrade, and carefully weighed in air. It is then suspended by a hair in boiling distilled water for at least an hour, and after cooling to the temperature of the air it is weighed in the water. The difference in the two weights gives the weight of an equal volume of water, which, divided into the dry weight of the stone, gives its specific gravity. The boiling is to drive out all enclosed air which is never done completely, so that the results are a little low, yet are satisfactory for the most practical needs. Also the boiling tends

to loosen any small fragments not removed, which also lowers the result. The most accurate way is to place the stone in the water under the receiver of an air pump and exhaust the air. This can be done in the more complete laboratories. This statement is to be remembered: the weight of a rock is proportional to the specific gravity, porosity, and water content.

c. The porosity of a stone is obtained in the above measurement by weighing the piece thoroughly saturated with water immediately on its removal from the water in which it was suspended. This gives the weight of the dry stone plus the weight of water absorbed in the pores of the substance. What is desired, the porosity, is the ratio of the open space in a rock to its total volume. To obtain this we divide the weight of a piece by the weight of the same material which would just fill the open places. The first weight of the dry stone is already known, and we obtain the second by multiplying the weight of water absorbed by the specific gravity of the whole. The great importance of this figure has already been pointed out, particularly in regions of great temperature variations and considerable moisture. A stone thoroughly seasoned, however, ordinarily suffers little.

d. The effects of freezing and thawing on a stone, both dry and saturated with water are properly tested under those conditions most nearly coinciding with those actually encountered. A cube of the rock may be exposed, both dry and wet, to the changing temperature of day and night during the winter, for a period of at least a month, and then tested for loss in weight and strength. The action of extreme heat, as in the case of fire, may be tested by heating a fragment to redness in an assay muffle, and noting the effect, first, on cooling slowly and second, on plunging the hot stone into cold water. The loss in strength is tested in the usual way.

e. Lastly, but not least important, much light can be thrown on all the above qualities of a building material by examination under a microscope. Sections of the rock are ground to a thickness of about two hundredths of a millimeter, and mounted on glass slides. An examination under a properly designed microscope shows everything about the minerals: their relative abundance, nature, size, and mutual relations. Also, texture and even structure missed in all the other methods of investigation, may be shown in this way. Yet the life of the stone might depend upon these very things. In short, a microscopic examination puts the finishing touches upon a thorough search after the

qualities of a building material, and such a search is incomplete without this investigation.

CHAPTER IV

BUILDING STONES OF NEVADA

In actual amount, Nevada is well supplied with rocks which can be used as building material. At present, with a territory only beginning its true development, comparatively little is used, and few quarries are opened. Were the following list taken only from those actually quarried, a poor showing would be made. It has been the aim to include also those rocks which can easily be made use of at a profit, in order that both capital and attention may be attracted. All throughout the west, a region of first class building stones, the fact remains that the value of imported stone runs annually into the hundreds of thousands of dollars. The reason seems to be that people refuse to take advantage of natural opportunities and to develop their own resources, largely because imported material is easy to obtain and is less common than home products. It is true that the commoner uses of stone, as curbing, abutments and some buildings, are supplied by materials produced here, but for the finer uses a very large percentage of imported stone is placed. The west suffers from a lack of red granite for ornamental work, as in monuments, yet there is some first class rock of this color both in Nevada and California which should be developed. At the present writing, nothing can be given in the way of figures of invested capital, costs of handling stone, wages, et cetera, for the simple reason that they are not obtainable. Not one quarry in the state is working, and except when a lot of stone is needed for some sudden purpose, no work is ever done. Needless to say, the capital invested is at the most but a few hundred dollars, outside the value of the land, hence is not important. The location and the possibilities of building stones are the most valuable part of what follows. Much in this chapter will be of no immediate value; much will be fragmentary, for it is difficult to obtain accurate data throughout. Many of the important qualities of a stone can be determined only after a quarry face has been opened, and as yet the University is not equipped with a testing machine, hence it will be some years before a detailed report can be published.

The rocks will be mentioned in the order given in the classification in chapter II, beginning with the plutonic igneous, or, as they are sometimes called, the "granitic rocks."

PLUTONIC OR GRANITIC ROCKS

Under this division there are several important stones actu-

ally in use, and others with first class possibilities. And in classifying these rocks a slight difficulty is presented. Such rocks are called popularly granites. Some of them are granites; others are not, but all are related. The geographical belt lying on the east flank of the Sierra Nevada and along the foothills is characterized by an abundant development of these, all more or less connected in origin, yet varying from those properly termed granites to those of dioritic nature. As a group, chemically they stand between these two types of plutonics, containing an excess of soda over potash, and often considerable lime. Some contain an abundance of free quartz, others show little to none. As any petrographical discussion is here out of place, only a few remarks of this nature will be presented under each rock. The writer hopes to show later, in a petrographical paper, the true relationships of the granitic rocks of this western portion of Nevada. For the present, the term granite will be used exclusively for those rocks showing free quartz.

GRANITES.

Laughton's Station: This stone occurs in the immediate vicinity of Laughton's Station, to the north of the Southern Pacific Railroad track, about five miles west of Reno. Considerable amounts of rough stone have been taken out at the outcrop directly on the railroad, but no real quarry face has been opened. In color this granite is a medium to light gray, with occasional splotches of a darker shade. The rock is able to take a good polish, quite in contrast to the rough finish. Considerable joint structure is developed on a large scale, sufficient to make quarrying easy, and yet not enough to preclude the possibility of extracting large blocks. The texture is of medium fineness, or grain, in the main phase of the stone, but varies considerably. The normal rock has much more white mineral than dark, but often rounded spots occur which contain a much larger percentage of black constituents. These spots are at times thickly interspersed throughout the main mass; often they are seen as isolated dark centers surrounded by many feet of surface of the normal variety. The minerals to be seen by the naked eye are quartz, feldspar both orthoclase, the potash variety, and plagioclase, the soda-lime variety, brown mica, and black hornblende. The mica is the chief dark mineral in the normal rock, but hornblende preponderates in the dark spots. Under the microscope the orthoclase feldspar is seen to be in crystals much larger than those of the other minerals, and is also greater in amount than the plagioclase.

The quartz is not in great percentage. Little or no pyrite is present. As in all granite, the hardness is considerable. The rock is rather brittle, and the crushing strength is medium for a granite, the variation in grain lowering this value. The stone, because of its location on the railroad, is available at once and in large amount. The railroad owns that part of the mass now quarried at all, and can furnish vast quantities when required. Unless a well opened quarry should show a more uniform grade of material, the uses of the stone will be limited. It can be used for ornamental work if no variations in texture are present, and for all the more common demands, such as foundations, curbing, walks and the like it will give satisfaction.

Verdi: In the vicinity of the town of Verdi, which is about ten miles west of Reno on the Southern Pacific railroad, considerable areas of granite exist. Much of it is directly on the railroad, south of the town, along the Truckee river. From Verdi to the south the surface rises steeply for about two hundred feet to a level terrace of granite, with boulders of andesite dispersed over it, the last remains of an extensive flow. Several faults occur on this terrace, with resultant rise of the plutonic rock and increased opportunity for quarrying. No quarrying has yet been done, but the possibilities are surely worth serious consideration. There are two types of granite which will be described.

1. This first type of rock is that which makes up most of the mass. The color is a rich dark gray, with a faint trace of pink, giving as a result a very handsome stone. It is able to assume a high polish, showing quite dark in comparison with the rough surface. As no quarry face has been opened, nothing can be stated about the structure of the rock, except that as some faulting has occurred, joint planes are probably developed. From the outcrops existing, the texture appears fairly constant, there being a slight change in color in widely separate localities. However, the stone seems to be remarkably free from imperfections in this respect. The minerals present are quartz, feldspar, mostly orthoclase, hornblende, and mica. The hornblende is the more plentiful of the dark constituents. The pinkish tint is due to the color of the orthoclase, which is a pleasing flesh color. Quartz is not very plentiful, whereas the black minerals are, hence the dark color of the whole. The sulphides are very small in amount. The hardness and toughness are perhaps a little higher than in the Laughton stone, and sufficient for all purposes. But like the Laughton stone, it is so situated that it is available at any time with lowest

possible cost of handling. An opening to exhibit the character of the mass is all that is needed to show it up properly. For monumental work as well as for all the best uses, this granite should find a ready market, if present indications have much weight.

2. The second variety of granite from Verdi is found at present only in boulders lying on the worn surface of the other. It undoubtedly occurs as veins in the main mass, and should properly be called a pegmatite. These dykes must be of large size, because of the dimensions of the largest fragments derived from them. A quarry is necessary to outline any facts about the matter. The color is either a light red ground through which are irregularly dispersed black shining crystals of tourmaline, or more rarely, a white ground with the dark mineral. The general effect is very pleasing to the eye, presenting a sharp contrast to the other variety of granite. The texture is peculiar, for the minerals are not at all regularly distributed. The mass of the rock is made up of quartz and feldspar, usually reddish orthoclase, through which occur bunches of black tourmaline crystals. The quartz and feldspar are of fine grain, while the black mineral, in coarser crystals, is in spots in size from a quarter of an inch up to a foot or more. The stone will take a high polish, differing little from the unfinished surface in shade. It should meet with favor for some kinds of ornamental work, as well as for building material, if it can be obtained in large enough amount.

Washoe: This granite outcrops west of the old town of Washoe, on the Virginia and Truckee railroad, and is a part of the great granite mass occurring at the east base of the Sierra. A quarry is opened about a mile west of the town, on land owned by Mr. John Barrett, the stone cutter of Reno. Not a great deal of work has been done, yet the stone has been shown to be of fairly uniform color and grain. The color is a medium dark gray, with a very faint pinkish tinge, lighter than the Verdi rock. There appear to be few or no imperfections in structure debarring the extraction of large pieces for use, but, in common with most of these rocks of the region, the texture varies somewhat. At times splotches of dark constituents occur to mar the even aspect of the surface. Careful selection, however, should eliminate this evil. A good polish is taken, quite dark compared with the unfinished stone. The minerals are quartz, both varieties of feldspar, mica and hornblende. The two dark constituents are about equal in amount while the quartz is sparingly distributed. The sulphide minerals are rare, as in all of these rocks. Both hardness and

toughness are fairly high, and should improve as deeper cuts are made in the quarry. This stone is not quite so readily available as those already mentioned, as a haul of a mile to the railroad is necessary. At present the granite is used for monuments and ornamental purposes by Mr. Barrett.

Nearer the railroad, and in fact, directly on it, is an occurrence of volcanic and plutonic boulders, in which are some of granite. This stone is the same as the Washoe granite just mentioned, and is quarried by the railroad for use in culverts, abutments, and the like. Such a source is, necessarily, limited in extent, yet it does sufficiently well for immediate needs. And it may be well to note here that most of the granite now used in and about Reno for curbing, mounting blocks, and such commoner demands, is obtained from the vast quantity of boulders existing in the river wash covering much of the adjacent territory. It is needless to remark upon the cheapness of this source, yet the best quality of material cannot be furnished in such a way, so that the ultimate cheapness is lessened. Only a well opened quarry will deliver the best stone, and when substantial, long-lived buildings are to be constructed, field boulders should never be used unless of exceptional size.

Ophir: This rock is well exposed at Ophir, about a mile northwest of Franktown, on the Virginia and Truckee railroad. A little preliminary quarrying has been done at a point just south of the wood flume, on the small creek here draining down from the mountains. The stone rises up about a hundred feet above the creek, giving some opportunity for working. As yet the solid mass of the granite has not been reached, the quarrying has been done in the more or less broken surface material. The color is the lightest of all those described being, in the average, a very light gray. Some varieties, small in amount, are darker in shade. A good polish is possible, which is little darker than the rough surface. Jointing is well developed, insuring ease in quarry work while not preventing the extraction of large blocks. In texture the rock as a whole varies considerably, though the main mass is fairly constant. Normally the crystals of the component minerals are fine in grain, with longer black crystals sparingly distributed throughout. The minerals of fine even grain are quartz, both feldspar and brown-black mica, the larger black crystals are hornblende. The quartz is very plentiful, giving almost a glassy luster to the rock. Also, many small grains of a yellowish mineral are dispersed rather plentifully. The other varieties are due to the

change in the relative amounts and kinds of the minerals present. Some show an abundance of large shining mica flakes with little or no hornblende; some show much hornblende with no mica; and others show a great amount of clear colorless quartz. These, however, are in small amount. This granite is very hard, but more brittle than the others. Its availability is apparent, being less than a mile from the railroad. Its possible uses are limited by its variation in texture to the commoner ones, such as curbing, mounting blocks, foundations, and pavements, though its light color might find favor for contrast in monumental work.

Lakeview: This stone is well shown in the railroad cuts south of the station of Lakeview, three miles northwest of Carson on the Virginia and Truckee railroad. The railroad grade winds around a hill composed chiefly of this rock, thus making it possible to obtain vast quantities at a minimum cost. No quarrying of any sort has been done, as the stone is not of the best quality for building needs. The color is a light gray, similar to, but darker than the Ophir granite. In the exposed outcrop many little dots of red are to be seen on careful inspection. The mass of the rock is quite faulted and jointed, but blocks of large size can be taken out, judging by the weathered portion. The texture is rather coarse in appearance, because of the large size of the hornblende crystals; the light colored constituents are of finer grain. The minerals are quartz, feldspar, again both kinds, with a slightly larger percentage of orthoclase, hornblende and mica. The hornblende is the chief dark constituent. Quartz in nominal amount. A considerable number of small grains of a yellowish mineral are present, as in the Ophir stone. One other substance is worthy of notice; the mineral magnetite, which shows quite plentiful under the microscope. Such a rock as this is limited in usefulness to the commoner demands, and it is also possible, on account of the mineral content, to use it as a road metal. Its vast amount, easy of access, its small mica percentage and its comparatively large percentage of iron, make it easily possible that it might prove a success as a material for macadamized roads.

Carson Prison: On the Prison Hill as it is called, a granite similar, or the same, outcrops from beneath the andesite flows. This locality is not on the line of the railroad, but is easily approached by teams. If the stone proves a good road metal, this would make a good locality to furnish material for those parts of the region nearby.

Luning: Near the town of Luning, in Esmeralda county

and five miles from the line of the Carson and Colorado railroad, there is an occurrence of a fine grained white granite. No real quarrying has been done, and only a small amount of stone has been extracted. Small pieces show a finer grain than in the other granites described, and exhibit a contrast with them. The land and stone is owned by Mr. Lindsay, of Carson, who has the stone for sale, as well as for his own use in building work.

Mason Valley: This stone occurs near Mason Valley, in Hudson Pass, Lyon county, about eighteen miles from the Carson and Colorado railroad. As with most of the other rocks, no quarrying of any amount has been done, and the stone awaits a market. The color is rather striking, being a light mottled pink-gray. On close inspection three distinct colors present themselves, due to the different minerals; white, pink and dark green. The polished surface brings these out well, and presents a considerable and pleasing contrast with the rough finish. The grain is medium and even, with an occasional large white crystal. The polish brings out clearly most of the component minerals. To the naked eye no quartz is present, and the rock looks like a syenite, or that rare rock standing between a syenite and a diorite—a monzonite. The minerals easily seen are feldspar, including stout pink crystals of orthoclase, and long white crystals of plagioclase. Under the microscope, quartz is apparent, making the rock a granite though a basic one. Both hardness and toughness are high. The stone is not as available as could be desired, yet its color and other qualities are such that its value is high. It can be used for monumental work, and buildings, and should find a ready market. The owner of the present "quarry" is Mr. Lindsay, of Carson.

Winnemucca: Two varieties of granite are used in Winnemucca. The first is quarried twelve miles to the north of the town, and hauled in by teams. It is a medium light gray stone, taking a fine polish, and is sufficiently good for the best class of work. The grain is of medium coarseness, with little variation in color or mineral content. The minerals are the usual ones already mentioned, with not a great deal of quartz. By way of illustrating availability, some figures of cost of hauling for this stone will be given, which are fairly good for others removed from the railroads. A trip from Winnemucca to the quarry and return occupies two days, with a large wagon. Seventy-five cubic feet of stone are hauled at a trip, for which eighteen dollars are charged. This stone has found some favor for monuments in the town, and can

be used for ornamental and construction work. Mr. Joe Pasquale is owner.

The second granite used in Winnemucca is taken from boulders found on the lower slopes of the mountain bearing the same name as the town. In color and general appearance it is much like the first, but takes a poorer polish. It also has found some demand for monuments and buildings, but is inferior to the first because of longer exposure in fragments. However, it is well adapted to all the commoner uses.

Elko: Much granite exists both to north and south of the town of Elko but at some distance. At present one variety is quarried, and used in the town for nearly all purposes. This rock comes from a spot about thirty miles north, necessitating a long haul. The distance from the railroad limits its use and market, for when a quarry is well opened on the line of the railroad, as can be easily done, at a place like Verdi, such a stone will be driven from use by its cheaper rivals. It is possible to find some first-class monumental granites in the region about Elko. And there are many other possible stones. Granite is plentiful at Steamboat Springs, and more at Verdi, up Dog Creek Canyon. Likewise in the eastern part of the state there is much similar stone, most of it unknown in value and qualities. But for some years only the most valuable granites existing away from transportational facilities can be available, because of the wealth of easily obtained poorer stone outcropping directly on the railroad lines.

DIORITES

Virginia City: The mass of Mt. Davidson, upon whose eastern flanks Virginia City lies, is chiefly of a dioritic rock. It is not urged that this rock would make a first-class building material, for its color is a somber gray, its grain fine, and the whole aspect uninviting. It is mentioned in this place because of its possible use as a road metal. Its constituents are feldspar and hornblende, with usually some iron pyrite. The texture is one of interlocking crystals, causing very great toughness. There are several phases of the stone, each with its own color and general appearance. The summit outcrop develops a gray granite looking rock; the tunnels and crosscuts in the mines often show a much darker variety. For a road metal, the binding power should be good, while the toughness will be vouched for by every miner who has driven a drill into it. As mentioned in the chapter on road metal, the rock may prove easily a most valuable one for use on roads underlying heavy traffic.

Beckwith Pass: This rock is found near Beckwith Pass, in California, but as its development must come through Nevada, it is here included. Like all the granite rocks, it exists in practically unlimited quantity. A little quarrying has been done, sufficient to show up the stone fairly well. The color is a very dark gray, darker than the Verdi granite, which it somewhat resembles in appearance. It takes a perfect polish, which does not present a great contrast to the rough surface, as the stone is essentially so dark. The grain is of medium coarseness, and very constant; the stone is quite free from irregularities of all sorts. The minerals present are plagioclase feldspar, with mica and hornblende in nearly equal amount. Black magnetite also occurs. The hardness and toughness are fairly high. It is yet necessary to haul the stone some distance to the railroad, which militates slightly against it's use. With the advent of the proposed Western Pacific railroad, this difficulty will be largely eliminated. The quarry now operated is owned by Mr. John Barrett, of Reno, who has been mentioned as owning a Washoe stone. This diorite is now used for monumental work entirely, and is well fitted for all the best class of uses. It also might prove a valuable road material, for which the chippings and waste could find a market.

VOLCANIC ROCKS

RHYOLITES

There are two stones used in Nevada which are classed with this group of rocks. Both are from the region just south of Virginia City, near the American Flat Tunnel on the line of the Virginia and Truckee railroad, in Lyon county. Both are quartz-porphyrates in a general sense, though there are variations from a true quartz-porphry or rhyolite, to a quartz-andesite, or dacite, based on the nature of the included feldspars. In detail these rocks are as follows:

1. The first stone is quarried from the great mass covering many acres, at a point on the railroad one-fourth of a mile west of the American Flat tunnel. The color is a not unpleasant yellowish white, a suitable shade for a dry, dusty climate. The texture is porphyritic, and even throughout large volumes. On close inspection the color is seen to be due to the ground mass; while the crystals showing are chiefly clear quartz, and white feldspar. Some small grains of iron bearing minerals, as mica, are present in small amounts. The general effect is good, a little different from the usual run of stones. The rather large glassy quartz grains, particularly, give the rock a distinct individuality. The

hardness is high; the toughness a little less, and both rank with the best. Much resistance to atmospheric changes is given, so that long life to a structure of this material is assured. The quarry cut is directly on the railroad, so that any amount needed can be easily obtained, the railroad, of course, owning the land. This stone was much used in the early days on the Comstock, chiefly for foundations. It shows no evidence of change where so used. The railroad now constructs of it abutments, culverts, retaining walls and other similar structures.

2. The second quartz-porphyry is quarried five-eighths of a mile east of the tunnel already mentioned. The color in the mass is a medium dark purplish, which color is a not inconsiderable factor in the worth of the stone. The texture like that of the other, is porphyritic, with well developed crystals of quartz, feldspar, and dark mica. The color is due to the purplish-gray ground mass, in which the other minerals show distinctly. The main difference between these two rocks is in the color, and the increase in the amount of mica in the purplish variety. This latter stone is decidedly pleasing to look upon, and should find favor for buildings. Its hardness, toughness, and other characteristics are identical with those of the first of these rocks, and likewise it is quarried by the railroad and used in some of its culverts and abutments. It has been used in one of the railroad crossings at Steamboat Springs, and makes a fine appearance.

ANDESITES

There are several quite prominent building stones under this rock group, including some of great promise. As the demand for such materials of construction increases, they should all find ready markets, particularly as they are easy of access and near the centers of population.

Southwest of Reno: This stone is the one used largely in the erection of the new Carnegie Library Building in Reno. It is locally called a sandstone. It comes from one of the large andesite flows which bathed the lower eastern flanks of the Sierra in recent geological time. The quarry is situated at a point about four miles southwest of Reno in an air line, though nearly two miles further by road. The work here has just begun, and is due to the construction of the building just mentioned. Enough has been accomplished, however, to show some of the larger characteristics. The quarry shows well the flow structure of the mass; the planes of motion lie nearly horizontal, greatly facilitating the extraction of large blocks. On this account, the cost of quarrying is very

low, aided also by the absence of any overburden, or surface waste material, beside a few feet of rocky soil. The color is a medium light red or red-gray, similar to but redder than the tint of the quartz-porphry from Virginia City. The texture is porphyritic, showing white feldspar crystals with smaller ones of mica and hornblende, in the red-gray ground mass. The white feldspar is all that shows on a cursory examination, and as much of this mineral is present, the popular term sandstone has been employed. These more or less lath shaped crystals of feldspar are arranged roughly parallel along the flow planes. The red color of the ground mass owes its nature to the decomposition of the iron-bearing ground mass, with the resultant deposition of iron oxide throughout. The effect produced is fair to look upon, but the stone is weakened thereby. The hardness and toughness are low for a rock of this type, and are little better than in an average sandstone. It would crush, probably, at a pressure of about six thousand pounds per square inch. This is sufficient for all ordinary demands, but not enough for the very largest buildings now erected. It will withstand much in the nature of temperature changes, as will all the rocks of this group.

Being situated near Reno, it should be used in many more buildings to be erected in the near future. Its general appearance counts strongly in its favor.

On the western side of the ridge on which the above quarry is situated, is a second outcrop of the same rock. There is a difference, however, for here the red color is replaced by a gray, due to the non-oxidation of the mass. The other features are the same, except that the lasting qualities are much better. The two stones are in pleasing contrast, and will undoubtedly find favor in a short time.

Huffaker: There are two varieties of andesite at this point, five miles south of Reno on the Virginia and Truckee railroad. The railroad here skirts the foot of a rather low hill, on which outcrop the rocks in question. They are both part of the same mass.

The first is a red stone, a shade darker than the library andesite. It forms most of the surface material and can be obtained in quite large amount. No quarry face has been opened, so that nothing can be told about its structure. It has no flow planes like the first mentioned andesite. It is porphyritic in texture, showing well formed crystals of black hornblende, red discolored lath shaped crystals of feldspar, and all in the red ground mass. The hornblende is quite plentiful, the feldspar is about equal in amount, but decomposed and reddened as is the ground mass. The hard-

ness is medium, the toughness somewhat less. The availability of the material is a strong point in it's favor, as it outcrops less than a hundred feet from the railroad track. It is on the Huffaker ranch, and has been used locally to some extent.

The second variety is a granitic looking rock, and by the average individual would possibly be called a granite. It outcrops on the same hill as the other, and, due to the fact that less decomposition has taken place, lacks a red color. It is a medium light gray stone, apparently showing quartz, feldspar, and hornblende. Careful study, with and without the microscope, show it to be a truly porphyritic rock, of medium grain and even texture. The minerals in well formed crystals are white feldspar, black hornblende, and a few flakes of mica, set in a glassy, colorless, ground mass. It is this glass which has the appearance of quartz. The general aspect of the rock is decidedly in its favor. As no real quarrying has been done, and no thoroughly unaltered rock exposed, it's other qualities are not known. From it's construction it must be a very hard though perhaps brittle, stone. The Huffaker residence, a large two story structure, is made of this material, which shows no change in its thirty years of service. These two andesites are worthy of careful investigation and some work done to exploit them.

Fulton's Quarry: The rock exposed in this place exists to the north of Reno, over considerable territory. The quarry itself, in the best material, is about two miles north of the University campus, just above the line of the Nevada, California and Oregon railroad. What work has been done is all on the surface; no quarry face has been well opened. The color is a light greenish gray in the mass, and a restful one to the eyes, especially in the glare of the sunlight in a hot, dry climate. The rock is rather strikingly porphyritic on close inspection, though of even appearance at a little distance. Large glassy feldspar crystals half an inch in length are frequent. Also, many flakes of dark mica are present, with a little hornblende, and all set in the compact, greenish-gray ground mass. In selected pieces the texture is fairly constant, but as a mass much variation occurs. Inclusions of other materials are found, and small cavities lined with materials are at times plentiful, so that careless work may result in unsightly spots in buildings. The hardness and toughness are fair, and the resistance to weather changes is good. As it is on the railroad, it's availability is excellent, and there is a vast quantity in sight. The stone has been used considerably in Reno. Several of the newer University buildings contain it, as the gymnasium and

Lincoln Hall, and a few structures in the business part of town are made wholly, or nearly so, of the material. It's greenish tinge gives a pleasing aspect to the buildings containing it. Another possible use is that of road metal. In the search for such material soon to come, a test upon the rock would not be ill advised.

Virginia City: About two miles to the east of the old town of Virginia City runs a ridge approximately north and south. Sugar Loaf peak is part of this ridge, which is cut in two by Six Mile Canyon and Creek. An andesitic rock forms this feature of the topography, furnishing one, and able to furnish two, stones for building purposes.

The first of these is quarried at a point just east of the Brunswick Lode, on the east side of a small hill rising from the ridge. Considerable rock has been taken out here, yet in a more or less careless manner, and no well cut face is shown. The structure of the mass is quite remarkable. Rock columns averaging two feet or more in diameter compose the whole, like a bundle of sticks laid carefully parallel to one another. These columns pitch to the northwest at a low angle, aiding very materially the quarrying. This stone is the most striking in appearance of all those described in these notes, and is almost beautiful. Any one word will fail properly to give the color, for the texture has given the rock a mottled aspect. This texture is porphyritic, and large roughly rounded feldspar crystals often half an inch across, with smaller prisms of hornblende and flakes of dark mica appear in a blue-gray, or steel blue ground mass. The feldspar is quite glassy, much in contrast to the lusterless colored ground. There is some variation in texture, which must be guarded against by selecting only the best. Frequently small inclusions with slightly different color and grain occur, which spoil the even effect of the whole. The hardness, toughness, and other characteristics are good, and need little consideration under ordinary circumstances. The stone is easily obtained, the quarry being less than two miles from the railroad, and an easy haul will deliver it at the station. It was used extensively in the early days of the town for foundations for large machinery. As it yet remains in place, one can see how well it stands. To state that it makes a beautiful appearance does not seem like exaggeration.

The second variety of these andesites occurs in Sugar Loaf, and in the exposed places in the immediate vicinity. It has not yet been quarried nor used. A fine exposure is present to the southwest of the road in Six Mile Canyon just where the bridge spans the creek at the base of Sugar Loaf. This rock is very

similar to the first, yet distinct in its general appearance. The ground mass is a very light gray, with a faint tinge of blue, and the well formed minerals are white feldspar, in smaller crystals than in the first phase, with black hornblende more plentiful than before, and a little dark mica. The other qualities are about the same as those of the first variety, and are good. A little harder pull by team is required to land it at the railroad yards, yet this will not count much against it. As far as known, this stone has never been worked, but it would make a very good building material.

TUFFS

There are three of these valuable building stones now in use in the state. They are softer than the average consolidated tuff, yet this lack does not prevent their being used in many important ways. They fill a want for certain kinds of materials better than any other stone, and at times rank with the best sandstones.

Merrimac Station: This tuff outcrops in the Virginia Range in the canyon of the Carson river, at Merrimac Station, on the line of the Virginia and Truckee railroad. This point is a few miles east of Empire, and within easy reach of all important points. The quarry, owned by Mr. J. W. Adams, of Carson, is on the south bank of the river, and is one of the very few well opened ones in Nevada. The color of the stone is a light pink, almost a flesh color, and does not vary throughout the mass. As it is composed of volcanic ashes, with some mineral fragments, its texture might be taken to indicate a very fine grained sandstone. The fragmental character is clearly shown, and the absence of stratification planes or layers indicates to the unaided eye the nature of the material. The ash is largely glass, in minute fragments, in which are imbedded angular pieces of mica, quartz, and feldspar in small amount. The grain is very even for such a stone, and its general effect is very good. In hardness and toughness it stands low, about equal to a soft sandstone, too low to warrant its use under much stress. It tempers a little on standing, but not sufficient to raise much its strength. It is rather porous, as are all the tuffs, yet withstanding temperature changes well, because of its internal structure. It has been used very largely in and about Carson and Reno, chiefly for copings, cornices, lintels, arches, and such others requiring little strength. When used with brick, a very pleasing contrast is presented, as is done with any other material harmonizing with it in color. The Gymnasium and Lincoln Hall of the University Buildings both contain it, some brick residences in Reno are much improved by its use;

and the new Elk's Hall shows it to advantage. This tuff should be much used for the demands befitting it.

North of Reno: This tuff comes from a mass of consolidated ash almost twenty miles northeast of Reno, on the Spanish Springs Valley road. A little stone has been quarried and used in Reno in ways similar to the Merrimac rock. It's color is a light pink, a little lighter than the first material. These two stones are very similar in their features and can be used in precisely the same ways and for the same demands. This second tuff, however, is more irregular in texture, containing angular fragments of other rocks, largely andesite and granite, thereby appearing somewhat mottled when closely inspected. It tempers slightly better than the other. Careful selection should eliminate the unsightly stone from that quarried. The owner is Mr. Wm. Schrader, of Reno.

Lovelock: This rock is located in the hills to the northeast of the town of Lovelock, on the line of the Southern Pacific railroad. The point from which it has been obtained is about four miles from the station with not a hard haul over the distance. The color is a purplish-gray, of a medium depth of tint. The structure and texture are in general the same as in the other tuffs. Many small fragments of volcanic rocks are interspersed throughout the mass, and small glassy crystals of feldspar are quite noticeable on careful inspection. The rock inclusions are dark gray, so that a close view exhibits many seeming imperfections in grain. Used in a building these are not apparent, and the whole aspect is a very pleasing one. The usual shade of purple will give a pretty contrast with other stones whose color blend with its own. The hardness and strength are good, ranking well up with that of the best sandstone, while at the same time it is resistant to atmospheric changes. A vast amount is in sight, and when once introduced, a ready market should follow.

Washoe: A rock similar, yet different, from the three tuffs mentioned, is found at Washoe, on the Virginia and Truckee railroad. This notice is of value chiefly from a historical standpoint, as several of the old abandoned buildings of the once thriving town are made wholly of this stone. In its nature it is a volcanic agglomerate, or a consolidated volcanic mud, and an unusual material for purposes of construction. The old quarry is on the hillsides above the railroad track just north of Washoe station, in a surface cut only a few feet in the mass. One is tempted to describe it as having a mud color, this feature is so

very inconspicuous. More specifically the color is mottled light and medium dark gray, and the surface usually appears dusty. The texture is quite porous. Nothing in the way of definite substances or minerals can be easily determined or distinguished. Its lasting qualities rank with an average sandstone, but its strength is less. It is easily available, but its use cannot be urged in the face of much more and better stone.

ATMOSPHERIC ROCKS

SANDSTONES

Nevada has had developed up to the present time only a few rocks of this family, and none of them can be called first-class. They are all of recent geological age, and owe their qualities to their youth. As the development of the state goes on, more such will surely be found, perhaps some of the very best. These stones will be needed as the cities and towns grow, and the best will command a good price.

Carson: The first and most important sandstone is the well known one at the State Prison, near Carson. The quarry constitutes the prison yard, and has had the most work done of any in the state. The sandstone beds or strata occupy the site of an extinct lake, and exhibit the quite famous animal tracks on the present floor. The color is a yellowish-gray, a gray unfortunately, streaked with a light yellow, and not uniform. The rock is rather heavily bedded, with the bedding planes nearly horizontal. This position is probably the same one the stone has always occupied, although slight tilting may have occurred. On this account, of horizontality, quarrying is easily done. That mineral content shows the stone to be derived from the weathering and decomposition of a granite, the yellowish tinge being due to the oxidation of the iron bearing substances. The constituent grains are cemented by secondary silica. The grain of the rock is of medium fineness in the average, but at times becomes quite coarse, containing pebbles up to half an inch in size. The hardness and strength are medium, sufficient for all ordinary needs, and the resistance to other forms of change is good. There is much material in sight at the prison yard. The stone has been used largely in Carson and Reno. The new chemistry building at the University is constructed wholly of it, and presents a very satisfactory appearance. A small amount has found a resting place in the stone entrance to the University grounds, as is shown in the frontispiece.

Fallon: This sandstone occurs near the town of Fallon, in Churchill county. Little quarrying has been done, but samples of the rock show its main features. In color it is a cream white very uniform in the small pieces shaped for exhibition. The grain, too, is uniform, and quite fine. It's hardness and strength are about equal to those of the Carson stone, and satisfactory. It should resist the weather well, and appear to be a very fair stone for building purposes. Mr. L. B. Self, of Reno, is the owner.

Winnemucca: There are two varieties of these stones quarried near and used in Winnemucca. Neither are first-class in any respect, though they do well enough for the local uses. They are taken from the old lake beds, to the northeast of the town.

The first stone is quarried nine miles from the railroad station and hauled in by team. The color is a light drab, and quite uniform. The minerals and substances comprising the stone do not show, on account of the fineness of the grain. Some black flakes of mica are noticable, but nothing else. The hardness and strength are low, too low for anything but the smaller structures and the uses demanding little power to withstand pressure or stress. It stands temperature changes well, and were its strength higher would be an admirable building stone. Some new buildings have recently been erected in Winnemucca composed largely of this stone. Such local uses are well met, but the demand for such a rock will of necessity be limited to the town itself. Mr. Joe Pasquale is owner of the stone.

The second variety of sandstone is quarried from a point four miles from the town, and much more available. However, the quarry has been abandoned, on account of numerous faults and breaks in the material, which render the cost of obtaining stone fit for building almost prohibitive. The color is a light gray; the texture is coarser than in the first variety, and somewhat variable. The hardness and strength are considerably more than in the first, so that were the stone to be easily obtained its use would be wide. New developments later may show different and more favorable conditions. The new fire company house in Winnemucca shows a handsome front of this material. Mr. Pasquale is owner of this stone, as of the first.

Elko: At Elko there is a sandstone much like the first one described from Winnemucca. As with the rest of the soft materials, its use is limited to small buildings, where the strain upon it is light. The local demands are met sufficiently well by it, but it can never have wide use. There is surely much first class build-

ing material to be developed in this part of the state as the population increases.

MARBLE.

The marbles in Nevada are well represented, although little has been done to develop them. Only a few are quarried, due, of course, to the scattering demand and difficulty of gaining a market against other stone now used. It should not be many years before a steady market is open to them, not only in this state, but in others as well.

La Moille Valley: On the borders of this valley, in Elko county, exists a vast amount of a fairly good variety of marble. No quarrying has been done, but some stone has been taken out to show its character. The color is white in one variety, and a gray, or a laminated gray and white, in another. The white is clear, not marked by yellowish spots or flaws. The stone is rather finely crystalline, and takes a good polish. The marbles are all hard, brittle, and easily, though slowly, soluble in atmospheric waters, as has been discussed in a previous chapter. The rock is not very far from transportation facilities, and should meet with some demand. The uses are mainly interior ones, such as tiling for floors, mantels, mosaic work, and others. Mr. W. T. Crane, of Lee, Elko county, is the owner.

Humboldt Mountains: In these mountains a considerable amount of coarsely crystalline marble exists, which may prove of some value upon more careful investigation. What rock has been seen shows a pure white color with few impurities appearing on weathering. This is not the only place where such rocks are known to exist; it is cited merely as an instance of the little knowledge regarding these things.

Luning: More marble, of gray and white colors, exists in the region in the vicinity of Luning, Esmeralda county. Some of this has been quarried and used by Mr. Lindsay, of Carson, and it ranks with the others mentioned. It outcrops on the line of the Carson and Colorado railroad, hence is easy of access, which is a strong point in its favor. More facts concerning it are needed.

Topaz, California: Considerable marble is found in Antelope Valley, in California, opposite Douglas county, in this State. As its use and development comes naturally through Nevada, it needs a mention here. The stone varies considerably in color, from white to blue, gray, and yellow. As the locality is off the railroad, the development work has lagged, but the rock deserves some atten-

tion in the near future. The uses are those already mentioned. Mr. Lindsay, of Carson, owns much of the material.

Inyo County, California: Considerable marble has been quarried in Inyo county, California, and used both in Nevada and California for tiling, mantels, mosaic work, and such demands. Some of the rock is laminated; most is not, but cracks and flaws are quite common. There are three distinct colors of the marble, white, yellowish-white, and dark gray. The contrast between these is very pleasing to the eye. The lasting qualities are the same as the other stones of like nature possess. The stone works on the Truckee river above Verdi are handling this rock almost entirely and have some large contracts on hand.

TRAVERTINE.

Bridgeport, California: This variety of stone is related to the limestone, having been deposited by springs. A great deal of these deposits are to be found over southeastern California, Nevada, and Arizona, marking the sites of old springs. The only occurrence yet exploited in or near Nevada to any extent is near Bridgeport, in Mono county, California. The stone is a variegated reddish, and yellowish, very handsome when polished. It was used in the new City Hall in San Francisco. The work of exploitation needs to be carried farther, as it will be when more demand is made for the material. Its uses are purely ornamental.

It is needless to say that very many more stones suitable for purposes of construction exist in the State. Only those actually used, and those about ready to be used, have been listed. There are many more known; there are vast amounts to be discovered.

The frontispiece shows a number of the rocks mentioned actually in use in the "University Gates." The large columns supporting the gates are made from granite taken from boulders near Reno. The smaller pillars just outside are composed of Washoe granite, a shade darker than the first. The stone wall exhibits two more. The first, or ground course of blocks in the wall to the left is made of the andesite from the Fulton quarry, north of Reno. The upper three courses of stone are all the Carson sandstone. The finish throughout is rough, and the appearance very pleasing.

CHAPTER V.

ROAD METAL AND SOME GENERAL PRINCIPLES OF ROAD MAKING.

This subject does not come strictly under the head of building stones, yet its vast importance to the welfare of any community, together with the fact that some knowledge of rocks is essential to a proper understanding of it, more than justifies a short chapter setting forth a few fundamental considerations. The bicycle and other horseless vehicles have done one great work, if nothing else; they have shown conclusively to all people the value and immense importance of good roads.

Time was when the old earth road was held sufficient for all needs, and such roads were not even crowned. We still have many earth roads, which, when properly compacted and graded, do well enough for light traffic in sparsely settled regions. Where travel is at all heavy, however, earth roads become a makeshift, and some material which will not cut to pieces is needed. Very naturally, men have turned to rocks to furnish such material, termed in general, "road metal." The roads made by crushed rock on an earth foundation are called macadam, from the name of the man who introduced them.

For the purposes of road construction we have a vast abundance of rocks of various kinds and character. Bearing in mind the classification of rocks in Chapter II, we realize the range of choice. All of the igneous, atmospheric and metamorphic rocks, of hardness greater than earth, might be used. By class the igneous rocks are hardest, the atmospheric, softest; the igneous are more or less crystalline, the atmospheric largely fragmental. The metamorphic rocks are intermediate in their qualities. In Nevada there is a large development of all these kinds, easy of access. But this wide range of choice not only furnishes abundant possibilities, but also allows the selection of the best. It must be self-evident that all road materials are not of equal, nor anywhere near equal value. There is always a best and a poorest for every case. In order to select the best road metal for a certain street or road, a knowledge of the principles underlying such choice must be had. A brief account of these will be presented.

The fundamental fact on which all road making is done is the simple one that a highway is constructed to withstand constant wear. It must first be known, therefore, of what this wear consists. The wasting of a road is due, first, to chemical agencies; second, to physical agencies; and, third, to mechanical agencies.

The chemical agencies are those constantly at work in the atmosphere, and producing (1) solution and (2) decomposition, as pointed out under building stones. The physical agents are likewise atmospheric, and are: (1) frost, producing disruption of the road and of the individual rock fragments; (2) the effects of rain falling on the surface, running off, loosening the road surface and transporting the material away; (3) the wearing effects of the wind in carrying off the fine particles as dust. The mechanical agencies are due to the action of living things; the wearing down and grinding up of the surface; the crushing effect of heavy loads and impact of the feet of animals; and the possible injurious effects of roots. With roads properly constructed, of those forces tending to impair their usefulness the physical and mechanical agencies are most important.

Enough has been written of chemical agencies under a previous head, so that a mere mention is all that is here necessary. Such processes in nature are so slow that roads suffer little comparatively from them. However, chemical reactions play an important part in the process of compacting, or binding a road bed and making it durable. This power of binding, or cementing, in a road metal, is an essential quality, and the higher it is the better. All other things being equal, the ideal road material is that one which will furnish a large percentage of mineral, or minerals, that do not alter or which change very slowly, with some other mineral or minerals capable of furnishing, by slight decomposition, sufficient cementing substance to bind the whole together as a solid mass. The particular minerals best fitted to accomplish this end are those containing iron and alumina, with silica. Lime bearing minerals also are valuable. By way of a homely illustration, this process may be likened to a sidewalk made of nails, which, on being allowed to remain for some time, becomes rusted into a solid condition. There are several more important binding materials, as clay, secondary iron minerals, calcite or lime, and sometimes silica. These must form, in order to be of greatest good, in just the right amount to bind the gradually pulverized surface coating, as well as to harden the whole.

Of the physical agencies, in regions of considerable range of temperature, the action of frost may be of some moment. As mentioned under rock weathering, water, entering the pores of a stone and in cracks, on freezing becomes a powerful lever tending to disrupt the material. Also, the mere alternate cooling and warming by daily variation, gradually weakens a rock. In mild climates these things play no part. The effect of rain in loosening

ing and wearing away the road surface may become a source of danger in poorly constructed highways. The greater effect of rain is its power of transporting the layer of fine material necessary on every well kept road. This action is measured by the specific gravity of the minerals composing the rock surface, their shape, and their state of compactness. For instance, mica is a poor miner to have in a road metal, because of its flaky nature which allows of its easy transportation by the rain and wind. The selection of a stone must consider all these points. In like manner the winds are constantly picking up and carrying off as dust the lightest rock flour from the surface, often sweeping the streets clean of loose fragments and depositing dust over nearby houses and vegetation. Thus, the rain and wind, together or singly, are mainly responsible for the loss of that layer of finely ground rock which should constantly cover the top of every road and street a small fraction of an inch in thickness.

The mechanical agencies are the most easily seen, and are chiefly the grinding and pounding of the travel over the highways. The pulverized surface is thereby constantly loosened ready for the wind or rain, and just as fast as this disappears more is worn from the underlying rocks to replace it. Also, if the mass of the road be not well compacted, it will loosen, tending to form "chuck holes." Obviously, the heaviest traffic will do the most damage, and will be the most difficult to meet. The disrupting effect of roots should be reduced to nothing by a proper construction of the road bed.

Keeping these considerations in mind, it can be seen that a choice of road metal is made by considering for every case (1) the requirements which the road must fulfill; and (2) the power of given materials to meet these conditions. In any one locality the mechanical wear and tear is all that varies appreciably, the rest remaining practically constant. In other words, the traffic changes from place to place, so that we need harder and firmer highways in a city than in the open country. These five divisions of traffic are commonly made to denote this: City (perurban), urban, suburban, highway, and country road. City traffic is that existing on the streets of large cities, and no ordinary macadam can withstand it. Stone and wooden blocks, asphaltum, vitrified brick, and some few other substances are commonly used. Urban traffic is that common to city streets not used for continuous heavy teaming. The hardest and toughest macadam must be used, for the wear is heavy. Suburban traffic is, as the name denotes, that found on city streets in their outer limits, and in the main thor-

oughfares of country towns. A rock of less hardness and toughness is required. Highway traffic is that found on the main country roads, for which a material of medium qualities should be used. Country road traffic exists on the less used roads in the least settled districts. A comparatively soft rock is needed in these localities. This division of traffic is purely arbitrary, yet of the greatest importance. At first thought it might appear that a rock well fitted for the heaviest traffic would surely be satisfactory for lighter travel. No greater mistake could be made. The two opposed forces: the wear on a road, and the hardness, toughness and binding power of the material used, giving resistance to wear, must actually balance each other to give the highest results in any given case. The road surface, composed of the necessary layer of fine material, must be renewed just as fast as it disappears. In other words, speaking broadly, as fast as the wind and water carry away the materials from the top of a road, just so fast should the under rock fragments grind down under travel to form new surfacing. The amount of work done by the wind and water should be reduced to a minimum by selecting a road metal with maximum binding quality. Then the other qualities of the stone must be fitted to the needs of the travel destined to be over it. If too small a supply of fine surface material, or "binder," be furnished, because of too light traffic for the particular stone used, the road "ravels," and the underlying rock fragments project, making the road rough as well as weak. If too much protecting surface be supplied, from too heavy traffic, the excess results in dust or mud. In a moist climate a thicker layer of surfacing is permissible than in a dry climate.

Having these few fundamental considerations in mind, it is possible to choose a road metal with greater chances of its success. The three main characteristics which must be considered first are hardness, toughness, and binding power. Hardness is the resistance of a rock or mineral to rubbing, as by grinding on an emery wheel, and to force applied to crush the stone. Toughness is the resistance to fracture by blows, as continually delivered upon a road by travel. The cementing power has been explained as due to slight chemical change in the rock. It is also due, in small part, to the mere presence of a little moisture. It is well known how firm wet sand is compared to dry. In all cases, a slight percentage of water in the mass of road material is necessary. There is, naturally, much diversity of opinion regarding the values of the various road materials. A rock suitable in all respects for one locality may easily prove a total failure in another. A stone much

affected by frost should not be used in a cold region, nor will a brittle one give the best results in a dry climate. It appears to be the consensus of opinion that, all things considered those rocks called popularly "traps" are the best. These rocks are found typically as dykes, hence are intermediate in texture, and are largely diabase and diorite. They are among the toughest of the rocks, and usually have good binding power. The best varieties of these traps make satisfactory roads for urban traffic, but are too hard and tough for the lighter travel. The finer grained plutonic rocks probably come next in order of value, the more basic being the best as a rule, because of better cementing qualities. Granite is often frowned upon, yet some granites have given good results. The presence of hard, but brittle, quartz seems to be the chief objection, while micaceous granites, as well as all rocks containing mica, are unsatisfactory. However, given a binding power in a stone, any ordinary amount of free quartz is of real value, because it is not decomposed under ordinary conditions, and furnishes an unchanging base for the road. The volcanic rocks are of varying values. Basalt blocks are used for paving for city traffic, but for macadam their field is limited. Preference is given the crystalline rocks. Rhyolites, with sufficient binding power, have given excellent results in some localities. Andesites might also make good roads. The crystalline metamorphic rocks, the gneisses and schists have been used with good results. Of the atmospheric rocks, few seem to find favor. In the West, especially in California, such rocks have been largely used, with eminent success. In Golden Gate Park, San Francisco, a dark red chert has furnished material for the excellent roads, which are among the finest in the State. At other points around San Francisco bay, and in the interior valleys, where the climate is much like that of western Nevada, a metamorphic sandstone has made fine roads. Also, a dark basic diorite has been used for heavy traffic with satisfactory results. Limestone would seem on the face of the matter to be almost worthless as a road metal, yet some roads have been constructed of it in the east with great satisfaction. Some varieties are hygroscopic, that is, attract moisture from the air and might prove of service in a dry climate. Here in Nevada, and particularly near Reno, where the construction of stone roads will begin, there are several promising rocks. An immense supply of rhyolite containing considerable iron outcrops less than a mile north of Reno, and an abundance of a medium basic granite, much of it without mica, or with little, exists to the south and west. The latter rock, considering the traffic, might

easily prove a success. Andesite and basalt, of unknown value, are also near by. The reddish andesite used in the Carnegie Library should make an excellent material for light travel. More rock of a similar nature is to be obtained in abundance at Huf-faker's, on the line of the V. & T. railroad. The diorite of Mt. Davidson, and much of the unaltered rock extracted in the mines, should make a satisfactory rock for heavy traffic. Crystalline limestone, or marble, occurs in large amount in the eastern part of the state, as do many other desirable rocks for road metal. The possible value of lime rocks for road purposes in this dry climate has already been mentioned.

But in spite of these few general principles, and list of possible materials, there comes the one question "will such and such a stone be a success?" We are apparently confronted by the truth of the old maxim "the proof of the pudding is in the eating." Very fortunately, however, we are not driven to the necessity of actually constructing roads merely to test certain materials. The application of general principles to measurements of the various qualities of a rock not on a road building scale will tell almost everything needed in the way of information. Laboratories for the testing of road materials have been installed at several places in the United States. The two of particular value to Nevada are the laboratories at the University of California and at Washington, D. C., under the Department of Agriculture. In the latter case, any person may have a full test made of a rock for road construction free of charge, the only expense being that of freight charges on the railroad. Requests for blank forms and instructions should be addressed to the Road Materials Laboratory, Office of Road Inquiry, Department of Agriculture, Washington, D. C. Full tests are made, and the fitness of a stone for road material is given in detail. The laboratories at the University of Nevada are poorly equipped to make more than a few simple tests, for special apparatus is required. Considerable aid can and will be given to interested parties, however.

Although much in the way of principles underlying success in road construction have thus far been given, the most important condition of all has been assumed complied with, namely that the road be properly constructed. It lies beyond the scope of these few notes to enter upon the engineering side of road construction, and it is only urged upon the citizens of Nevada to inform themselves before commencing the building of stone roads. A perusal of the few references given at the end of the chapter will furnish all the facts necessary, and every voter should be acquainted with

them. Macadam roads cost from \$4,000 to \$10,000 a mile, and an error in construction or judgment in selecting suitable material may mean great loss to a community.

There are two more materials which deserve serious consideration used in constructing roads. The first, and perhaps of little adaptability or value to most of Nevada, is vitrified paving brick, laid like ordinary basalt blocks in a road. Roads of this nature have proved very efficient in the east, especially in the prairie States, and may prove of value elsewhere. A reference covering the subject is given. The second material is of the greatest value and adaptability to Nevada, with her dry climate. The unqualified and immense success of oil on roads, laying all dust and making a surface as smooth as asphaltum, recommends it as a possible boon to this section of the country, where water is scarce. When properly used, its success has always been immediate and great, and the consideration of its use is earnestly urged upon the citizens of this state. Its cost is nominal, and is partially compensated by the decrease in the cost of watering the streets treated. Some of the sandiest and dustiest roads in southern California have been made into perfect highways by its use, the result being much like a bituminized rock surface.

The following list of references will be found useful to all those interested. They may be obtained free of cost by applying to the Secretary of Agriculture, Washington, or at the Experiment Station at the University of Nevada.

(1.) "The Forces Which Operate to Destroy Roads, With Notes on Road Stones and Problems Therewith Connected." Circular No. 29. Office of Road Inquiry, U. S. Dept. of Agric.

(2.) "The Selection of Materials for Macadam Roads." Yearbook of Dept. of Agric., 1900.

(3.) "Historical and Technical Papers on Road Building in the United States." Bull. No. 17. Office of Road Inquiry.

(4.) "The Testing of Road Materials." Bull. No. 79. Bureau of Chemistry, Dept. of Agric.

(5.) "Methods of Constructing Macadamized Roads." Circular No. 21. Office of Road Inquiry.

(6.) "Highway Repairing." Circular No. 24. Office of Road Inquiry.

(7.) "Brick Paving for Country Roads." Circular No. 25. Office of Road Inquiry.

(8.) "Earth Roads." Farmers' Bulletin No. 136. Dept. of Agric.

(9.) "The Use of Oil on Roads." Year book of Dept. of Agric., 1902.

(10.) "The Social, Commercial and Economic Phases of the Road Subject." Circular No. 34. Office of Road Inquiry.

(11.) "Going in Debt for Good Roads." Circular No. 26. Office of Road Inquiry.

(12.) "Wide Tires." Bull. No. 12. Office of Road Inquiry.

CHAPTER VI.

CONCLUSION.

There are a few points to be emphasized and a few explained before bringing this paper to a close. The real need of such publications, incomplete as they must necessarily be in a new and undeveloped State like Nevada, is surely apparent to all progressive citizens. The vast size of the unknown and undeveloped in the State is almost appalling when contrasted with what little is known. And the work of the future, the proper opening up of the State in all possible ways, depends largely upon the methods of its accomplishment. The haphazard stage has been passed, and we must build solidly and scientifically. The bonanzas have been exhausted from the great Comstock, and the future of that famous lode rests upon the scientific mode of attacking the problem now present: that of working immense bodies of low-grade ore at a profit. And with the agriculture of the State, that industry which heretofore lagged behind the rest, the great problems of irrigation are fundamentally connected. Every detail must be worked out scientifically, in accordance with law and order. Likewise with the building stones of Nevada. No order, and little real knowledge has governed the choice and use of materials in the past. No harm has been done, because the needs were few and simple. But with the growth of large towns and cities, new and great buildings will be required, and real scientific facts about the materials of construction available will be needed. And so with many other lines of human activity. We need not only to know, but to know in the right way; to have scientific knowledge, to understand law and truth. It is largely to aid in bringing about the acceptance of such considerations that this paper has been written.

Regarding the subject matter, a few words of explanation seem necessary. First, the rock classification may strike petrographers as rather behind the times. It is, and necessarily so. The tendency of modern petrographic thought is toward the drawing of fine lines, and the classification of rocks in accordance with new ideas and conceptions. This is all necessary and right, but the uninitiated have no use for such terms as "persalane," "dofemic," and the rest. A popular terminology will and must always be distinct from the petrographic, if such names are universally adopted by scientists. The main idea underlying the writing of the chapter on the classification of rocks is this: To convey some definite idea to the practical man re-

garding the meaning of the general names of rocks, with the characteristics appertaining thereto. Very unfortunately, it seems to the writer, that with the advent of more exact petrographic nomenclature must come more or less of a dual classification of rocks. The old terms are good and sufficient for all practical needs, and need no change for these purposes, no matter to what lengths the more exact terminology may go. Moreover, they cannot be changed, for obvious reasons, and this must not be forgotten by the scientist in his search after truth.

The chapter on the qualities of building stones is complete enough for the purposes of the present paper but will need more details for a larger report. The larger facts are, of course, given in full. Amplification of the methods of testing building materials is likewise needed when a final report is issued.

Regarding the rocks themselves, the list brings to light some important facts. It is to be seen that at present some amounts of stone are used, and that this use is daily increasing. Also it is stated with the awakening of the State to new and better times, a great increase in stone buildings will occur. But the cardinal point is this: So very little is known definitely about Nevada; the welfare of the State depends largely upon this knowledge of her resources, not only in the one small line of building stones, but in all the ways of human activity. This thought should not be lost sight of for an instant.

The chapter on road metal is included because it is believed to fill a real need for information. Reno must soon lay new streets to meet the demands of an increasing population, and it will not be long before some of the other large towns follow suit. And road construction, like many other engineering works, looks easy to the uninstructed. To the business man, mining appears to consist of digging a hole and taking out ore. Likewise to the same ordinary man of business, road making seems to consist merely of dumping a lot of rock on a road and smoothing it off a bit. Both ideas are greatly in error, and it is high time every good citizen knew something of the proper construction of roads. And it is to be remembered that it is not always, nor often, that the street which costs the least to construct is the cheapest.

Lastly, it is to be stated that all in his short paper has been written in the dawn of the light coming from the new day of prosperity for the State of Nevada, with her boundless wealth of material things just beginning to awaken due appreciation.

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