

ART. LII.—*Igneous Rocks of Yogo Peak, Montana*,* by
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THE two great geographic provinces of Montana, the Plains and the Cordilleran region, which form the eastern and western parts of the State respectively, are quite as sharply delimited as is usually the case along the Rocky Mountain front. In the central part of the State, however, the broad level expanse to which the Cretaceous rocks have been reduced is broken by several mountainous tracts, rising abruptly above the plains and suggesting the Indian designation of "Island Mountains." To the westward the continuous but irregular front of the Rocky Mountain Cordillera stretches in a sinuous, indented line, in a generally northwest and southeast direction.

In the northern part of the State the Rocky Mountains present an abrupt chain of rugged, serrated peaks, which are visible for a hundred miles eastward. To the southward, where the Missouri emerges from the mountains and enters the open plains, the main chain or continental watershed is flanked by the low and broad mountainous area of the Belt ranges, and still farther south, where the waters of the Yellowstone Lake feed the mountain drainage, the front of the Cordillera is composed of several lesser and detached mountain systems.

The Belt Mountains, although a part of the Rocky Mountain Cordillera, constitute an area between the western limits of the Plains and the mountain valley of the Missouri river. This broad and relatively low mountain district is separated by the wide, intermontane valley of Smith river, a tributary of the Missouri, into two ranges, known as the Big Belt and the Little Belt mountains. Yogo Peak, whose rocks form the subject of the present paper, is a conspicuous summit of the Little Belt Mountains, the easternmost of these two ranges.

The Little Belt Mountains thus form a distinct geographic unit in the topography of the State. They are flanked by the valley of the Musselshell river on the south, and extend, from the Judith Gap on the east, westward to their union with the Big Belt Range in the canyon of the Missouri river. They are embraced between the meridians of $109^{\circ} 45'$ and 112° west longitude, and the parallels $45^{\circ} 30'$ and $47^{\circ} 15'$ of latitude.

The Belt ranges together constitute a broad anticlinal uplift formed by the union of the lesser anticlinal axes of the two ranges. The Little Belt uplift has a southeast and northwest trend and dies out in the eastern point of the range at Judith Gap. In the central portion of the mountains the anticlinal uplift is

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broken by profound faults, while the outer flanks of the range show many subsidiary folds further modified by laccolitic and other forms of igneous intrusions. Metamorphic rocks, which belong to the Archean complex of the region, are exposed in the central portion of the range and are covered by a series of sediments known as the Belt Mountain formation, belonging to the Algonquin (or possibly lower Cambrian) age. The overlying Paleozoic series is well developed, characterized by abundant fossil faunas, and includes all the subdivisions thus far recognized in the northern Rocky Mountains. The Mesozoic does not occur within the mountain region, but is everywhere upturned upon the flanks of the range.

The topography of the area is a consequence of its geologic structure. The heavily-bedded Paleozoic limestones, which are nearly horizontal in the central portions of the mountains, form broad and level, pine-clad plateaus whose average elevation is 8,000 feet above the sea and 4,000 feet above the adjacent plains. These plateaus are trenched by the streams whose valleys vary in character with the nature of the rocks, being especially bold and rugged where cut through the massive, heavily-bedded Carboniferous limestones. This is especially noticeable along the course of Belt Creek and in the canyons of the Judith river, the two principal streams which drain the mountains. The former exposes excellent sections along its course, the stream cutting through the Archean area, flowing in a high-walled canyon across the Cambrian rocks and emerging from the mountains through Sluice Box Canyon, a narrow gorge cut in the heavy Carboniferous beds. A branch of the Great Northern railroad, built along the course of the stream, runs to Neihart, a well-known mining town situated near the head of Belt Creek.

While the range as a whole consists of uplifted sedimentary strata, this structure is greatly modified by igneous intrusions in the northern part of the mountains. Several large typical laccolites, only partly stripped of their sedimentary cover, form the dominant peaks of this part of the range, and two centers of igneous intrusion have been found where massive, granular, igneous rocks occur. One of these is found at Barker, a town at the head of the dry fork of Belt Creek; the other at Yogo Peak, the most striking and nearly the highest peak of the mountains.

Yogo Peak.—Yogo Peak is from many points of view the most conspicuous elevation of the Little Belt range. Although not snow-capped, it projects above the timber line, and its sombre crown of crags, formed of massive igneous rock, is in sharp contrast to the rounded summits and level plateaus adjacent. It is situated 8 miles east of Neihart and on the high

divide between the waters of Belt Creek and the Judith river, and reaches an elevation of 9,000 feet above tide. The ridge above which the summit stands has an open and park-like character. The adjacent streams have cut deeply through the horizontal sedimentary rocks, and the broad valley bottom of Dry Wolf Creek on the north and the placer bars of Yogo on the south are 3,000 feet below the crags of the mountain summit. The region about Yogo Peak is formed of Paleozoic rocks in which there are numerous intrusive sheets and occasional dikes of igneous rocks. The mountain mass itself is due to the resistant nature of the massive igneous rock, which forms a stock breaking up through the horizontal sedimentary rocks. The flanks of the mountain show these bedded rocks well exposed and forming benches which mark the more resistant beds. The stock itself is a huge chimney of massive rock that has produced considerable contact metamorphism near its junction with the sedimentary rocks. On the southwest side of the peak an uplifted block of the limestones has been broken off, tilted and injected with a number of intrusive sheets thrust in from the adjacent volcanic neck. The northern slopes are obscured by debris and talus slides which hide the exact contact between the stock and the sedimentary rocks, but on the south face of the mountain a branch of Yogo Creek has cut an amphitheatre, whose massive walls of naked rock rise hundreds of feet above the basin whose deep blue lakelets and perennial snow banks form a pleasing feature of the mountain scenery. The marbleized and altered limestones are here seen in actual contact with the massive rock. In general, the alteration of the sedimentaries adjacent to the stock rock has been accompanied by mineralization, producing ore deposits that have been prospected at a great number of points, although they have thus far proved of too little value to warrant working. The summit of the peak is composed of three knobs or hills, separated by small saddles and grassy Alpine meadows. These summits lie in a nearly east and west line, the two outer knobs being a mile and a half apart. They are covered with projecting crags or piles of debris, with the rock in place below them. To the east the peak ends in a shoulder covered by a heavy mantle of platy slide rock, which extends down to a low saddle separating it from the low mountain ridge which extends eastward to Woodhurst Mountain. The mountain summit shows no evidence of glacial action, and a small moraine in the amphitheatre is the only record of former glaciation. The Yogo Peak core is thus a huge chimney of massive granular rock, having a length of two miles in an east and west direction, and a width of one mile. The study of the region shows that this stock occupies the southwestern and expanded end of a great fracture which

has ruptured the sedimentary series, and extends for 10 miles to the northeast in a somewhat irregular line. This fracture is marked by a series of upbreaks of igneous magmas of various types which form intrusions of varying width, accompanied by laccolitic masses, intruded sheets and numerous dikes. The type of rock immediately adjacent to the Yogo Peak mass is a quartz syenite-porphry, forming the low saddle northeast of the peak and which is succeeded eastward by a repetition of Yogo Peak rock types. Although this rock comes in actual contact with that of Yogo Peak, the line is hidden by debris and its character cannot be determined.

The rock types whose varying phases are discussed in the present article are from the Yogo Peak mass itself, and as the stock shows a constant variation and gradation in its chemical and mineralogical composition along its east and west axis, three types have been selected to show the variation, the specimens coming from the east, middle and western points of the summit of the peak. For purposes of convenience, these will be designated as types from the east, middle, and west knobs respectively.

Petrography of the Yogo Peak Rocks.

Syenite. East knob rock type.—The rock mass composing the high eastern shoulder of Yogo Peak possesses a platy parting which causes it to split readily and to form piles of debris and talus slopes, above which project the low and much-jointed exposures of the rock in place. The joint blocks are short, stout rhomboids, or heavy plates a foot or so long. They are very hard and tough, ring sonorously under the hammer, and are broken with difficulty, the rock being unaltered and fresh. These characters prevail for the entire Yogo Peak mass.

On a freshly fractured surface the rock appears evenly granular, of moderately fine grain, and is compact in character and with few miarolitic cavities. The color is a medium gray with a strong pinkish tone. The rock is clearly a feldspathic one, and of syenitic aspect. Examined with the lens, it is seen to be chiefly composed of light-colored feldspar, dotted with small, dark, formless spots of green pyroxene or hornblende.

The microscope shows the following minerals to be present: apatite, titanite and iron ore, pyroxene, hornblende and biotite, orthoclase, oligoclase and quartz. The apatite and titanite are of the usual characters common to such rocks. The iron ore is not abundant and occurs in small grains of about 1^{mm} in diameter. The pyroxene is a very pale green diopside and is much cracked and broken up. It frequently appears like a bundle of rods. It is rarely alone and generally occurs in

common with a brownish-green hornblende. The two minerals are very frequently found together in stout, ill-shaped crystals from 1 to 2^{mm} long, the pyroxene forming a core, surrounded by the hornblende. In such cases the amount of pyroxene is inversely proportional to that of the hornblende. The appearance and association of these two minerals clearly show that the hornblende is paramorphic after the pyroxene. The latter rarely occurs alone, while the hornblende frequently does so. Biotite is rare and occurs only as occasional brown pleochroic shreds.

Orthoclase is the predominant feldspar, occurring in irregular masses. A much smaller quantity of plagioclase is also present, the optical characters proving it to be oligoclase. It is more idiomorphic than orthoclase and is, indeed, often surrounded by a mantle of the latter mineral. A small amount of interstitial quartz completes the list of minerals.

In structure the rock is hypidiomorphic, but only partly so, as the pyroxene and hornblende are themselves rather ill-formed and irregular, and the tendency is toward an allotriomorphic structure. The average size of grain is about 1^{mm}.

The following analysis shows the chemical composition of this rock. It has been made by Dr. W. F. Hillebrand of the U. S. Geological Survey, a chemist whose skill and painstaking accuracy have been of such vast service to American petrography.

Syenite from Yogo Peak.

SiO ₂	61.65
TiO ₂ .....	.56
Al ₂ O ₃	15.07
Cr ₂ O ₃	trace
Fe ₂ O ₃	2.03
FeO	2.25
MnO .....	.09
MgO	3.67
CaO	4.61
BaO .....	.27
SrO .....	.10
Na ₂ O	4.35
K ₂ O	4.50
Li ₂ O	trace
H ₂ O at 110° .....	.26
H ₂ O above 110° .....	.41
P ₂ O ₅ .....	.33

100.15

The above analysis is that of a syenite with moderately high lime, iron and magnesia for a rock of the syenite group. The

comparatively large amount of soda present cannot be entirely in the oligoclase, and the unstriated feldspar undoubtedly contains the albite molecule to some extent. The barium and strontium are possibly present in the feldspar. The mineral and chemical nature of the rock show it to have a somewhat dioritic tendency.

Yogoite. Middle knob rock type.—West of the eastern knob of Yogo Peak the rock forming the summit of the mountain gradually changes in character until it assumes the type which characterizes the middle knob and which is so well displayed in the crags which form this point. The rock has a parting similar to that of the syenite described above, and is like it in its general characters. On a freshly fractured surface the rock is, however, seen to be of a very much darker gray in color, with a greenish tone, and to be more coarsely crystallized, so that it possesses a mottled appearance, recalling a diorite in its habit. Even at a casual glance the rock is seen to be more basic than the syenite, and the ferro-magnesian minerals appear to make up half the bulk of the rock. The reflection of light from numerous cleavage plates of small biotite crystals is also noticeable.

Microscopically, the minerals are seen to be the same as those in the syenite, but with the following differences: The augite, which was a nearly colorless diopside, is here a clear, light green mineral, quite idiomorphic, and having the usual cleavage and appearance, and containing frequent shreds of biotite and granules of iron ore as inclusions. It is very abundant in rather small, stout crystals, and constitutes, in fact, the main ferro-magnesian component. Paramorphs of augite and hornblende are still seen, but they are rare, and the hornblende has dwindled to a very small amount. Iron ore is more abundant than in the syenite and the grains are larger. Biotite is quite abundant in strongly pleochroic tablets of the usual type. The ratio of the plagioclase to the orthoclase is nearly the same as in the syenite. It is, however, somewhat more basic, approaching andesine. The orthoclase is like that of the syenite, but shows a more marked preference to surround the plagioclase and to appear in broader plates. Quartz is wholly wanting. The two predominating minerals are augite and orthoclase, and the great increase of the former over the latter, as compared with the ratio prevailing in the syenite, is disclosed in the chemical composition, as shown in the following analysis by Dr. Hillebrand:

Analysis of Yogoite.

SiO ₂	54.42
TiO ₂ .....	.80
Al ₂ O ₃	14.28
Cr ₂ O ₃	trace
Fe ₂ O ₃	3.32
FeO	4.13
MnO .....	.10
MgO	6.12
CaO	7.72
BaO32
SrO13
Na ₂ O	3.44
K ₂ O	4.22
Li ₂ O	trace
H ₂ O at 110°22
H ₂ O above 110°38
P ₂ O ₅59
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	100.19

The features of this analysis are the moderate silica and alumina percentages, with the high amount of iron, lime, magnesia and alkalis. Although the minerals (if not quantitatively expressed) are those of the syenite, its chemical composition removes it very far from any typical syenite. The chemical characteristics are, indeed, those of the lamprophyre group, yet it is a fairly coarse-grained, evenly granular rock, forming a transition phase in the center of a great stock. It is to this type that we have given the name of "*Yogoite*," and the reasons for so doing and its systematic position will be discussed later.

Shonkinite. West knob rock type.—The character of the outcrops occurring on the western end of the peak differs somewhat from those which have been previously described. The rock does not possess the thick, platy parting that prevails to the east, but has an exceedingly massive character, giving rise to bold, heavy crags and castle-like forms, often of curious shapes, which rise abruptly from the small grassy plots lying between them. The rock is exceedingly tough and breaks under the hammer with great difficulty. It has changed gradually in character until here it is as much darker than the *Yogoite* of the middle knob as the latter is with relation to the syenite. On a fresh fracture the rock is of a very dark stone color, and at first glance recalls many coarse, dark gabbros. On inspection it appears that the quantity of ferro-magnesian minerals is very large, and the eye is caught by the reflection of numerous plates of a dark brownish biotite, which average several millimeters in diameter. With the lens a great

abundance of small augites are also seen in the feldspathic constituent.

Under the microscope the same minerals are present as in those of the two types just noted, but the augite, biotite, and iron ore have greatly increased in amount. The increasing tendency of the orthoclase to surround the plagioclase has here resulted in producing broad plates in which small, stout plagioclase laths lie scattered about unoriented. The plagioclase has become more basic and is now andesine. Its amount, compared with that of the orthoclase, has gradually diminished from the syenite down. The broad areas of orthoclase not only contain the plagioclase, but also the other constituents, in a poikilitic manner. Pseudomorphs after olivine are sometimes seen, with an occasional unaltered remnant of olivine substance still remaining. The augite is darker than in the preceding types, and occasional paramorphoses to hornblende still occur. The biotite is fresh, clear, and strongly pleochroic, at times changing to a clear, dark green variety. Apatite is more abundant and is in larger crystals. The structure is a hypidiomorphic, granitoid one. The analysis by Dr. Hillebrand is as follows:

	Shonkinite of Yogo Peak.	Shonkinite of Square Butte.
SiO ₂	48.98	46.73
TiO ₂	1.44	.78
Al ₂ O ₃	12.29	10.05
Cr ₂ O ₃	trace	----
Fe ₂ O ₃	2.88	3.53
FeO	5.77	8.20
MnO .....	.08	.28
MgO	9.19	9.68
CaO	9.65	13.22
BaO .....	.43	undet.
SrO .....	.08	undet.
Na ₂ O	2.22	1.81
K ₂ O	4.96	3.76
Li ₂ O	trace	trace
H ₂ O at 110°26	} 1.24
H ₂ O above 110°56	
P ₂ O ₅98	1.51
F22 Cl18
	<hr/>	<hr/>
	99.99	100.97
O=Fl	.08 O=Cl	.04
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	99.91	100.91

The consideration of this analysis shows the relatively low silica and alumina and the very high amounts of iron, lime and magnesia. The alkalis are still present in considerable amount,

the potash predominating. The analysis is essentially that of a minette, but recalls also the composition of certain tephrites and leucitites. The rock is, however, a rather coarse, massive, evenly granular, stock form, consisting chiefly of augite and orthoclase with considerable accessory biotite, iron ore, and plagioclase, with a lesser amount of olivine and apatite.

At the west end of Yogo Peak a variation of the above type is found that forms large, irregular masses near the contact, the rock being noticeable for the very large, spongy, biotite crystals which it carries. These biotites are at times 1^{cm} across a cleavage face. They are made up of a number of smaller, nearly similarly oriented individuals mixed in with other constituents. Although the mica is subordinate in amount, it has the appearance of being predominantly present, and the rock appears at first glance to be almost wholly made up of these coarse biotite crystals. Examined in thin section under the microscope, it is seen to be composed of the same minerals as the type last described, but the olivine is fresh, showing little or none of the change into resorption pseudomorphs, and the total amount of iron ore, augite, and biotite is greater. The augite is still the predominating ferro-magnesian mineral. The orthoclase shows a still greater tendency toward the poikilitic structure, occurring in broad plates, enclosing other minerals—that is, filling the interspaces between them in similarly oriented areas. It is noticed also that the biotite occurs at times in this manner with respect to olivine, iron ore, and augite, and hence it is later in formation. Sometimes the olivine is surrounded by orthoclase, an uncommon association of these two minerals. In its period of formation, however, the olivine antedates all the other minerals.

As yet, no analysis has been made of this type, but from a study of the section and its comparison with the foregoing types, and of their analyses with one another, it is clearly evident that the process of differentiation which is under description has advanced somewhat further than in the last analysis, and that this rock would show still lower silica, alumina, and soda, with higher lime, iron and magnesia and considerable potash dominating the soda.

Recently under the name of *Shonkinite** we described a rock type from Square Butte in the Highwood Mountains of Montana, some forty miles to the north of Yogo Peak, where it occurs, as the outer differentiated zone of a laccolite composed chiefly of sodalite syenite.

It is a rather coarse, granular rock composed chiefly of orthoclase and augite with accessory iron ore, apatite and biotite with a very small accessory amount of sodalite and traces of nephe-

* Bull. Geol. Soc. Am., vol. vi, pp. 400-422, 1895.

lite, the appearance of these latter minerals in minute amount being clearly influenced by its association with the sodalite syenite. Its recognition as a distinct rock type is founded on its coarse granular structure and the predominance of the ferro-magnesian minerals over the feldspathic one, orthoclase. For purpose of comparison its analysis is quoted beside that of the type described above.

From what has been said it will be seen that the West Knob type of Yogo agrees very closely with the shonkinite of Square Butte, and this agreement is even more marked in the variation with large micas than in the type analyzed. They agree in structure, mineral composition and chemically. In the hand specimen they have a somewhat different habit, owing to the fact that in the Square Butte type of shonkinite the augite crystals are much larger and more idiomorphic than in that from Yogo Peak, while the actual amount of biotite is somewhat less. Under the microscope they closely resemble each other and both have the broad, poikilitic orthoclase areas and the large skeleton biotites. It gives us pleasure to announce the occurrence of this rock type from a second distinct locality.

Differentiation at Yogo Peak.—From what has already been stated it is evident that at Yogo Peak we have a stock of intruded igneous rock of an oval shape which shows a progressive differentiation along its major axis. The rock mass contains essentially the same minerals throughout, but there is a progressive increase in the ferro-magnesian species toward the western end. This is brought out still more strongly by a comparison of the chief rock-making oxides.

	Syenite.	Yogoite.	Shonkinite.
SiO ₂	61·65	54·42	48·98
Al ₂ O ₃	15·07	14·28	12·29
Fe ₂ O ₃	2·03	3·32	2·88
FeO	2·25	4·13	5·77
MgO	3·67	6·12	9·19
CaO	4·61	7·72	9·65
Na ₂ O	4·35	3·44	2·22
K ₂ O	4·50	4·22	4·96

Here almost without exception the change is progressive. The silica, alumina and soda diminish; the iron oxides, lime and magnesia increase; the potash remains the same or relatively increases. In this connection it is interesting to observe the conduct of the rarer, less essential oxides, which occur in amounts sufficiently large so that the differences between them are evidently not those which fall within the limits of analytical error.

	Syenite.	Yogoite.	Shonkinite.
TiO ₂	·56	·80	1·44
BaO	·27	·32	·43
P ₂ O ₅	·33	·59	·98

The change is of precisely the same character as with the main oxides, there is a progressive increase toward the basic end, the titanium is concentrated in the iron ore and the phosphoric anhydride shows itself in the larger amount of apatite present, while the function of the barium is somewhat uncertain. Instances of intrusive stocks which vary in composition in different parts of the same mass are well known, such as for instance that of Carrock Fell, which has been so ably described by Harker,* where the mass grows steadily more basic toward the margin, or that of Ramnäs mentioned by Brögger,† where the reverse is the case. In his recent important monograph‡ Brögger names a rock series which occurs in one individual mass, and which has been formed by the differentiation of the mass in its final resting place ("laccolitic differentiation"§), a "*Facies suit*" to distinguish it from a series of rocks formed from independent magmatic eruptions which show also a continual progression or gradation in their mineralogical and chemical composition. The series is termed a "*Rock Series*" (*Gesteins serie*) in the latter case. The Yogo Peak mass shows an excellent example of the first class, but it is also to be expected that in many given regions a "*facies suit*" in one erupted mass will correspond to a "*rock series*" which may be developed in the region at large.

This may be shown, in part at least, for the Yogo district by taking in addition to the series of analyses of Yogo Peak three others, one of a quartz syenite porphyry constituting an immense uncovered laccolite at Big Baldy Mt., some miles northwest of Yogo, and one of a rather coarse-grained augite minette that forms a thick intrusive sheet a number of miles southwest of Yogo, one of a great series that is genetically connected with it in the Little Belt Mts. series of intrusions. These are taken from very complete analyses by Dr. Hillebrand, but here only the important rock-making oxides are considered. To these is added also the analysis of the shonkinite from Square Butte previously given.

* Quar. Jour. Geol. Soc., vol. 1, p. 311, 1894, vol. li, p. 125, 1895.

† Zeitschr. f. Kryst., vol. xvi, page 45, 1889.

‡ Gesteine der Grorudit-Tinguait Serie, p. 179, 1894.

§ Loc. cit., p. 153.

	Quartz syenite porphyry. Big Baldy Mt.	Syenite Yogo.	Yogoite Yogo.	Minette Sheep Creek.	Shonkinite Yogo.	Shonkinite Square Butte.
SiO ₂	67.04	61.65	54.42	52.26	48.49	46.73
Al ₂ O ₃	15.25	15.07	14.28	13.96	12.29	10.05
Fe ₂ O ₃	1.69	2.03	3.32	2.76	2.88	3.53
FeO	1.13	2.25	4.13	4.45	5.77	8.20
MgO	1.75	3.67	6.12	8.21	9.91	9.68
CaO	2.17	4.61	7.72	7.06	9.65	13.22
Na ₂ O	4.09	4.35	3.44	2.80	2.22	1.81
K ₂ O	5.10	4.50	4.22	3.87	4.96	3.76

The very regular gradation which this series shows is quite remarkable, as may be seen in the above table. There are very few irregularities in it. The variations are all along the same lines as those shown at Yogo Peak itself—the gradual fall of silica, alumina and soda together, with the predominance of potash over soda, may be taken as characteristic of this “petrographical province.” From consideration of the analyses and the character of the differentiation that has taken place at Yogo Peak, together with the fact that the coarse mica type of shonkinite shows this differentiation in a higher degree than the type analyzed, it seems probable that it must agree in chemical composition with the Square Butte rock even more closely than the type analyzed does.

Classification of the Yogo rocks.—Here we enter a vexed field. Those who believe in classifying rocks solely by their structure and the *kinds* of minerals they contain without placing any importance upon the *relative quantities* present, or in other words place no stress upon the chemical composition of the magmas from which the rocks are derived, would doubtless call all of the rock varieties at Yogo Peak syenites, since they are composed chiefly of augite and orthoclase.

It seems to us that the time has come when a sharp distinction must be drawn between the use of general terms used by field geologists, such as granite, porphyry, trap, greenstone, etc., and the more exact and definite nomenclature demanded by the needs of petrology. Such general terms have a definite and proper value just as tree, bush and vine have in botany, but the science of petrology demands at present a terminology which will not only be *qualitative* but also *quantitative* in its meanings. While it is neither possible nor desirable to classify rocks on a strictly chemical basis, it is clearly evident that the lines of mineral and consequently of chemical variation must be more strictly drawn than has hitherto been done. This will find its natural manifestation in a more strict regard to the relative quantities of the various minerals which are present and these quantities within reasonable limits must be expressed.*

* See also the discussion of this subject by Brögger (Gest. der Grorudit-Tinngait Serie, p. 91, with whose excellent presentation of the subject we, in the main, heartily agree).

The present work has shown that, starting with the most acid form, we have at Yogo Peak a series of partial magmas with gradually rising lime, iron and magnesia, falling silica, alumina and soda, with potash as the dominant alkali. These crystallized into a series of massive, evenly granular rocks composed chiefly of augite as the ferro-magnesian mineral, but with accessory iron ore, biotite and possibly amphibole and olivine, while the feldspathic component is essentially orthoclase with which may be associated accessory plagioclase. For this series (adding the natural extremes not found at Yogo) we propose the following classification:

All orthoclase, no augite = Sanidinite.
Orthoclase exceeds augite = Augite-syenite.
Orthoclase equals augite = Yogoite.
Augite exceeds orthoclase = Shonkinite
All augite, no orthoclase = Pyroxene and peridotite rocks
of various types.

Such a method of classification is a natural one and it does not present hard and fast arbitrary boundaries, but leaves a certain amount of elasticity in the determination of the types. Within certain lines it must also determine the chemical composition. Under the term augite is, of course, included the other accessory ferro-magnesian minerals, as the accessory feldspathic ones are included under the orthoclase.

Summary and Conclusion.—While there are many points of interest connected with the Yogo massif, which in the brief limits of this article have not been touched upon, such as its contact phenomena, the occurrence of aplitic dikes cutting it and its connection with radial dikes and encircling intrusive sheets of various rocks as well as questions of theoretic petrology to which its discussion must give rise, we have endeavored to present the following facts, which will be of general interest.

That Yogo Peak is composed of a core or stock of massive, granular, igneous rock, and that this rock is composed chiefly of augite and orthoclase. That the mass shows a progressive differentiation along its east and west axis, with a continual increase in the ferro-magnesian elements over the feldspathic ones. The resultant rock types have been classified into three groups: syenite, where feldspar exceeds augite; yogoite, where they are practically equal, and shonkinite, where the augite dominates, the latter being similar to a rock type previously described.

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