STATE OF SOUTH DAKOTA
M. Q. Sharpe, Governor

STATE GEOLOGICAL SURVEY
E. P. Rothrock, State Geologist

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REPORT OF INVESTIGATIONS

No. 48

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# PEGMATITES IN THE BEECHER ROCK BASIN

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by

Charles S. Gwynne

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University of South Dakota
Vermillion, S. Dak.
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SOUTH DAKOTA

STATE GEOLOGICAL SURVEY

# PEGMATITES IN THE BEECHER ROCK BASIN

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Iowa State College

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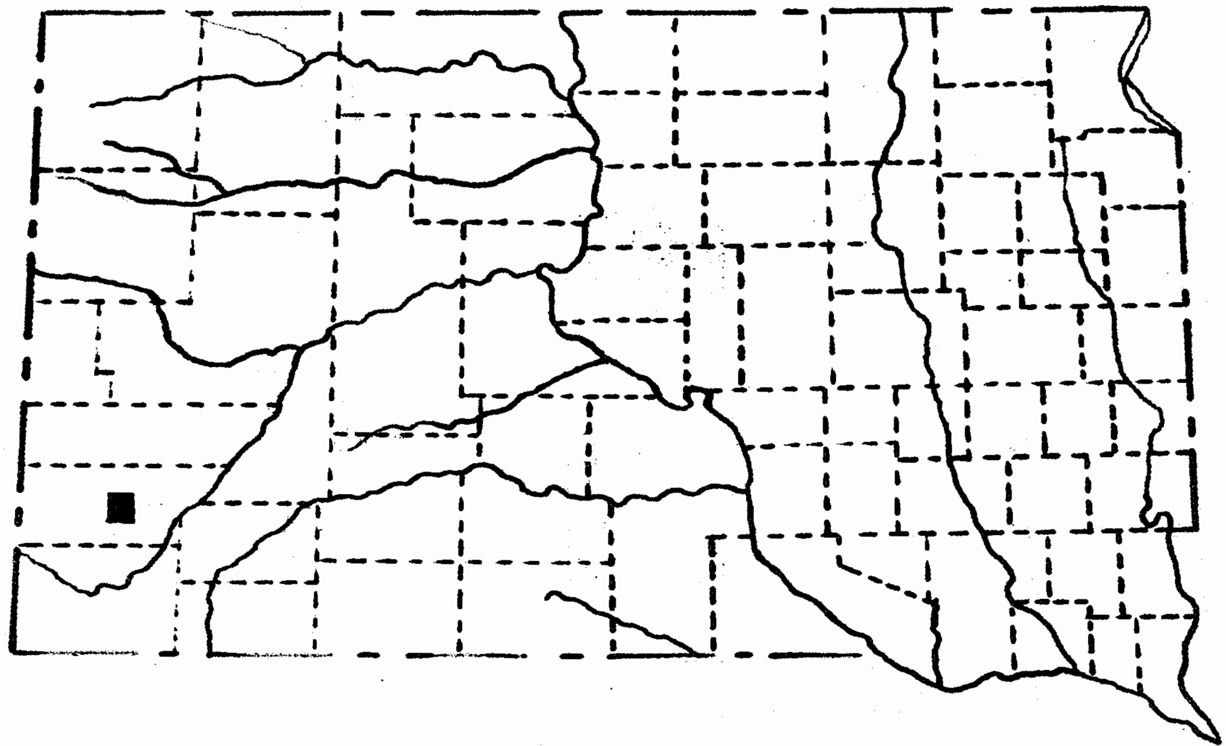

■ Location of the Beecher Rock Basin

# PEGMATITES IN THE BEECHER ROCK BASIN

by

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## INTRODUCTION

### General Statement

The principal purpose of this study has been to map the pegmatite bodies of a part of the pre-Cambrian of the Central Black Hills. The area selected is in the north-central part of Custer County, South Dakota, and lies between the approximate limits of 103°34' and 103°38' W. Longitude, and 46°40' and 46°46' N. Latitude. The northern boundary is approximately three miles south of Custer, one of the larger towns of the southern Hills.

Although the general geology of the area as a whole has been known for many years, no detailed geologic map showing the location of these within schist or granite areas has been available. It is believed that the accompanying map should serve those engaged in exploration for the industrial minerals found in the pegmatites and in the development of the deposits of this selected area. It should also serve, in part, as a basis for further detailed study of the structure of the surroundings of the Harney Peak granite mass. Much of this description is intended particularly for the non-professional individual, and it is therefore hoped that it also may be of assistance to property owners and prospectors interested in industrial mineral development of this region.

The pegmatite bodies have been and are important producers of many industrial minerals, including feldspar, mica, beryl, spodumene and amblygonite. There has been much prospecting of them and many mines, mostly small to be sure, have been developed. These advances have been made with incomplete knowledge of (1) the distribution of the pegmatites and (2) possible relation of the occurrence of economically valuable minerals to the position or location of the pegmatites within the schist and granite areas. It is believed that the construction of a detailed geologic map of the entire area wherein the pegmatite bodies are found, should constitute one of the first steps toward obtaining a more thorough and systematic knowledge of these pegmatites and of the occurrence within them of commercial deposits of the industrial minerals.

## Field Work and Acknowledgments

The writer was occupied in field work of this project from July 17 to September 11, 1943. Other members of the party were in the field a week earlier. The mapping was done by the writer and Mr. Bruno Petsch, Geologists, and Mr. Robert Lawton, and Mr. Donald F. Rothrock, Instrument Men. Messrs. Petsch and Rothrock mapped the rougher townships in the eastern part of the area, as well as the tier of northern sections. The diligence and unselfishness of these co-workers are gratefully acknowledged.

The hearty support of Dr. E. P. Rothrock, State Geologist of South Dakota, is also acknowledged. Dr. Rothrock conceived the idea of mapping these areas in detail and was most active with advice on field problems and in forwarding the work in every possible way.

The ranchers, land-owners, and miners of the area, and the staff of the Custer District of the Harney National Forest were helpful in various ways.

Many of the photographs were contributed by Mr. Lloyd Pray. Their assistance is also herewith acknowledged.

## Summary of Results

The pegmatite bodies of fifteen square miles of an area in which they are exceptionally numerous have been mapped in the course of the field work of the summer of 1943. The results are presented in Fig. 1, on a scale of approximately 1:9000. The total area within which the pegmatites occur is of the order of 300 square miles, so that the present work may be considered as possibly only the beginning of study on a much larger problem.

Much data on the location, size, strike, etc., of the pegmatites in this selected area have been secured in the course of the present field work. Prospect pits, abandoned or inactive mines, and mines operating in the summer of 1943 have also been located and are shown by appropriate symbols on the accompanying map. Conclusions have been confirmed with regard to structural relations of the dikes to the surrounding schists. It has not been possible, from this comparatively limited study, to draw conclusions with regard to the relation of the position of the pegmatites in the area to the occurrence within them of industrial minerals.

Attention is called to features under "Additional Observations" (pp.17-19), which may warrant further study as opportunity affords, and which may have a bearing on the structure and geologic history of the area.

## SURVEY METHODS AND OBSERVATIONS

The mapping was primarily by plane table, on a scale of 1 to 12000. Horizontal control was established through United States Geological Survey bench marks, Public Land Survey corners and Chicago, Burlington and Quincy R. R. elevations. Homestead Entry Survey corners were used as checks when convenient to traverse lines. Much of the country has a thick forest cover, making plane table work in such places difficult, if not impossible. For this reason some of the pegmatites were located by compass and pace traverse. Lengths and widths were either paced or estimated, depending upon the size and accessibility of the bodies.

Many observations of strike, on hanging wall, footwall, and along the approximate axis, were made, and these have been used in the preparation of the map. Determinations of strike made on well exposed hanging or foot walls of large dikes proved undesirable for mapping purposes, because of the lens-like or bulbous character of the bodies or because of variable strike of the dike as a whole. Those made along the approximate axis were more suitable, although subject to the error arising from the approximation. The strike of most of the dikes shown on the map has been made that of one of a group, or of one in the vicinity for which it was believed a satisfactory determination had been made. The true strike of individual dikes is believed to fall reasonably close to that shown.

Many dip determinations were also made on hanging and foot walls, but have not been included on the map since the general or average dip of a dike, owing to variation through the length, could be only approximately determined.

In general, dikes less than a foot thick and 50 feet in length were few in number and were disregarded. Many dikes or other bodies of pegmatite were known only from the presence at the surface of a mass or string of boulders. These were mapped where they appeared to be the result of weathering of bodies of sufficient size.

No attempt was made to differentiate between those clearly pegmatitic and others which might be more or less normal granite in texture through most of their extent. Casual observation led to the belief that practically all outcrops were to some degree pegmatitic, as is true of most of the granite of the region, according to other investigators. The term pegmatite is here used for all of the rock related to the Harney Peak intrusion.

Outcrops of country rock were scarce over much of the area, and elsewhere its character could be determined only from scattered fragments in the mantle. Some observations, limited by the time available, were made but these were not considered sufficiently informative to warrant inclusion in the map.

Airplane photographs of the area were of great assistance in planning the work, and also in the more accurate determination of some of the features. The general strike of the larger dikes, and that of the vertical or near-vertical joint systems of such dikes can be determined more satisfactorily from these photographs than from the ground. The general strike of the schistosity and of the dikes is clearly shown by these photographs.

## Choice of the Area

The area mapped was chosen because of its numerous dikes, typical of a much larger area, its many small mining developments; and its proximity to Custer, which is a center of interest in the development of industrial mineral deposits of the pegmatites. The northern boundary lies about two miles south of Custer, the county seat of Custer County and the center of much of the mining. The area totals fifteen square miles and included all except the southern sections, 31, 32 and 33, of the eastern half of T. 4 S., R. 4 E.

Most of this was mapped by Darton and Paige (Fig.2) as "slate and mica schist, (cut by many granite and pegmatite dikes)," but there are also smaller areas mapped as (1) "granite and pegmatite," (2) "granite and pegmatite, (containing many inclusions of schist)," (3) "slate and mica schist," (4) "quartzitic schist, (cut by many granite and pegmatite dikes)" and (5) "amphibolite". Industrial minerals have been produced from mines and dikes of the first four of these, but the dikes are most numerous in the areas of "slate and mica schist, (cut by many granite and pegmatite dikes)". It should be noted, however, that the areas mapped as "slate and mica schist," which might be thought to lack pegmatite bodies, are by no means devoid of them.

## Culture

The area has a sparse ranching population of perhaps only a few hundred. Mine operators and workers are for the most part residents of Custer. The South Dakota State Tuberculosis Sanitorium occupies an area of approximately 20 acres in the NE $\frac{1}{4}$ of Section 14. The institution has approximately 200 patients and a staff of 80.

Geologic Map*

of the

BEECHER ROCK BASIN
Custer County, South Dakota

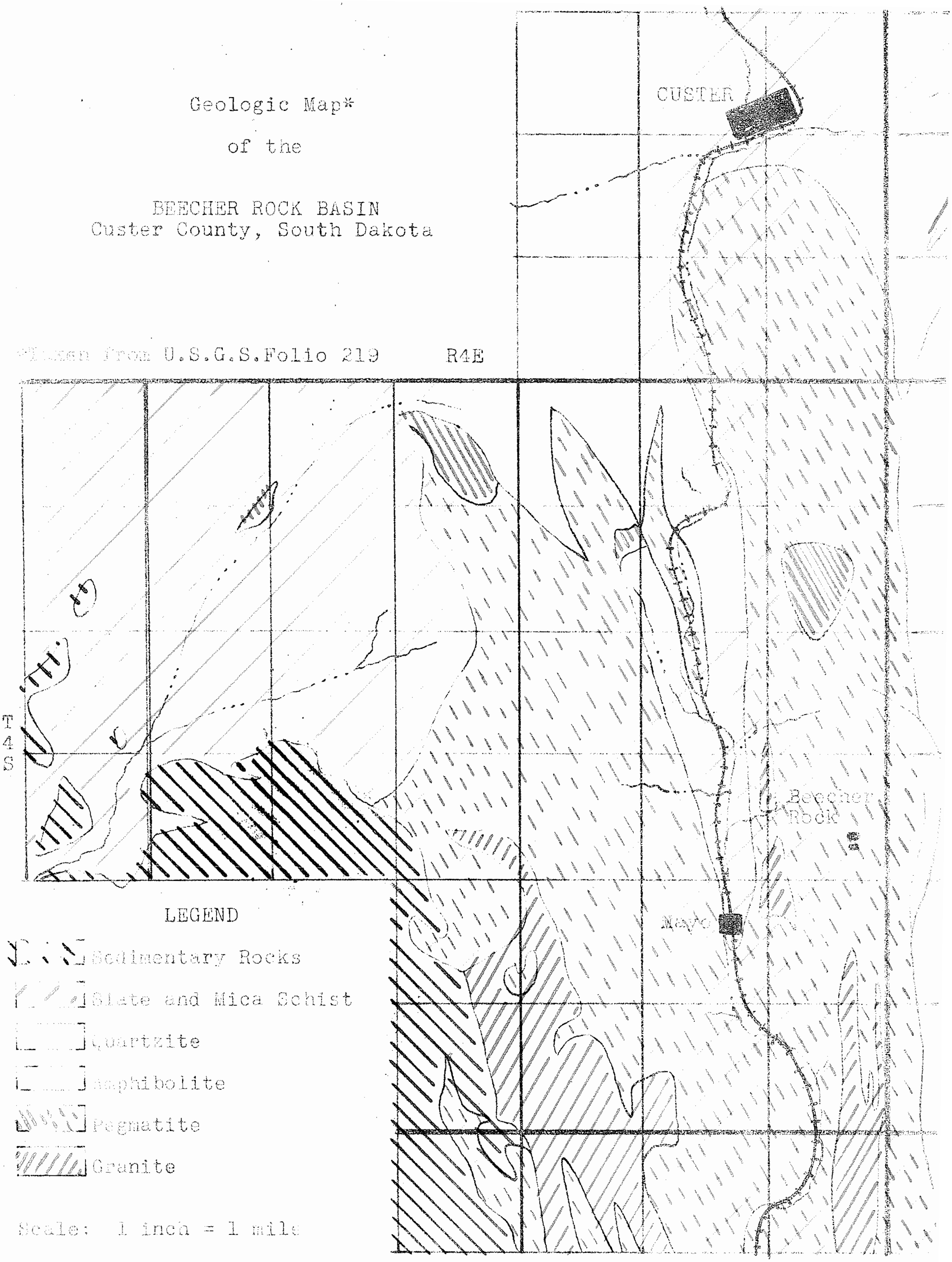


Figure 2

Considerably over half of the area is forested, chiefly with second-growth western yellow pine, (Pinus ponderosa), and is within the confines of the Harney National Forest. The broader valleys are given over to grazing and the raising of small grain and hay. Grazing is also conducted on the forested areas, particularly where tree growth is thin.

The Edgemont Deadwood branch of the Chicago, Burlington and Quincy R. R. traverses the middle tier of north-south sections, and railroad right-of-way following the valley of Beaver Creek. U. S. Highway 85 - Alternate, the main north-south highway through the Hills, follows a route adjacent to and within one-half mile of the railroad, on the east side for all of the distance except a mile or so at the north. The old Pringle road, a county highway, traverses the east side of the area from north to south. Dirt roads also reach every section in the area; and minor ranch roads, old lumber roads, and mine trails help to make most of the remainder reasonably accessible.

## Drainage

The area has an average precipitation of approximately 17 inches, and most of the streams are intermittent. The major part of the area mapped is drained by headwater tributaries of Beaver Creek, which takes more definite form about five miles south in the vicinity of Pringle and has thence a general southeastward course for about 25 airline miles to its confluence with the Cheyenne River. Minor parts of the northwestern sections are drained to the west by headwater tributaries of Fourmile and Hay Creeks, in turn tributaries of Pleasant Valley Creek, which flows into Hawkswright Creek, another tributary of the Cheyenne River, about 18 miles airline south-southwestward. An area of a square mile or so in the northeastern corner is drained by tributaries of French Creek, also confluent with the Cheyenne, to the east-southeastward, in an airline distance of about 30 miles. The area thus lies at the headwaters of tributaries which reach the major stream, the Cheyenne River, by widely divergent courses.

## Physiography

The maximum relief is approximately 1800 feet, and the lowest altitude 5000 feet. Sections 24 and 25 in the southeastern part have the highest relief, approximately 1600 feet, but the others have relief of only a few hundred feet. Much of the township of which the area is a part is on the whole less rugged and has less relief than any other in the pre-Cambrian area of the central Hills.

Broadly considered, most of the area is part of a basin, herein referred to as the Beecher Rock Basin, the name having been taken from the prominent and well known landmark (Fig.3) in section 24. The basin extends into the townships immediately north and south, and lies between the excarpment of Paleozoic rocks on the south and west, rather rugged hills of quartzitic schist and pegmatite on the east, and hills formed of outlying masses of the Harney Peak granite with associated resistant schists, on the north. The basin has a north-south length of approximately fourteen miles and an east-west width of from two to six. As viewed from various prominences the elevations within this basin, extending well north of the area which has been mapped, form a remarkably even skyline (Fig.4).

The country is in topographic maturity. Most of the valleys are mature, although some of the smaller tributary headwater ravines, particularly where relief is high, may be classed as youthful. The principal valley, that of Beaver Creek or its headwater extension, and the one followed by the railroad right-of-way, is a broad sag, averaging approximately a few hundred feet in width, and with side slopes generally of less than ten degrees. There are other smaller valleys of similar characteristics tributary to that of Beaver Creek, viz., (1) crossing from west to east through sections 22 and 23, (2) south through sections 15 and 22, (3) southeast and east through sections 12 and 13. A valley of the same sort, but tributary to that of Four Mile Creek, crosses south and west through section 10. The many valleys in the higher land on the east side of the area, all tributary to that of Beaver

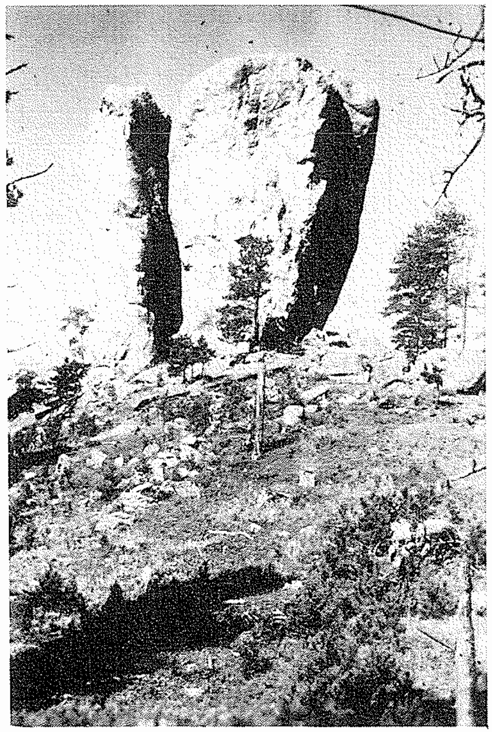

Figure 3
Beecher Rock
View from the east

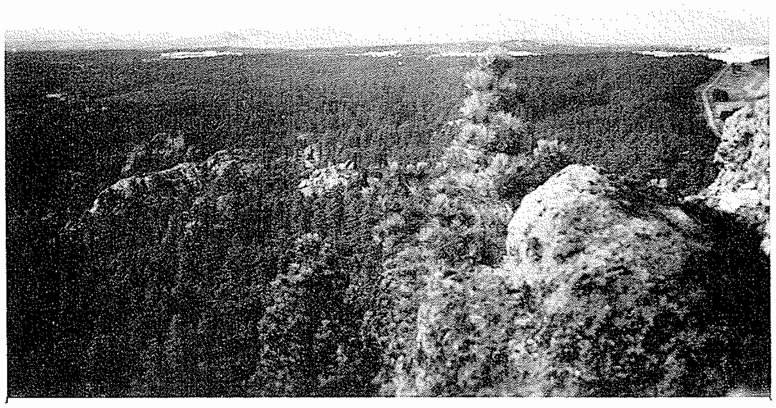

Figure 4
Beecher Rock Basin

The view is toward the northwest from a high point in the NE 1/4 Sec. 24, T.4S., R.4E., Custer County. The limestone escarpment is on the skyline at the left. Granite hills and mountains north of the basin form the remainder of the skyline. The dark timbered area is the Basin.

Creek, are more restricted and more youthful than those just described. These are in sections 12, 13, 24 and 25.

The main branch of Beaver Creek valley is the only one occupied by what can be considered a permanent stream, though some of those in the eastern tier of sections have flowing water in them most of the time. Occasional seeps and small springs are present in numerous places along others but in most years these do not have sufficient flow to maintain permanent streams.

Most of the inter-valley areas are characterized by fairly gentle slopes of less than ten degrees, except where larger dikes or massive pegmatites occur. In such places, as along the eastern margin of the area, in sections 24 and 25, there may be relief of as much as 500 feet within 160 acres, and vertical, nearly vertical, or even overhanging cliffs are numerous. In the inter-valley areas away from the eastern margin, the only steep slopes are on those hills and spurs having closely spaced transverse granite dikes, or where granite dikes upward of approximately 15 feet in thickness outcrop. On these larger granite dikes the eroded hanging wall sides may present slopes steeper than 45 degrees (Fig.5). The foot wall sides in many cases form overhanging ledges. Where the dikes are wide, their outcrops are in the form of high walls, and where they are within one hundred feet or so of one another, they may be separated by intervening depressions, some almost in the form of trenches (Fig.6).

# GEOLOGY

## General Geology

The Black Hills, in which the area is located, are in the southwestern part of South Dakota. They are developed on an uplift, elliptical in plan, the long axis of which trends southeast. The axial dimensions of the uplift are approximately 175 miles by 90, and the included area, which extends into northeastern Wyoming and southeastern Montana, totals approximately 11,000 square miles.

Erosion following the uplift has exposed systems from pre-Cambrain to the Cretaceous. The pre-Cambrian, an area of approximately 920 square miles in the central part of the Hills, consists of the Harney Peak mass of pegmatitic granite, surrounded by a variety of metamorphic rocks and smaller pegmatitic granite bodies. The area of the main granite mass and smaller closely-associated adjacent bodies totals approximately 110 square miles. Almost all of the granite is in the southern part of the pre-Cambrian area.

Most of the small intrusives, in the form of tabular and lenticular bodies,* are in the area surrounding the larger ones, although some are within the larger granite bodies themselves. In general they become less numerous with distance from the main area in which Harney Peak is located. Most are southeast, south and southwest of the Harney Peak mass.

* These are at least "dikelike" and will be referred to as dikes.

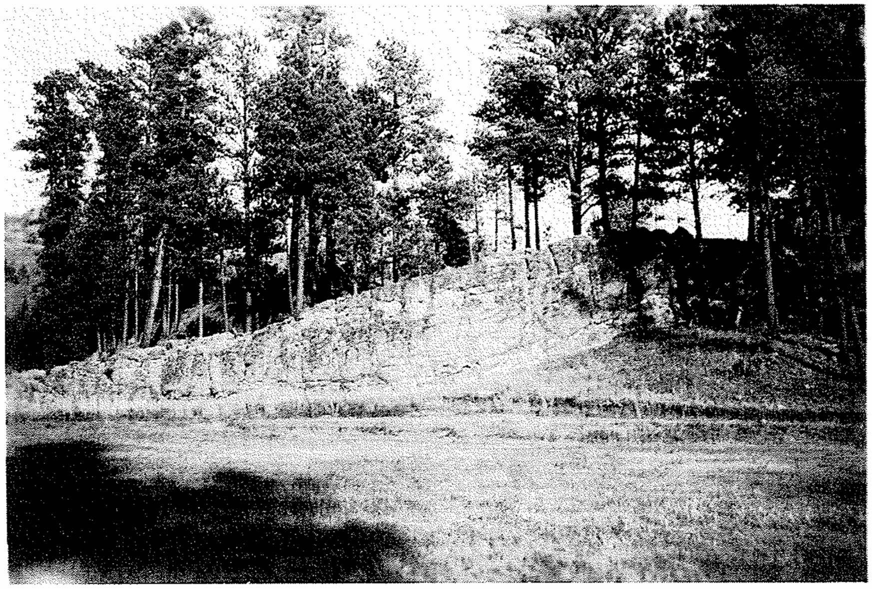

Figure 5
Typical dike, with steep hanging wall, the SW 1/4 Sec. 26, T.4S., R.4E., Custer County. Such dikes with steep hanging-wall sides are abundant. This one is crossed by prominent quartz veins.

Figure 6
Closely spaced dikes in the SW 1/4 Sec. 24, T.4S., R.4E., Custer County.

## Previous Work

As has been stated, the area has not previously been mapped in detail. The geology of the central Black Hills, an area which includes the Deadwood, Rapid, Harney Peak and Hermosa standard United States Geological Survey quadrangles, has been described by Darton and Paige, * and mapped by them on a scale of 1:125,000. The area included in this present report is south of the center of the Harney Peak quadrangle.

The mineralogy and petrography of the pegmatites of this particular area and of other parts of the central Black Hills which carry commercial deposits of industrial minerals have been dealt with considerably in the literature.** The bibliography in the report by Fisher includes many references of value from this standpoint. Some of the descriptions in the various writings may afford information as to the dimensions, structure and relations of individual bodies of pegmatite, but do not bear otherwise on the purpose of the present report. Fisher's statement regarding the dikes of the Custer area sums up adequately present ideas with regard to the general shape of the dikelike bodies and the mechanics of their intrusion. "Many of the smaller ones (dikes) are tabular-shaped bodies, but the larger ones are more commonly bulging, so as to resemble and irregular biconvex lens. With one exception all those examined have been intruded into foliated metamorphic rocks. They have been pushed in like the water in a blister, causing the schist layers to spread apart. The schist bends out and around the pegmatite, and only very rarely is a cross-cutting relationship observed. In the third dimension, (along the dip of the schistosity) all but the smaller pegmatites tend to be shaped like a biconvex lens. There is definite field evidence that these bodies are not shaped like a pane of glass, thus extending down to some mass of parent igneous rock with only minor changes in thickness. Rather they seem to be more or less isolated masses suspended at bulges in the schist. They are not dikes in the ordinary elementary textbook sense of the word. In places they are so thick that apparently discon-

* See bibliography at end.

** See particularly references by Connolly and O'Harra, Fisher, Tullis and South Dakota State Planning Board.

nected bodies may be part of one single mass which has extremely pronounced pinch and swell structure; these may represent truly disconnected bodies (pinched to zero thickness) or they may be connected below the present surface, or they may have been connected above the present surface."

The conformity of the strike and dip of the lenticular and tabular pegmatitic bodies to that of the surrounding foliated metamorphic rocks and the mechanics of their intrusion were described by Darton and Paige, and have been considered by others. Balk has made a detailed study of the structure of the Harney Peak granite, and has confirmed that the intrusions were accomplished by distension of the strata.

## Structure of the Pegmatites

In considering the structure of these masses it is well to recognize that the information regarding them has been gained from the section provided by their intersection with the surface, and from weathered and eroded outcrops. Relations may be perfectly clear in some places, but in others they may be uncertain because of the degree to which the bodies and the country rock have been affected by erosion and weathering, and the extent to which the mantle may or may not have been removed. Moreover, much of the country has a thick cover of forest or slash so that many of the outcrops are greatly obscured.

It is evident from the field study that the pegmatites are very diverse in shape and size. Essentially tabular dikes (Fig.7) are most numerous, others are more nearly lenslike in cross section, and there is a smaller number of larger massive bodies of rounded, elliptical, irregular or unknown outline. Those essentially tabular or lenslike are referred to as dikes and shown as lines or ellipses on the map. Those more definitely rounded or irregular or of uncertain shape may be referred to as chonoliths. Their position and boundaries, known and inferred, are also shown on the map.

Figure 7
A small dike, essentially tabular, in the NW 1/4 Sec. 34, T.4S., R.4E., Custer County. Dikes similar to this in size and form of outcrop are abundant in the Beecher Rock Basin.

Sizes and shapes of the dikes.

The dikes range up to 100 feet or more in average thickness and as much as 1000 feet in length. They probably average eight feet in thickness and a few hundred feet in length, the ratio of thickness to length at the surface thus being of the order of approximately 1:25-40. Some recorded and mapped as having a length of many hundred feet may actually consist of two or more dikes, placed closely end to end or closely en echelon. This has resulted from the difficulty of correctly interpreting short gaps of 50 feet or so in a dike outcrop or in a ridge underlain by a dike; many were interpreted as due to erosion, whereas in reality the dike may not be continuous.

It has been concluded that over most of this part of the pre-Cambrian, particularly that wherein dikes are numerous, there are few less than approximately a foot thick, and but little rock of the lit-par-lit type; except that closely associated with larger dikes. Thin dikes obviously would not appear in bold outcrops, as do the thicker ones, but if they exist fragmental material derived from them should be present in the mantle of areas predominantly schist. Very little such fragmental material has been observed. Furthermore, thin dikes and rock of lit-par-lit character were rarely noted in outcrops of schist. Apparently the intrusions in most of this area took the form of bodies more than a foot or so in thickness, seemingly a reflection of the relatively high viscosity of the cooling magma at this distance from the main intrusive mass.

Most of the individual dikes, as has been noted, are either essentially tabular or in the form of thin lenses in cross-section. They vary greatly in the ratio of maximum to minimum thickness, but the thicker ones, 100 feet or so in thickness near the middle of a length of many hundred feet, are generally only a few feet thick near the ends. Many have a fairly uniform thickness throughout, a length perhaps of as much as 500 feet, but these are generally not more than six to ten feet thick, and thus relatively thin. There are other relatively thick ones, up to as much as approximately 30 feet, that have almost uniform thickness for lengths ranging from one to several hundred feet. Some thicken and thin noticeably but gradually, say from 5 to 50 feet, throughout their exposed lengths. These are not numerous. A common characteristic also is their multiple or branching form. Dikes, of some 20 feet thickness for example, when traced along the strike, are found to develop into two or more closely parallel or sub-parallel dikes. Some places in the area have dikes so closely spaced that it was not possible to show the relations accurately on a map of the chosen scale. There may be, for example, as many as six dikes within a distance of 250 feet across the strike, with average distances of 30 to 40 feet between them. Thus not all are shown on the accompanying map where they are thus closely spaced.

Strike and dip of dikes.

The general strike and dip conform with the strike and dip of the enclosing schist. Many of the dikes strike rather uniformly throughout their length while others, longer ones particularly, vary in places as much as 10 to 15 degrees from the general strike of the dike, notably for short distances at the ends. Some appear to have variable strike of similar amount here and there throughout their length. This apparent variable strike may be real, or it may result from the interpretation as one dike of what is in reality more than one, spaced en echelon only a few or several feet apart. Where dikes are relatively thin, much eroded and weathered, and close together, and where the area is covered with a thick growth of small trees, it is difficult to determine exact relations.

Most of the dikes in this part of the pre-Cambrian area dip steeply, usually as much as 65 degrees. In sections 15 and 23, where they are numerous, they have an average dip of approximately 75 degrees, and the variation from this is not more than approximately 10 degrees. The dip is westward over most of the area, but eastward in the eastern part. The approximate position of the line dividing the area containing those of eastward dip from those of westward dip is shown on Fig.1.

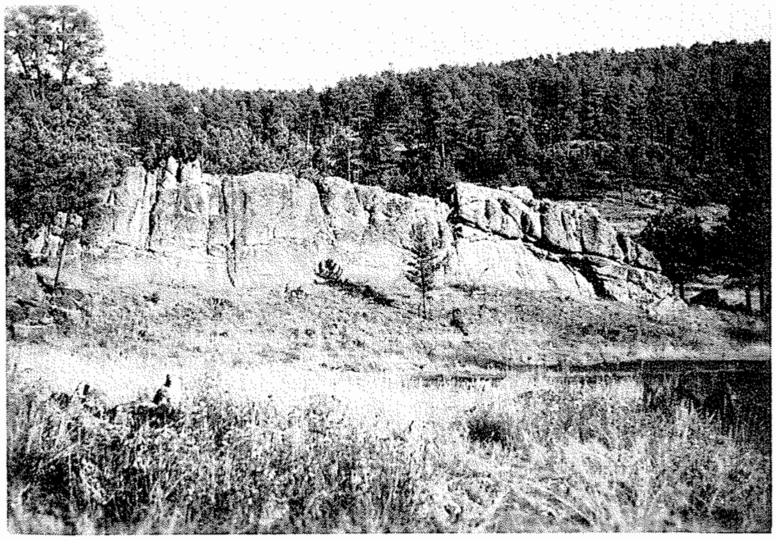

Figure 8

Dike with many steeply dipping joints, in the approximate center of Sec. 25, T.4S., R.4E., Custer County. Most dikes lack the numerous joints shown here. This dike also has a few sheet joints.

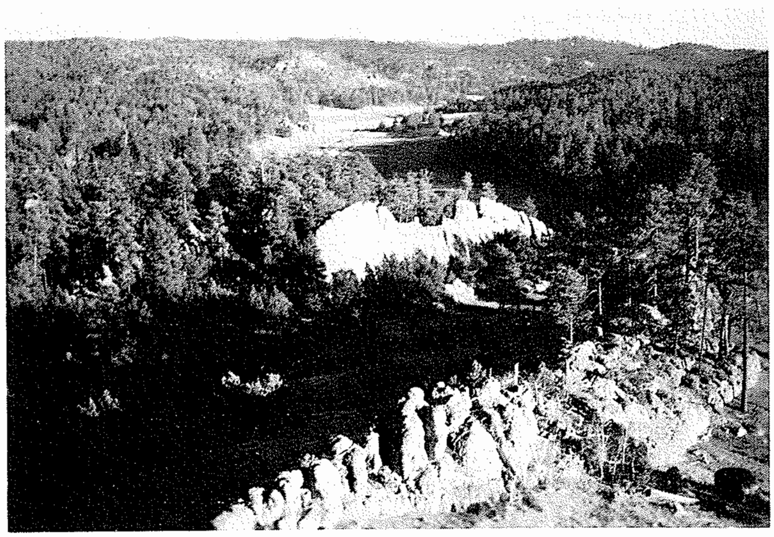

Figure 9

Dikes in the SE 1/4 Sec. 26 and NE 1/4 Sec. 33, T.4S., R.4E., Custer County. The wide dike in lower right is weathered to pinnacles along numerous joints. The one in the center is the form of a high sloping wall. The valley is one of the typical low broad sags. The forested areas contain numerous pegmatites. The accordance of summit level is apparent here also.

### Massive pegmatites.

Numerous rounded masses of granite, best referred to as chonoliths, form part of the bedrock of the area. There is every gradation from the dikelike masses having tabular or lenslike outline in cross-section through those that are elliptical, rounded, and irregular. Some are massive but of unknown outline, and some shown as massive pegmatites may consist of thick closely spaced dikes. Boundaries have had to be inferred in some cases, where the relief is low and there is a lack of granite outcrops. Some of the areas underlain by these massive pegmatites are hundreds of acres in extent. Much of the topography in such places is rough and characterized by knobs and cliffs.

### Relation of pegmatites to schist structure.

As has been pointed out by others, the dikes generally conform to the structure of the schist in their emplacement. It is only at the stubby ends of thick dikes that the schist has been found to vary from its normal regional strike and to wrap around the pegmatites. Examples of this are found where the ends of dikes outcrop on steep slopes, since in such places the schists are more likely to show also in outcrop close to the dikes. It is believed that detailed study of the relations at the ends of the dikes would confirm the impression that the dikes do not extend to great depths, but that they rather are isolated masses in the schist, and that their original near-vertical extent was more or less of the same dimension as their horizontal.

The foliation of the schists is also presumed to conform with the boundaries of the massive pegmatites throughout, although only limited observations were possible owing to the lack of suitable outcrops.

### Joints in the dikes.

The dikes are not characterized by abundant joints, although exceptions are easy to find (Fig.8). Sheet joints, in particular are not numerous. Transverse joints having a high angle with the surface are presumed to be present in many, as evidenced by weathering of the dikes into spires and knobs (Fig.9). They are assuredly present in some of the larger dikes, and while strike and spacing cannot be determined satisfactorily from the ground, it is apparent in airplane photographs. Judging from what has been learned by others in detailed studies of the pegmatites in particular mines, it is likely that many of the bodies are traversed by shear zones, faults of small movements, or shatter zones. These may not be apparent from casual surface examination, because they are most markedly affected by weathering.

## Distribution of the Pegmatites

Features that stand out in an over-all inspection of the map are: (1) The great number of dikes in the western tier of sections and their range in numbers for areas of a given size in those sections. (2) The comparative scarcity of pegmatite in large parts of sections 2, 3, 10, 11 and 14. (3) The presence of thick rounded bodies and massive outcrops of pegmatite in the eastern tier of sections. (4) The variation in strike of the dikes over the area as a whole, but the general conformity within limited areas.

There is obviously great range in the distribution of the dikes and similar bodies through the area. In some places they are close together, so close they could not all be shown on a map of the scale used. In some sections, as in 15, every 40 acre tract has numerous dikes. The areas shown in Fig. 10 and 11 are typical of those of numerous dikes. In other sections there are many tracts of similar size where they are lacking or present in only small numbers.

Massive and irregularly shaped bodies of pegmatite, probably best called chonoliths, are most numerous in the eastern half of the area, especially in sections, 1, 12, 13, 24 and 25. A large part of section 12, approximately a third, was mapped as granite by Darton and Paige. Several massive pegmatite outcrops are present in this area and have been shown on the map. The western boundary, mostly inferred, of

Figure 10
Airview, Sec. 26, T.4S., R.4E., Custer County, near Mayo.
Approximate size of area: 1 x 1.5 miles

Dikes are no more numerous here than in much of the forested area, but are more apparent because of the absence of trees.

an area which is believed to be largely granite, passes through sections 1, 12 and 13, so that the granite area of Darton and Paige falls within or to the east of it. East of this boundary, in sections 12 and 13, the pegmatite outcrops as rough knobs and hills, and the tabular or lenslike structures so numerous elsewhere occur only here and there. The areas of massive pegmatite outcrop are shown. Those without outcrop are possibly in part underlain with schist.

There are other massive pegmatites, a few immediately west of this granite-schist contact, and many more beyond it to the southwest in sections 13, 14, 23, 24, 25 and 26. There are also a few in sections 3 and 10. Most of the areas of outcrop are generally elliptical to sub-circular, with the long axes parallel to the schistosity.

The strike of the dikes in the western half is generally N 10° - 25° W. In the northwestern part, nearing the main Harney Peak mass, it is N 30° - 50° W. This change to a more northwestwardly strike is in line with the conformity between schist structure and the periphery which is found close to the Harney Peak mass. Along the eastern side of the area and in the southeastern and north-central sections the dikes strike more neanly N-S, and in the eastern part of section 25 they strike N 5° - 15° E.

## Additional Observations

### Schist joints

Joints in the schist, in two or more sets, dip northward at steep angles. Weathering of such jointed schist results in the development of outcrops characterized by a surface of crude stubby southward-pointing pyramids, a foot or so across. Such joints are well shown in Fig. 12. The possible relation of this jointing to the mechanics of intrusion of the pegmatite magma in this region can only be determined through further investigation.

Boundaries of timbered areas.

Airplane photographs show that many timbered areas are smoothly bounded on the north and that southern boundaries have narrow pointed southward-projections (Fig.13). While this may have no significance, it is believed not to be related to climate or weather, but rather in some obscure way to the geology of such areas. The forested areas are those containing dikes and southward-extending lines of trees are on dike outcrops. This suggests that the northern ends are on a smooth curve, and that because of unequal length the dikes extend south to varying distances at the surface. The significance and possible explanation of this feature await further consideration.

Fault lines.

Airplane photographs disclose the presence of several approximately straight lines traversing various parts of the area. These are up to more than a mile in length and strike in various directions. Roads follow them in part, and some lie along valleys, but the linear appearance is given in other places by a contrast in vegetation. The one shown striking almost east-west through sections 22 and 23 (Fig.14) lies partly along a valley and is also followed for a short distance by a ranch trail, but it coincided with no known survey line. Others similarly lie partly along valleys but do not follow survey lines. These lines are tentatively interpreted as fault lines, and further study of them is believed warranted. Apparent drag at ends of pegmatites exposed at the south side of the valley of Fig. 13 is believed partially to confirm this interpretation.

Old erosion surface.

The accordance of summit level in Beecher Rock Basin, already referred to in the description of the physiography, is notable. It is believed that most of these elevations are held up by pegmatites. The level might possibly represent the highest approximate level of intrusion of the pegmatites, but it is believed much more likely that it is the remnant of an older erosion surface. Darton and Paige have concluded that after uplift at the end of the Mesozoic the area of the Black Hills had been lowered through erosion by the time of the Oligocene. This surface may have been developed in the

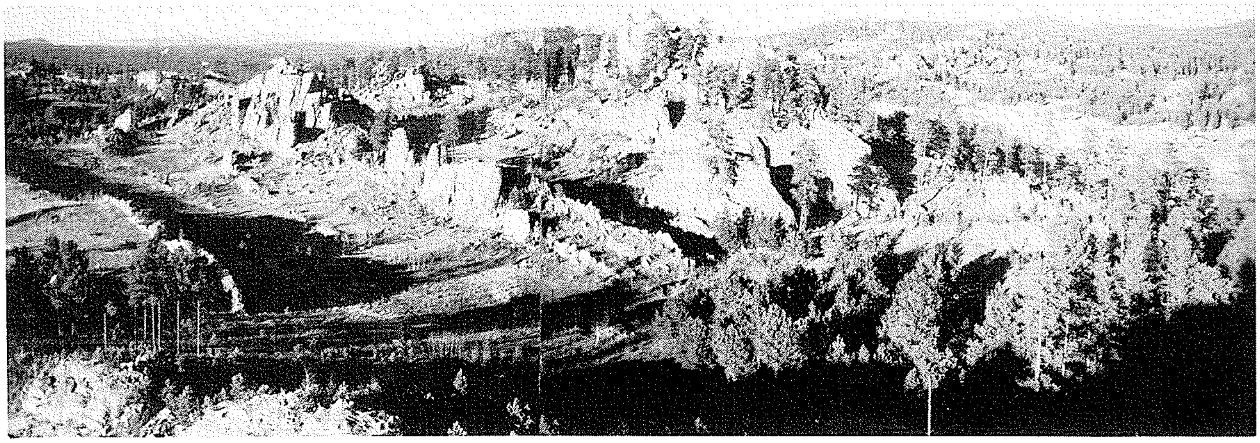

Figure 11
An area of numerous dikes, northeastward from an elevation in the SW 1/4 Sec. 26, T.4S., R.4E., Custer County. Beecher Rock on the skyline at right.

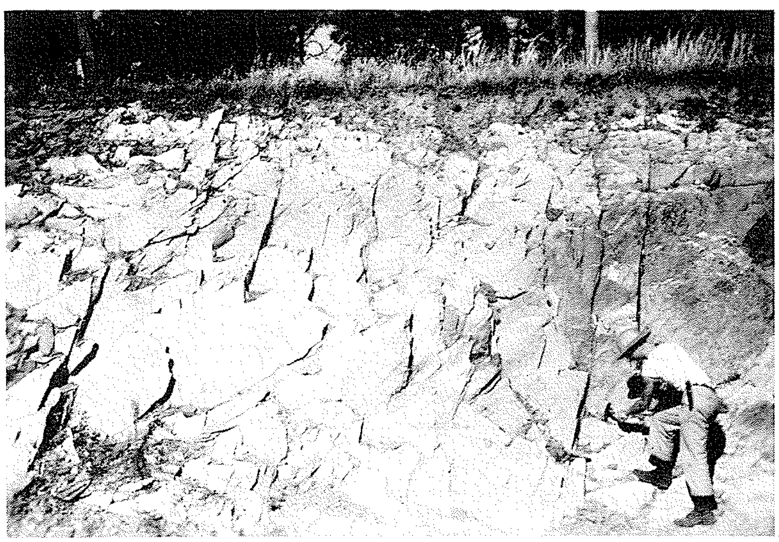

Figure 12
Road-cut in schist, Sec. 35, T.4S., R.4E., Custer County. Northward dipping joints in two or more sets cut the rock in such manner as to produce pyramidal surfaces, pointing southward.

course of this erosion, or it might even be a relic of a pre-Cambrian surface, exposed by the removal of later sedimentary rocks.

Country rock.

Limited observations on the country rock made in the course of the mapping lead to the belief that quartz mica schist underlies almost all of the area. Good outcrops are comparatively rare (Fig.15). Weathered fragments of amphibolite were found in widely separated places, and quartzite, noted in outcrops, holds up some of the ridges in the eastern tier of sections, in places where pegmatite is lacking.

Quartz veins, more nearly related to the intrusives than to the country rock, are a conspicuous feature locally in at least three areas. (1) A large block of milky quartz 40 feet long, 20 feet wide, and 10 feet high is exposed a quarter of a mile northeast of Beecher Rock. (2) Four large veins or groups of veins comprise a second area about 500 feet west of the Beecher Mine in the northeast corner of Section 13. These are known chiefly from the float which is present, and are of considerable size judged by the amount and the area over which it is distributed. (3) The third locality is in the northern part of the area map and contains two dikes or dike groups, one a thousand feet north of the Buster Mine in the northwest corner of Section 2, and the other about 1500 feet to the west.

Quartz veins have been noted traversing many of the dikes elsewhere but ranging as they do to those of inches in thickness no attempt has been made to map them. Many have been prospected and apparently have been looked upon by some prospectors as favorable to the occurrence of some of the sought-for minerals.

## Conclusions

The dikes have been found to be widely distributed over these 15 square miles, but to be most numerous in the western part. Notable features are the persistence of their strikes within limited areas, and the change in strike east and west across the area, and north and south. Persistence in direction and amount of dip within limited areas is noted as is also the division of the area into one of eastward and one of westward dipping dikes.

The concentration of more massive bodies of pegmatite in the eastern half of the area is notable, but the extension of mapping eastward is necessary before more can be said with regard to this.

Thus far nothing has been found in the distribution of mines in the area to suggest any particular relation between the position of the dikes or their character and the location of deposits of industrial minerals. It is apparent that the construction of the included map constitutes the first step toward determining such relationships. It is also apparent that much more regarding the mineralogy of dikes than has come to us from the presence of prospects and mines will have to be available before progress can be made along this line. The large number of pegmatites in the area however, is believed to offer favorable opportunities for exploration and development.

Figure 15
Schist and pegmatite outcrop,
SE 1/4 Sec.26, T.4S., R.4E., Custer County
Schist, weathered along joints to pinnacles and pyramids, outcrops at right. A steeply dipping dike at the left.

## ECONOMIC FEATURES

### Economic Development

The greater part of the Black Hills production of mica has come from the vicinity of Custer. This has included a notable amount, particularly during the past two years, from the mines of the Beecher Rock Basin. A large tonnage of feldspar has also been produced from the area surrounding Custer, and there has been a lesser production of beryl and the lithium minerals. Mines in the Beecher Rock Basin have also contributed considerably to the production of these minerals.

The pegmatites in the vicinity of Custer, including those of the area of the Beecher Rock Basin, have been the only ones to produce sheet mica, but scrap mica has been produced from other parts of the pre-Cambrian area, particularly from that near Keystone 12 miles northeast of Custer. The mica of the pegmatites in the vicinity of Keystone, according to the descriptions in the literature, occurs in the form of aggregates of small crystals bordering the pegmatite knobs. The sheet mica of the dikes of the vicinity of Custer including those of the Basin area occurs in "runs" or "rolls" along the walls. It is possible that experience gained in the present surge of mica-mining may throw more light on the manner of occurrence of the mica along the dike walls. Thus far it has been shown that little is to be gained from exploration or mining of the entire thickness of the dikes.

Following the opening of the Crown Mica Mine a few miles northwest of Custer in 1879 the production of mica in the Hills ranged greatly for a few decades, but in 1907, with the entrance of the Westinghouse Company into the area, it took on the character of a boom which continued until 1911. There was only intermittent production of scrap mica between 1911 and 1942, but beginning in 1942 there was a great expansion in the production of punch and sheet mica,* as well as a scrap up to 1935 had totalled approximately $1,400,000, of which over two-thirds had been produced in the years prior to 1913, and almost all of which had come from the Custer district. It is not possible to give figures for the greatly expanded production of the past few years but the rate has greatly exceeded anything of the past, and the mines of the Beecher Rock Basin area have contributed their full share.

Feldspar has been mined in the Black Hills since 1923, and the production of crude through 1940 has totalled approximately 300,000 tons with a value of $1,000,000. Fifty-five thousand tons with a value of $157,000 were produced in 1940. The largest production of feldspar has been from the mines near Keystone, but a large but unknown amount has come from the Custer area, and the part of this from the mines of the Beecher Rock Basin. There has also been some production of lithium minerals from the Custer and Beecher Rock Basin areas, but the Keystone area has produced much more of the tonnage of these minerals.

## Prospecting and Mining Methods, and Outlook.

Prospecting practice in the search for mica is to look for surface indications of the mineral at or near the base of exposed hanging and foot walls and in adjacent soil. Excavation by one or two men along promising leads is then made and continued as long as mica continues to be uncovered. So far as known there are no rules by which one may recognize the most likely part of a dike wall. Obviously the occurrence of "books" several inches across is most actively sought, as there is the largest yield of sheet mica, the most highly

* "Punch" mica, according to Spence, is that yielding a circle $1\frac{1}{4}$ to $1\frac{1}{2}$ inches in diameter. That of larger size is here referred to as "sheet".

valued, from this type. "Ruled" mica and "A-mica" yield only scrap, but often enclose pieces on punch or sheet size. Clear and unspotted mica constitutes the highest grade. Development work and much of the mining is a matter of work by crews of only a few men. Open-cut or quarrying methods are usually employed in mining. With extension of the deposits to depth however, adits or shafts may be found necessary.

It is obvious that there is great opportunity for exploration in the Beecher Rock Basin area; and the chances of finding additional deposits, particularly of mica, are considered reasonably good. All of the dikes, approximately 1500 in number, present possibilities, and certainly many of these have not been carefully examined. Places of rather complete and careful examination are the mines and prospects shown on the map, (Fig.1). Presumably the larger dikes are the more likely ones but, as even those apparently small at the surface might be larger in depth, they should not be neglected.

As far as feldspar is concerned, the problem is to discover deposits wherein the mineral is in massive form and as free as possible from admixture with other minerals. Much of the feldspar is in the rather undesirable form of graphic granite, an intergrowth of feldspar and quartz, named from its resemblance to ancient cuneiform writings of the Assyrians, in which the quartz is arranged in the feldspar in parallel rows of wedge-shaped grains. Commercial feldspar deposits extend irregularly through the dikes and in some cases make up a large part of them. Once a promising outcrop has been found, the only possible procedure is to continue development until the deposit has been thoroughly tested as to its commercial possibilities. Here again the area of the Beecher Rock Basin with its large number of pegmatites would seem to offer favorable opportunities. Probably larger pegmatites are the most likely ones, judging from the past development of successful mines.