diagram[11] shown in Fig. 2. Some of the points on this diagram vary from the average position more than is to be expected, but, nevertheless, the mean position seems to be along a line inclined at least as much as required by the writer's theory.

The writer is gratified to learn from Dr. Hallimond's recent discussion[12] that he is ready to admit the presence of "small quantities of other molecules" in micas not having the constant ratio $K_2O:SiO_2=1:6$. The only question seems to be, then, whether these "small quantities" can become large quantities in some cases. It seems to the writer more reasonable to accept a small variation in the $K_2O:SiO_2$ ratio rather than to assume a large variation in that ratio such as would be necessary to explain the results of some analyses if one is to cling to the idea that the main part of every analysis consists of mica having the 1:6 ratio. If the $K_2O:SiO_2$ ratio varies only a little from 1:6, then, obviously, large quantities of such molecules must be present to explain the results of some analyses.

The chief theoretical difficulty with the theory of Hallimond that MgO replaces $Al_2O_3$ in muscovite is that it requires one to believe that one atom of magnesium may take the place of two atoms of aluminum, and that one atom of oxygen may take the place of three atoms of oxygen, in the crystal space lattice. The chief practical difficulty with the same theory is that it is not in harmony with the modern analytical data on the composition of micas of the muscovite series.

## THE BLACK HILLS MINERAL REGION

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### INTRODUCTION

There is probably no other region 100 miles long and 50 miles wide that contains such a wealth of geological and mineralogical interest as the Black Hills of South Dakota. The pegmatites in the region around Harney Peak have yielded a number of rare minerals, some being new species, and large amounts of many more common ones. There too are found the largest known crystals of

[11] An error must be corrected: in the writer's former article on the micas (*Am. Mineral.*, July, 1927), the "86 molecules" mentioned in the fourth line from the bottom of page 272 should read "91 molecules."

[12] *Am. Mineral.*, **XII**, 1927, p. 413.

spodumene. Exceptionally large crystals and masses of other minerals are also abundant. Commercial production from the Harney Peak region has included mica, the lithium minerals—spodumene, amblygonite, and lepidolite—beryl, columbite-tantalite, wolframite, galena, gold and silver minerals. Cassiterite has been exploited but has not proved of much value to date.

In the northern portion of the Black Hills gold has been the principal mineral of value but ores of silver, lead, zinc, tungsten, and gypsum have also been produced. The importance of the gold production has been largely due to the Homestake mine, the largest gold mine in the United States. This mine has produced almost without interruption since 1876 and has a record of over $200,000,000 production.

Since the Black Hills were first opened to settlement in 1876 the varied mineral deposits have excited great interest. In fact it was the discovery of gold in 1874 which caused the opening of the area, and the resentment of the Indians over the loss of this fine hunting ground led to the Custer Massacre on the Little Bighorn River to the northwest in Montana on June 25, 1876.

## LOCATION

The Black Hills are situated in the extreme western part of South Dakota and extend somewhat into northwestern Wyoming. The region is served by the Chicago, Burlington and Quincy Railroad, the Chicago and Northwestern and a branch of the Chicago, Milwaukee and St. Paul. The region may be reached by way of Omaha, Chicago, Minneapolis, or Denver. Several good highways now approach the Hills and tourists visit them in increasing numbers each year. Suitable accommodations are available at many points and good roads lead to practically all of the mines and other points of mineralogical interest. The most convenient way to visit the points noted below is by auto, but the writer has made several trips to the region and used an auto but little, depending on trains, busses, and walking. Detailed directions and maps may be obtained at the hotels and tourist bureaus making it very easy for anyone to find the deposits. The maps prepared by Ziegler[1] are of great assistance. Anyone visiting the region will find it convenient to transfer the data from Ziegler's map to the topographic sheets of the region. A recent bulletin by O'Harra and

[1] Ziegler, V.; *S. D. School of Mines, Bull.* **10,** (1914).

Connolly[2] shows the location of most deposits of the Harney region on a key map, with notes on many deposits and the minerals found in them. The list of mineral localities on pages 94 and 95 is particularly useful to the collector.

## GENERAL GEOLOGY

The geology of the Black Hills has been described in general and in detail in a great many papers which are listed in a bibliography issued by Dr. O'Harra.[3] The main part of the region is well described in the recent folio by Darton and Paige.[4] Previous reports by O'Harra,[5] Darton,[6] Irving,[7] and Jaggar[8] are especially comprehensive.

The Black Hills are the farthest east outlier of the Rocky Mountain system with which they connect structurally by the Laramie mountains to the south. Physiographically they are not hills but mountains. The average elevation of surrounding plains is about 3000 feet while Harney Peak reaches an elevation of 7242 and other peaks in various parts of the region reach 6500 feet. Terry Peak not far from Lead in the northern part attains an altitude of 7071. The region is not lacking in the ruggedness usually associated with mountains and the term Black Hills is somewhat misleading in that respect.

The Black Hills were formed by a domical uplift at the end of the Cretaceous which on erosion exposed all of the Cretaceous and older formations down to the pre-Cambrian complex. Twenty-two formations are listed by Darton[9] in the generalized columnar

[2] O'Harra, C. C. and Connolly, J. P.; *S. D. School of Mines, Bull.* **14**, (1926).

[3] O'Harra, C. C.; A bibliography of the geology and mining interests of the Black Hills region: *S. D. School of Mines Bull.* **11**, (1917).

[4] Darton, N. H., and Paige, Sidney; Central Black Hills: *Folio* **219**, *United States Geological Survey* (1924).

[5] O'Harra, C. C.; The Mineral wealth of the Black Hills: *S. D. School of Mines, Bull.* **6** (1902).

[6] Darton, N. H.; Preliminary description of the geology and water resources of the southern half of the Black Hills: *U. S. Geol. Survey, 21st Ann. Rept.*, pt. 4, pp. 409–459 (1901).

Darton, N. H.; Geology and water resources of the northern portion of the Black Hills: *U. S. Geol. Survey, Prof. Paper* **65** (1909).

[7] Irving, J. D., Emmons, S. F., and Jaggar, T. A.; Economic resources of the northern Black Hills: *U. S. Geol. Survey, Prof. Paper* **26** (1904).

[8] Jaggar, T. A., and Howe, E.; The laccoliths of the Black Hills: *U. S. Geol. Survey, 21st Ann. Rept.*, pp. 163–307 (1901).

[9] *U. S. Geol. Survey, Folio* **219** (1924).

section. These embrace all periods except the Silurian and Devonian, although many periods are only partly represented.

Igneous rocks are abundant, the most important being the pre-Cambrian granite and pegmatites of the Harney Peak region and a great series of Tertiary porphyries which occur over a wide area in the northern part and form many well known masses, of which the Devil's Tower is especially well known. The variety of the exposed rocks accounts for the great number of minerals found in the region.

## MINERALOGY

PREVIOUS WORK.—So many papers have been published on the minerals of the Black Hills that no attempt will be made to list them all, but the reader is referred to Dr. O'Harra's bibliography or the bibliography in Ziegler's bulletin. The comprehensive work by Ziegler[10] deserves special note. It contains a complete list of minerals recognized up to that time with general descriptions of the properties, notes on localities, and special types found in the Black Hills. The writer has drawn freely on this and other publications for information. Unfortunately the copies of the bulletin are exhausted and it is necessary to refer to it in the libraries. The writer has been informed, however, that Professors O'Harra and Connolly hope to issue a revised edition within two years.

MINERALS.—Ziegler lists 182 minerals found in the Black Hills and immediately surrounding region. Many of these are comparatively rare and probably could not be found in any accessible openings. Many others would doubtless be found only by a very careful search. The list includes 7 native elements, 22 sulphides, tellurides and arsenides, 8 sulpho-salts, 7 haloids, 26 oxides, 13 carbonates, 65 silicates, 2 niobates and tantalates, 24 phosphates and arsenates, and 22 sulphates. A more varied group could scarcely be desired. Of Ziegler's list about 80 are reasonably easy to find or have been found in considerable amounts. By far the greater variety is found in the pegmatites surrounding the Harney Peak granite especially those near the village of Keystone. The mineralogist visiting the region should pay special attention to this interesting area.

[10] Ziegler, V.; The minerals of the Black Hills: *S. D. School of Mines, Bull.* **10**, 250 pages, 31 plates, 73 figures (1914).

LIST OF THE MORE COMMON MINERALS FOUND IN THE BLACK HILLS REGION.
(Those usually available are starred.)

actinolite*
aegirite*
almandite
albite*
alunite*
amblygonite*
andalusite*
andesine
anglesite
ankerite
apatite*
aragonite
arsenopyrite*
augite*
barite
beryl*
biotite*
bismuthinite
calcite*
cassiterite*
cerargyrite
cerussite*
chalcedony*
chalcopyrite
chlorite*
columbite*
cuprocassiterite*
cummingtonite*
dolomite*
epidote
feldspar* (see var.)
ferberite
fluorite
galena*
garnet* (see var.)
gold
glauconite
graphite*
griphite
grossularite
gypsum*
hematite*
hornblende*
huebnerite*
labradorite
lepidolite*
loellingite*
limonite*
lithophillite*
mica (see var.)
microcline*
magnetite*
malachite*
muscovite*
oligoclase
opal*
orthoclase*
phlogopite
purpurite
pyrite*
pyrolusite
pyrrhotite*
quartz*
saponite
scheelite
scorodite
serpentine
siderite*
smithsonite*
sillimanite*
sphalerite*
spodumene*
stannite*
staurolite*
struverite
talc
tantalite
topaz
tourmaline*
triplite
wolframite*
zircon*

DEPOSITS.—The Harney Peak granite is apparently only the top of a large batholith and much of the main mass is pegmatitic. Extending outward into the schists in all directions are dikes and irregular masses of pegmatite. Some of these are several miles horizontally from the main granite mass. The most interesting and economically important are these masses in the schists. The area around the village of Keystone contains the greatest number of commercial deposits but at other places much of interest may be found. The rose quartz deposits near Custer serve as an example.

Some of the many deposits deserve a few details, either because of the great variety of minerals found or the unusual nature of particular minerals and their occurrence.

The Etta mine near Keystone is the most famous of the Harney Peak group due to the immense crystals of spodumene found

there. The largest crystal recorded was forty-two feet long, from three to six feet in diameter, and contained thirty-seven tons of spodumene. Many others nearly as large have been mined. These are without doubt the largest crystals of any mineral thus far discovered. The pegmatite is roughly oval in outline with diameters of 200 and 250 feet,[11] and shows a rude zoning with the main body of quartz, spodumene and feldspar surrounded by a finer grained aggregate of muscovite with quartz and feldspar. Normally the spodumene crystals are embedded in masses of milky quartz. Aside from the minerals noted above the following are more or less common: columbite-tantalite, lepidolite, apatite, beryl, lithiophillite, cassiterite, triphylite, and opal.

At least three other deposits near the Etta mine should be visited by those interested in mineralogy. About a thousand feet west of the Etta is a huge mass of pegmatite in which the Hugo mine has been excavated. This pegmatite also contained large spodumene crystals but neither as large nor as abundant as those in the Etta mine. The large masses of nearly pure microcline are notable. Large masses of amblygonite and considerable amounts of mica are important constituents. Extensive mining in the last three years has opened up many new features in this deposit. The large masses and crystals of black tourmaline in the mine and surrounding pegmatite are most remarkable. Similar masses of blue apatite are occasionally encountered. In general this pegmatite seems to be an irregular body, rather than a dike, with a base of schist which dips sharply northwest. Large inclusions of schist are encountered in mining. As in the other deposits the greatest segregations of mica occur near the contacts.

The Peerless mine is located on a high hill midway between the Etta mine and the village of Keystone. In some respects this deposit is more remarkable than the Etta. For variety of minerals and their relationship it is perhaps the best opening at present. Many of Hess' illustrations of replacement were derived from this deposit.[12] A single pseudomorph of an unusual nature consists of a crystal about one inch in diameter and perhaps three inches in length. This was originally beryl with the characteristic hexagonal

[11] Schwartz, G. M.; Geology of the Etta spodumene mine, Black Hills, South Dakota; *Econ. Geol.*, vol. **20**, pp. 646–659 (1925).

[12] Hess, F. L.; The natural history of pegmatites: *Eng. and Min. Jour.-Press*, vol. **120**, pp. 289–298 (1925).

form but now consists of an interior of quartz with a coating of small albite crystals. The mine is now producing mica, feldspar, beryl, amblygonite, columbite-tantalite, and lithiophillite. Cassiterite is common and large masses of a fine green micaceous mineral presumably vermiculite, are also common. Numerous rarer minerals are found, particularly apatite, tourmaline and so on.

Mr. Hesnard states that the active mining of the past three years indicates the deposit to be a shoot dipping northwest and that a rough stratification exists with mica, large masses of muscovite, and finer grained vermiculite and liebnerite with some quartz and feldspar near the base. Above this is a zone with amblygonite, quartz, beryl, etc. The top is mainly feldspar and quartz.

The Bob Ingersoll mine is located about two miles west of Keystone on a high hill along the valley of Battle Creek. The openings are somewhat above one another on three dikes or masses of pegmatite, The lower pit contains considerable amounts of spodumene, amblygonite, beryl, feldspar and mica with some columbite and cassiterite. The middle pit at present shows mainly beryl and amblygonite. The upper contains very large masses of pure lepidolite in the center with considerable amounts of beryl, amblygonite, mica, cassiterite and columbite. A large mass somewhat pipe like has yielded unusually large amounts of high grade amblygonite. As stated by O'Harra and Connolly[13] the Ingersoll is particularly noted for its massive ledges of lepidolite and for the occurrence of what is probably the largest beryl crystal ever discovered. This is 46 inches in diameter and its full length has not been uncovered.

Other pegmatite deposits deserving special note are the Beryl Mica Lode, Climax, Everly, Wood Tin, New York, Crown, White Star, Pioneer Mountain, and Scott Rose Quartz.

The deposits of the Harney Peak region are the most interesting in the Black Hills from a mineralogic standpoint, but some of the deposits of the Northern Hills are not lacking in interest. A visit to the region would scarcely be complete without at least a short visit to the Homestake gold mine and the surrounding area. Perhaps the most interesting mineral, aside from the gold which is only rarely visible, is cummingtonite, a comparatively uncommon

[13] *Op. cit.*, p. 95.

amphibole. Cummingtonite schist is an abundant lode rock. Common minerals include arsenopyrite, pyrrhotite, chlorite and quartz.

A number of other deposits might be mentioned as well as specific occurrences of minerals. A recent bulletin by Professor Connolly[14] gives a great deal of information on the deposits of the Northern Hills. Those interested should refer to this and other papers cited above. A visit is necessary to even partly appreciate the mineralogic wealth of the Black Hills and the collector will not fail to find many interesting specimens.

## A MINERAL RELATED TO SAMARSKITE FROM THE WOODCOX MINE, HYBLA, ONTARIO*

H. V. ELLSWORTH, *Ottawa, Canada.*

The Woodcox feldspar mine[1] (lot 17, con. VIII, Monteagle township, Hastings county, Ontario) was noteworthy because of the occurrence of large individual masses of radioactive minerals, sometimes reaching a weight of 100 pounds or more. These masses were crudely globular in form and in most cases consisted not of one mineral species only but of several, each individually quite distinct. The association generally was cyrtolite, columbite, and black and brown minerals of the complex titano-tantalo-columbate types, the radioactive minerals usually making up from 75 to 95 per cent of the total mass, with columbite next in order of abundance. Walker and Parsons[2] have described black and brown hatchettolite which probably occurred in this way. The mineral here described was part of a large mass which originally must have weighed at least 100 pounds. It consisted chiefly of a brown complex columbate, with some black mineral (the subject of this paper) and columbite. There appeared to be little or no cyrtolite in this case. The brown mineral appears to be a more altered phase of the black one. The latter was analyzed because it presumably would represent more nearly the original composition of the mineral and might be expected to be more favorable material for de-

[14] Connolly, J. P.; Tertiary mineralization of the Northern Black Hills: *S. D. School of Mines, Bull.* **15,** (1927).

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[1] *G. S. C. Summary Report,* **1923,** Part CI, page 12 et seq.

[2] *Contributions to Canadian Mineralogy,* **1923.**