A PECULIAR SHONKINITE RELATED TO GRANITE.

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Introduction.

The shonkinite in Montana, from which the rock type was named,[1] is a rock with abundant augite, some alkali feldspar, and in places some nephelite or olivine. It is genetically related to leucite-basalt and sodalite-syenite. The term shonkinite has been found useful, however, in naming a number of other rocks, and the definition may well be broadened, as it was by the men who invented the term, to include other alkali feldspar rocks in which mafic minerals predominate.[2] Nephelite is certainly not to be considered essential.[3]

Shonkinites in this broad sense are notably abundant in the border zones of some Algomian granites in Minnesota. One spotted variety of the rock is so strikingly peculiar that it may deserve a distinct name as a rock type. It is here suggested that it be called shonkinite (Basswood type).

General Occurrence and Character of Shonkinite (Basswood Type).

The shonkinites here described have been seen in connection with four distinct granite masses. Most of the occurrences discovered are near the border of the granite, but a few are apparently blocks stoped in to the granite magma that remained liquid after the shonkinite crystallized.

The striking peculiarity of the rock under discussion is the occurrence of white spots in a dark matrix. See fig. 1. This appearance is not that of a granitoid rock with grains of different colors; but the dark granitoid

[1] Weed, W. H., and Pirsson, L. V., Highwood Mountains of Montana: Bull. Geol. Soc. Amer., vol. 6, p. 415, 1895.

[2] Weed, W. H., and Pirsson, L. V., Igneous rocks of Yogo Peak, Montana: this Jour. vol. 50, p. 476, 1895.

[3] Jour. Geol., vol. 9, p. 614, 1901. In this respect Johannsen's classification of shonkinite (see Jour. Geol., vol. 28, pp. 219-220) departs from the original.

matrix includes large light colored, somewhat rounded spots. The spots and background differ in proportion in different outcrops, but are commonly about equal in volume. In many outcrops the rock is in bands, not over 20 feet wide, alternating with other differentiates of the granite, and making up 10 to 50 per cent of the mass

FIG. 1.—Banded syenite near High Lake, Minnesota.

exposed. See fig. 2. The bands of spotted rock seem to be of the same series of differentiates as the bands of syenite with which they alternate, and there can be no doubt that the spotted rock originated by differentiation of an igneous magma.

This spotted rock is so easily detected and distinguished from the more nearly normal granitoid rocks that it is useful in identifying the border of an intrusion even when the wall rock is an older granite that might be mistaken for a phase of the same mass.

DETAIL OF OCCURRENCES AND ASSOCIATES.

The largest granite mass in Minnesota is a pink biotite granite of the Vermilion batholith in northern St. Louis County.[4] Along much of its south side and in a few places on its north side, there are hornblendic rocks,

[4] A general description of the batholith is in press in Journal of Geology.

much less acid than the main mass, grading to syenites, shonkinites, pyroxenites, and even magnetite segregations. The spotted rocks occur in this series and can be seen most readily on the north side of Frazer bay of Vermilion Lake. The most instructive outcrops, however, are those that are conspicuously banded; they out-

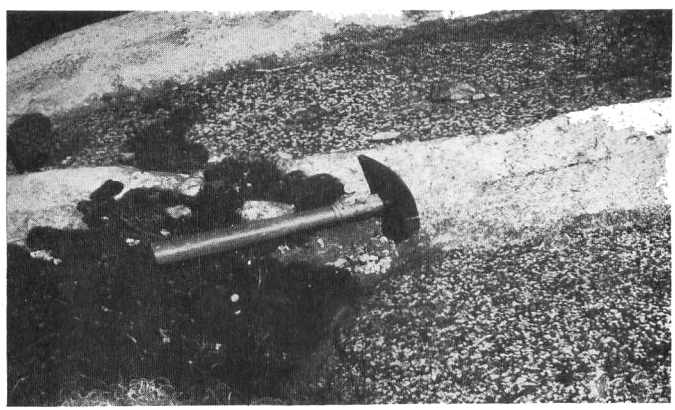

FIG. 2.—Shonkinite (Basswood type). This spotted rock alternates with syenite in wide bands.

crop near High Lake, and can be reached best by canoe, north of Ely.

An outcrop of shonkinite (Basswood type) in Sec. 21, T. 61 N., R. 21 W., is supposedly related to the Giants Range granite.[5] Several other dark hornblendic rocks outcrop near by, but the relations are somewhat obscured by the drift cover.

A stock of augite soda granite has long been known about the shores of Kekequabic Lake.[6] Doctor Grant recently called the writer's attention to a dark rock of doubtful origin along the south side of the granite. On careful examination it proves to be so similar to the spotted rocks above noted, that it is almost certain to have the same sort of origin. Its border position certainly favors the idea.

[5] This mass is being studied by Dr. I. S. Allison.

[6] Grant, U. S., The geology of Kekequabic Lake: 21st Ann. Rept. Minn. Geol. and Nat. Hist. Survey, pp. 8-58, 1893.

At Snowbank Lake is a stock of syenite and granite.[7] Several belts of dark rocks have been discovered in the stock and one of the largest belts, between Snowbank and Round Lake, is the spotted Basswood type, with normal syenites both sides of it.

The sequence of differentiates in each of these granites is to receive further description,[8] but notes are here given to indicate the relations of the new rock types. In the following table of measured modes, the plagioclase is in most cases oligoclase or albite, but in one case andesine. Most of the rocks show no unusual features as igneous rocks, but questions may be raised as to the origin of highly hornblendic rocks. Hornblendites are not rarely attributed to paramorphic alteration of pyroxene rocks. Some of the Minnesota shonkinites are found to be characterized by associated augite and biotite, others by augite and hornblende, still others by hornblende and biotite or by hornblende alone. There is no sign of alteration of one to the other, but the ferromagnesian minerals occupy similar positions, regardless of which of the three is present. The hornblende is believed to be primary.

Table of measured modes of Vermilion Granite and its border phases in Minnesota.

	Quartz	Potash feldspar	Acid Plagioclase	Biotite	Hornblende	Magnetite
Average granite	25	42	31	2	0	0
Series of border phases	10	25	48	1	15	0
	9	13	35	2	40	0
	7	30	28	3	32	0
	0	0	13	7	70	10
	0	5	40	5	50	0
	0	0	68	1	30	0
	0	0	20	24	50	5
	0	0	80	2	16	1

[7] This mass is being studied by C. W. Sanders.

[8] Rosenbusch, H., Micro. Phys. der Min. und Gesteine, vol. 2, pt. 1, p. 82, 1907. Refers to the variation in these masses of Minnesota granite, saying "Es wäre von Wichtigkeit diese Ubergänge näher zu studieren."

Petrography of Shonkinite (Basswood Type).

The spotted rocks are as peculiar petrographically as in field appearance. See figs. 3, 4 and 5. They have been found as bands not over 20 feet wide. The spots vary in diameter from 2 mm. to 20 mm. The rocks range in color from light to dark gray and in good specimens it may be noted that the light patches reflect light from a single large cleavage surface, though the patch is clearly a mixture of minerals. In other words, the feldspar is in large almost spherical grains poikilitically enclosing many grains of the dark minerals. In this late poikilitic occurrence of acid feldspar, these rocks much resemble the original shonkinites of Montana,[9] though probably the Montana rocks are not spotted.

The thin sections show that a poikilitic texture is the basis of the spotted appearance, even when the cleavage can not be seen in the hand specimen.[10] The ferromagnesian minerals are commonly euhedral to subhedral in the feldspar, but anhedral in the matrix. Accessory minerals are not abundant, but there is primary quartz in some specimens, and a small amount of apatite, titanite and opaque iron ore in most of them. Pyrite has been noted in several. Secondary minerals include much epidote and sericite, and a little quartz, chlorite and kaolin.

The feldspar is in nearly all cases acid, but it varies from microcline and orthoclase to albite and oligoclase, with some perthitic intergrowths. Two feldspars with quite similar inclusions may occur in a single thin section.

The dominant dark mineral is hornblende in the borders of the Vermilion batholith; light green augite and dark brown biotite are associated in the other three occurrences.

In the poikilitic feldspars, the dark minerals have haphazard orientations. In an average case dark minerals

[9] Weed, W. H., and Pirsson, L. V., Igneous rocks of Yogo Park, Montana: this Jour., vol. 50, 476, 1895.

[10] The poikilitic texture so commonly seen in contact metamorphic rocks might lead to the suggestion that these rocks at the border of a granite are of contact origin. This can not be maintained, because at High Lake the bands of syenite in the same series with the poikilitic rock show no such recrystallization.

FIG. 3.—Vermilion Lake. Plain light. X 60.

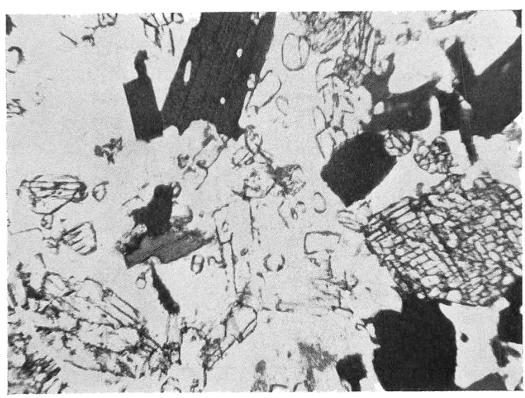

FIG. 4.—Snowbank Lake. Plain light. X 25.

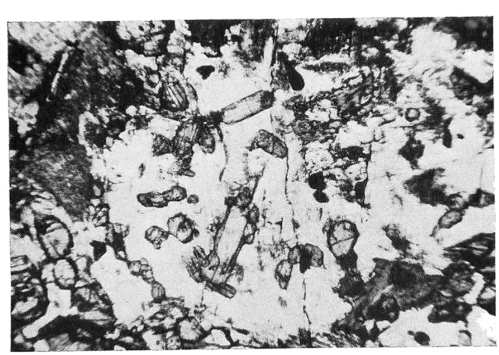

FIG. 5.—Giants Range. Plain light. X 25.

FIGS. 3, 4, and 5.—Shonkinites (Basswood type) all showing coarse feldspar enclosing poikilitically the dark minerals; hornblende in Fig. 3; augite and biotite associated in Figs. 4 and 5.

occupy about 25 per cent of the light areas, but different specimens range from 10 to 40 per cent. The spots, moreover, vary in abundance in the dark matrix, from 20 to 60 per cent of the whole rock. Thus the average spotted rock is considerably more than half dark minerals. Of the 15 thin sections measured, all but one (a small outcrop on Snowbank Lake) show over 50 per cent dark minerals.

An analysis of one of the freshest spotted rocks was made by Dr. I. S. Allison, and appears in column I below. It is from the Giants Range and is probably near the average in composition.

Analysis of Shonkinite (Basswood type),and similar rocks.

	I	II	III	IV
SiO_2	49.65	46.73	53.29	51.38
Al_2O_3	9.27	10.05	8.81	15.88
Fe_2O_3	5.00	3.53	4.68	
FeO	6.08	8.20	6.66	5.85
MgO	8.89	9.27	9.07	4.43
CaO	13.08	13.22	8.99	8.62
Na_2O	2.38	1.81	3.21	7.57
K_2O	1.71	3.76	1.87	4.20
H_2O+	1.71	1.24	1.51	.42
H_2O-	.28	–	.17	–
CO_2	none	–	none	–
TiO_2	.89	.78	1.41	.12
ZrO_2	.05	–	–	–
P_2O_5	.06	1.51	–	.98
S	trace	–	–	–
Cl	–	.18	–	–
Cr_2O_3	.04	–	–	–
MnO	.56	.28	–	–
SrO	.12	–	–	–
BaO	.16	–	–	–
	99.93	100.56	99.67	99.45

Specific Gravity 3.000

Norms

	I	II	III	IV
Quartz	–	–	.36	–
Orthoclase	10.01	22.24	11.12	25.02
Albite	17.29	1.05	27.25	5.76
Anorthite	9.45	8.06	3.89	–
Nephelite	1.70	7.95	–	28.40
Noselite	–	–	–	.37
Acmite	–	–	–	4.16
Diopside	44.91	38.19	32.55	29.74
Hypersthene	–	–	13.27	–
Olivine	5.32	11.54	–	3.18
Magnetite	7.19	5.10	6.75	–
Ilmenite	1.67	1.67	2.74	.30
Apatite	.15	3.70	–	2.35

I. Shonkinite (Basswood type), Giants Range, Minnesota. I. S. Allison, analyst.
II. Shonkinite, Square Butte, Montana. L. V. Pirsson, analyst. U. S. Geol. Survey Bull. 237, p. 102.
III. Hornblendite, (Kilauose) Garsbal Hill. Scotland: Geol. Mag., vol. 10, p. 540, 1913.
IV. Amphibole malignite, Pooh Bah Lake, Ontario, Sharwood, analyst. University of Calif. Dept. of Geol. Bull. 1, p. 359.

Classification and Comparison With Similar Rocks.

The spotted rocks are shonkinites grading into syenites (yogoites)[11] in the common qualitative systems of classification. An analysis of shonkinite from Montana, the type locality, is given in column II. In the C. I. P. W. system, the rock analyzed is salfemic, perfelic, domalkalic, and dosodic; classified as kilauose. No other kilauose in Washington's tables[12] has any such character and relations as this; probably the nearest is a hornblendite related to more acid rocks at Garabal Hill, Scotland.[13] An analysis is given in column III. In Johannsen's quantitative mineralogical classification,[14] the rocks may be put into several different families on account of the different feldspars; mostly in the melasyenite family with acid feldspar to be specified.

The peculiarity of the texture and the close relationship of the rocks make it desirable to have a distinctive name for the group.[15] The writer prefers, however, to avoid any increase in the complex nomenclature of petrography. It is therefore suggested that those shonkinites (and dark syenites) with peculiar spotted appearance due to poikilitic feldspars shall be distinguished by the qualification "(Basswood type)."

It is expected that shonkinites (Basswood type) may be found in many places related to granite; and they grade on one side into syenite, and on the other into hornblendite. No doubt there may be also gradations to dioritic rocks. Such genetic characters and the minor mineralogic details are not here included in the definition of the type.

Only a few granites seem to have been described as having shonkinite phases. The Long Lake, New York, mass,[16] which is perhaps large enough to class as a batholith, and the Yogo Peak, Montana, stock,[17] show gradations from quartzose alkali feldspar rocks to syenite, and

[11] Weed and Pirsson, this Jour., vol. 50, p. 479.
[12] U. S. Geol. Survey Prof. Paper 99.
[13] Wyllis, B. K. N., and Scott, A., Geol. Mag., vol. 10, p. 540, 1913.
[14] Johannsen, A., Jour. Geology, vol. 28, pp. 38, 158 and 210, 1919.
[15] Such as Basswoodite from its occurrence on Basswood Lake.
[16] Cushing, H. P., The geology of Long Lake, N. Y. State Mus. Bull. 115, p. 477, 1907.
[17] Weed, W. H., The Little Belt Mountains, U. S. Geol. Survey Folio 56.

through that to shonkinite. A number of other granites have syenitic phases, mostly light colored. Elsewhere through much of the world the records suggest that the common sequence in differentiated granite masses is not toward shonkinite, but through diorite to gabbro, and the darker rock in these cases is not invariably at the border of the mass.

The only rocks closely resembling shonkinite (Basswood type), descriptions of which have been found in the literature, are the malignites, nephelite rocks, found by Lawson in a somewhat similar and probably related intrusive in the same region.[18] He notes that several malignites have poikilitic texture.

Several other rocks may approach the type more remotely. Granites in Kanabec County, Minnesota, have poikilitic feldspars, but are not at all dark. A minette dike in Washington is described by Ransome as having poikilitic acid feldspar crowded with biotite, pyroxene, etc.;[19] but it is not described as spotted and it has much less silica and more lime than the shonkinite here studied. The rock, borolanite, is spotted and might resemble this shonkinite in hand specimen; but its origin and relations seem to be very different, and the spots are attributed to the alteration of leucite to a mixture of fine secondary minerals.[20] This is not at all like a large poikilitic feldspar.

[18] Lawson, A. C., University of California, Dept. of Geol., Bull. 1, p. 343, 1896.

[19] Ransome, F. L., An apatite minette from northeastern Washington, this Jour., vol. 26, pp. 337-341, 1908.

[20] Shand, S. J., On borolanite in Assynt, Trans. Geol. Soc. Edinburgh, vol. 9, p. 410, 1910.

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