Geology of the Calamity Peak Area Custer County South Dakota

By DONALD H. KUPFER

CONTRIBUTIONS TO ECONOMIC GEOLOGY

GEOLOGICAL SURVEY BULLETIN 1142-E

Prepared on behalf of the U.S. Atomic Energy Commission

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON : 1963

UNITED STATES DEPARTMENT OF THE INTERIOR

STEWART L. UDALL, *Secretary*

GEOLOGICAL SURVEY

Thomas B. Nolan, *Director*

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington 25, D.C.

CONTENTS

	Page
Abstract	E1
Introduction	1
Metamorphic rocks	2
Granitic rocks	4
Granite-pegmatite complex	4
Pegmatite	10
Unzoned or imperfectly zoned pegmatites	11
Well-zoned pegmatites	12
L–5 No. 2	12
Pegmatite 6	12
Pegmatite 7	13
Pegmatite 8	13
L–5 or Spring pegmatite	13
Pegmatite 12	14
Quartz veins	14
Sedimentary rocks	15
Terrace gravels	15
Alluvium and talus	15
Structure	15
Schistosity	16
Igneous structure	17
Faults	20
Mineral resources	21
Beryl	21
Mica	22
Feldspar	22
Gold	23
Gravel	23
References cited	23

ILLUSTRATIONS

	Page
PLATE 1. Geologic map and sections of the Calamity Peak area, Custer County, S. Dak	In pocket
FIGURE 1. Map of the southern Black Hills, S. Dak	E3
2. Textural layering in granite-pegmatite complex	5
3. Pattern of layering in the granite-pegmatite complex	6
4. Color layering in light-colored sodic granite	9
5. Wrinkles, sinuous quartz veins, and quartz-sillimanite knots in schist	17
6. Sketch of contact of pegmatite and schist	18
7. Outcrop in the schist core of the Calamity Peak mass showing schist cutting out upward against layered granite-pegmatite complex	19

TABLES

		Page
Table 1.	Analyses of granite and pegmatite	E7
2.	Mineralogy of pegmatite and granite	In pocket

CONTRIBUTIONS TO ECONOMIC GEOLOGY

GEOLOGY OF THE CALAMITY PEAK AREA, CUSTER COUNTY, SOUTH DAKOTA

By DONALD H. KUPFER

ABSTRACT

An area of 2½ square miles of Precambrian metamorphic and granitic rocks around Calamity Peak in the southern Black Hills, S. Dak., was mapped to determine the relation between the granite-pegmatite complex and pegmatites containing beryl and other industrial minerals.

Quartz-mica schists containing some garnet and sillimanite are the predominant metamorphic rocks; minor beds and lenses of quartzite, graphite schist, and amphibolite are also present. Metamorphism of the schist, as indicated by the size and number of quartz-sillimanite "knots," generally increases in intensity from southwest to northeast across the area. The main schistosity dips steeply to moderately southward. Bedding is poorly exposed. A secondary schistosity is present. Northeastward-trending high-angle faults are inferred to cross the area.

The granitic rocks consist of bodies of granite-pegmatite complex and locally crosscutting pegmatites. Pegmatite sills occur in the country rock. The pegmatites tend to decrease in abundance away from the granite-pegmatite complex. Textural layering in the granite-pegmatite complex consists of alternating layers of light-colored sodic granite and plagioclase-quartz-perthite pegmatite. The granitic layers locally contain a smaller scale color layering.

Pegmatites in the country rock are both zoned and unzoned. Zoned pegmatites typically consist of a very fine grained border zone rich in quartz, muscovite, and plagioclase; a fine- to medium-grained wall zone rich in quartz, plagioclase, and muscovite; an intermediate zone rich in perthite, quartz, and plagioclase; and a core rich in quartz and perthite. Unzoned pegmatites are similar in composition and texture to pegmatite layers in the granite-pegmatite complex.

The zoned pegmatites contain small resources of feldspar, mica, and beryl. A potentially large reserve of potassium feldspar and silica is present in the granite-pegmatite complex if an economic means of recovering the products becomes available.

INTRODUCTION

The core of the main Black Hills uplift is composed of metamorphic rocks of Precambrian age. In the southern part of the core is a complex of Precambrian granite and pegmatite. Individual pegmatites intrude the metamorphic rocks surrounding the complex and decrease in number away from the complex. The Calamity Peak area, 3 miles east of Custer, Custer County, S. Dak., is on the southwest flank of the granite-pegmatite complex in the transition zone between areas of predominantly granitic and predominantly schistose rocks (fig. 1). The Geological Survey chose this transitional area for detailed mapping in order to determine the relations between the larger masses of granite-pegmatite complex and the pegmatites containing beryl and other industrial minerals. The mapping was done on behalf of the Division of Raw Materials of the U.S. Atomic Energy Commission.

The maximum relief in the Calamity Peak area is about 600 feet. Bold outcrops and good exposures are common. A thin pine forest with little underbrush allows easy access to all parts of the area. Cool to moderate temperatures prevail in the summer and through much of the winter, although there are occasional periods of extreme cold. The average annual rainfall is 18 inches.

The Calamity Peak area was mapped during the summers of 1948 and 1949 on aerial photographs enlarged to a scale of 1:12,000. In the summer of 1948, Raymond E. Langen made a detailed outcrop map of the Precambrian rocks in 0.6 square mile (fig. 1). In the summer of 1949 I examined Langen's notes, briefly checked his map, added the Quaternary deposits, and mapped the additional 1.9 square miles (fig. 1).

METAMORPHIC ROCKS

Most of the metamorphic rocks in the Calamity Peak area occur around the granite-pegmatite masses, but large and small tabular to lenticular pendants or inclusions of schist (screens) occur within the granitic bodies, and schist underlies the Calamity Peak granite-pegmatite mass (pl. 1).

The principal metamorphic rock of the area is a quartz-mica schist [1] that generally consists of 60 to 90 percent quartz, 5 to 30 percent biotite, and a variable amount of muscovite; locally, biotite may constitute as much as 90 percent of the rock. Muscovite-rich schist is rare. Garnet and sillimanite are common accessory minerals.

A few discontinuous beds and lenses of massive quartzite, mica-poor quartz schist, medium-grained graphitic schist, quartz-amphibole schist, and massive amphibolite were mapped along the south edge of the Calamity Peak area but are not differentiated on the geologic map (pl. 1). Their outcrop pattern trends generally east-west and is somewhat arcuate—convex toward the south.

The metamorphic grade of the rocks in the Calamity Peak area increases from southwest to northeast toward the main granite-pegmatite mass of the Black Hills. The quartz-mica schist in the

[1] The petrographic descriptions are based on megascopic examination. Characteristic minerals in rock names are listed in order of abundance, with most abundant mineral first.

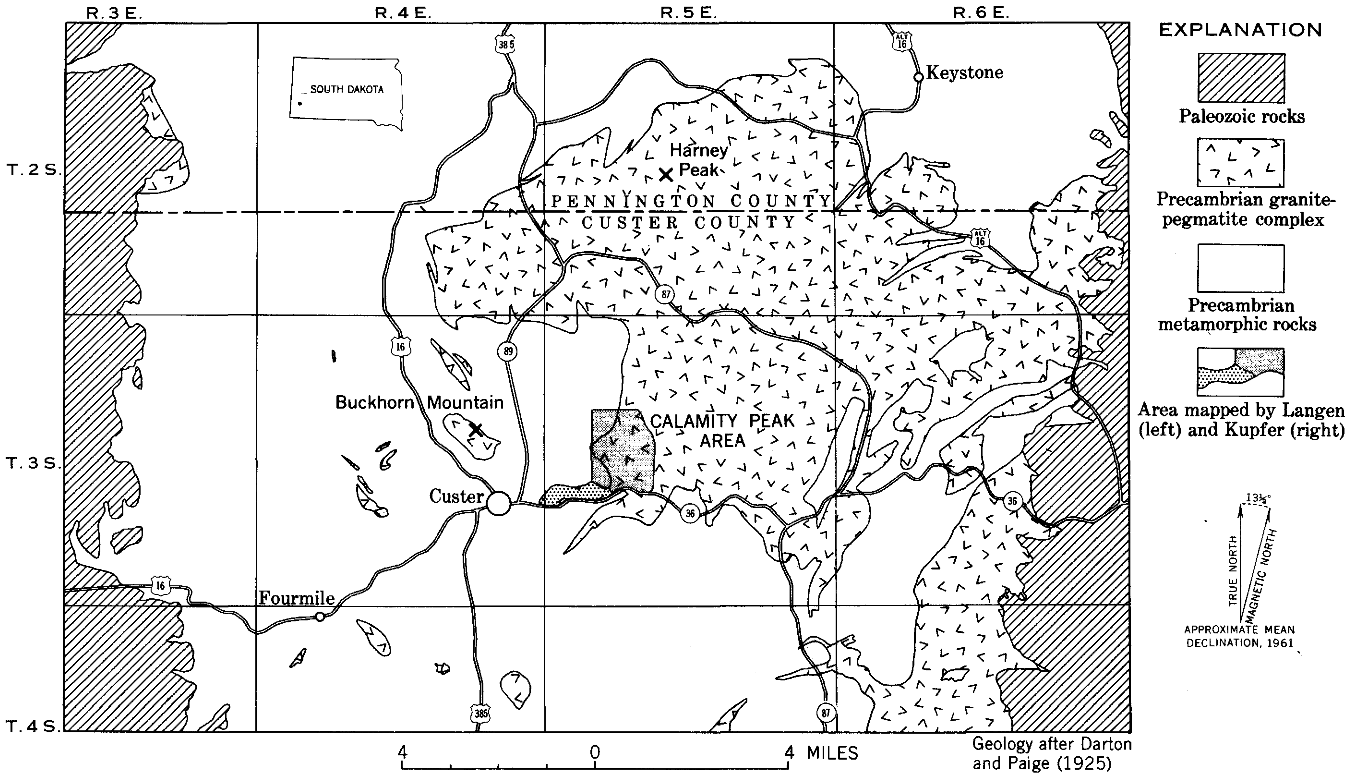

FIGURE 1.—Map of the southern Black Hills, S. Dak., showing the Calamity Peak area.

southwest part of the area (sec. 19, T. 3 S., R. 5 E.) contains garnet crystals; the amount of garnet is variable and probably related to the original composition of the beds. Northeast of the garnet-rich rocks, the schist contains small aggregates or "knots" of quartz with inclusions of minute sillimanite needles. On weathered surfaces these knots stand out in relief as hard white discoidal lenses. Harker (1939, p. 229) has briefly described similar quartz-sillimanite aggregates, which he calls "knots," "Faserkiesel," or "quartz sillimanitisé." The size and abundance of these quartz-sillimanite knots differ locally from bed to bed but generally increase northeastward with a corresponding increase in metamorphic grade. To the southwest (NW¼ sec. 20), the knots are absent in most places, but even where abundant they are less than one-sixteenth of an inch in diameter. Farther northeast, the knots are commonly ⅛ to ¼ of an inch in diameter; in the extreme northeast part of the area (NE¼ sec. 17) the knots are as much as 2 inches in diameter, but some areas are knot free. The quartz-sillimanite knots adjacent to the larger granite-pegmatite masses have been altered to muscovite by retrograde metamorphism.

GRANITIC ROCKS

Two rock units of granitic composition[2] have been mapped in the Calamity Peak area: (1) pegmatite and (2) granite-pegmatite complex. The first is normal pegmatite, both texturally and structurally. The second is layered granite and pegmatite.

The granite-pegmatite complex consists of alternate layers of light-colored sodic granite and plagioclase-perthite-quartz pegmatite. Two large irregular to somewhat tabular bodies and numerous small bodies of the granite-pegmatite complex are shown on the map (pl. 1). The irregular intrusive body at Calamity Peak and the large semitabular bodies to the north are typical masses of granite-pegmatite complex. The so-called granite batholith of Harney Peak (Darton and Paige, 1925, p. 5), north-northeast of the mapped area (pl. 1), is actually a group of separate or interconnected masses of granite-pegmatite complex.

Several types of pegmatites occur throughout the area but are most abundant near the borders of the larger granite-pegmatite masses. They form sills in the schist and dikes in the complex.

GRANITE-PEGMATITE COMPLEX

The larger granitic masses of the Calamity Peak area are layered owing to compositional and textural variations and are cut by locally numerous subparallel fracture fillings that in places resemble layering.

[2] Petrographic descriptions are based on megascopic examination. No thin-sections were examined. Feldspar determined by oil immersion.

The textural layering is the most abundant and prominent kind. Color layering, which is largely compositional, is less common and is confined to the finer grained textural layers.

Textural layering (fig. 2) is formed by alternate layers of granite and pegmatite. In outcrop, the coarse texture of the pegmatitic layers contrasts sharply with the fine-grained texture of the granite layers. This is the layering shown on the geologic map (pl. 1) and in figure 3. The layers are commonly 1 inch to 1 foot thick, but layers 1 foot to 6 feet thick are not uncommon and 25-foot layers have been observed. Most of the contacts between layers are moderately sharp; some are gradational.

Granite layers form 50 percent of the granite-pegmatite complex at Calamity Peak, but farther north, nearer the main granitic mass of the Black Hills, they form 80 percent. Locally the granite forms as little as 5 percent or as much as 98 percent of the complex.

The granite layers are equigranular light-colored sodic granite in which the grains are less than 0.1 inch in diameter. The rock is highly variable in composition but averages about 40 percent plagioclase (albite or sodium-rich oligoclase), 30 percent microcline, and 25 percent quartz. Tourmaline, muscovite, biotite, and garnet in places constitute as much as 10 percent of the rock. Three samples of the granite averaged 2.9 percent K_2O and 5.2 percent Na_2O (table 1).

The pegmatite layers of the granite-pegmatite complex are the same rock type that makes up most of the pegmatite sills in the metamorphic

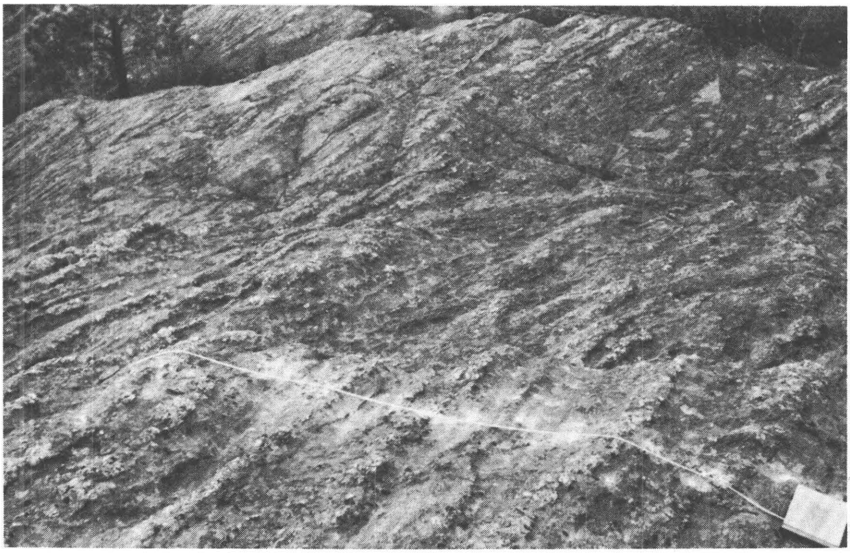

FIGURE 2.—Textural layering in the Calamity Peak mass of granite-pegmatite complex. Tape line indicates line of samples from location B (table 1). The average thickness of the layers is 3 inches.

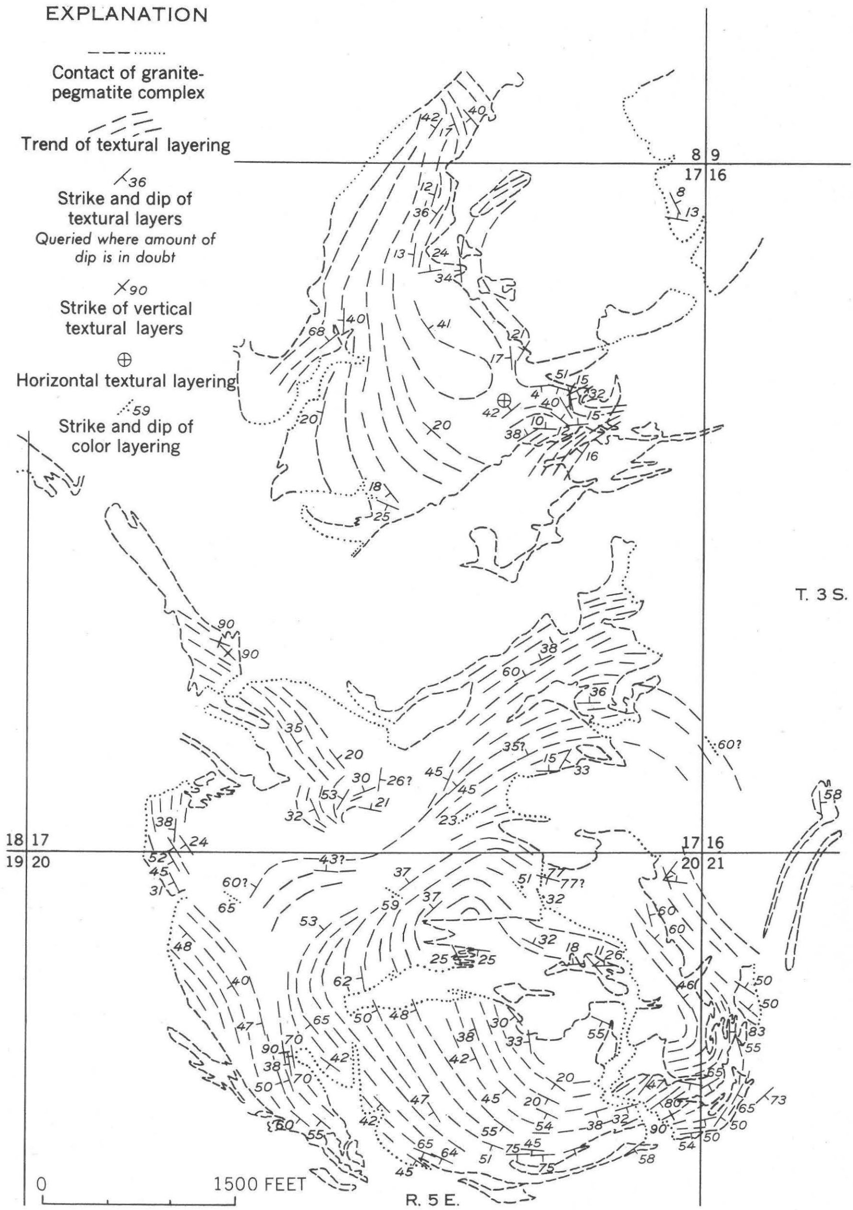

Figure 3.—Pattern of layering in the granite-pegmatite complex of the Calamity Peak area.

rocks and some of the transgressive layering in the complex. This plagioclase-perthite-quartz pegmatite rock is highly variable in composition (table 1) and in relative abundance of the characterizing minerals, but despite these variations the fundamental mineralogic, textural, and structural similarities of the rock justify its classification

TABLE 1.—*Analyses, in percent, of granite and pegmatite*

[Analyses by U.S. Geological Survey: Sodium, potassium, and lithium by flame photometer, S. M. Berthold and J. M. Dowd, analysts; other elements by spectrographic plates exposed for general scanning, J. D. Fletcher, analyst; averages and ratios calculated by D. H. Kupfer]

Location [1]	K_2O	Na_2O	CaO	MgO	Fe_2O_3	Ba	Mn	Cu	Zr	Ni	Cr	BeO
Granite												
A [2]	3.84	4.44	0.3–0.6	0.1–0.3	0.3–0.6	0.000x	0.x	0.000x	0.00x			0.0008
B [3]	3.84	4.68	.1–.3	<.1	.3–.6	.00x	.0x	.00x	.00x	0.00x	0.0x	.001
C [4] [5]	1.05	6.54	.3–.6	<.1	.3–.6	.00x	.0x	.000x	.00x	.00x	.0x	.001
Average	2.91	5.23										.0009
Pegmatite												
A [2]	6.54	3.27	0.1–0.3	<0.1	0.3–0.6	0.0x	0.0x	0.00x	0.00x	0.00x	0.00x	0.0006
B [3]	7.52	2.98	<.1	<.1	.1–.3	.0x	.00x	.000x				.001
C [4]	8.74	3.22	<.1	<.1	.1–.3	.00x	.00x	.00x				.0008
Average	7.60	3.16										.0008
Ratio of granite to pegmatite												
	0.38	1.65	>1		>1	<1	>1					1
Averages												
A	5.19	3.86										0.0007
B	5.68	3.88										.001
C	4.90	4.88										.0009
D [6]	4.28	2.99	0.3–0.6	0.1–0.3	0.6–1.0	0.0x	0.0x	0.00x	0.00x			.0008
Average	5.16	3.90										.0009
Transgressive layer												
D [7]	3.56	2.06	0.3–0.6	<0.1	0.3–0.6	0.0x	0.0x	0.00x		0.00x	0.00x	0.002

[1] See plate 1 for locations; A and D from same outcrop and 5 feet apart.
[2] Channel samples of textural layering; very sharp contacts; resembles transgressive layering.
[3] Channel samples; typical textural layering.
[4] Chip samples from centers of very thick textural layers; transitional material avoided.
[5] Pb=0.000x percent.
[6] Channel sample from very gradational layers; not sampled separately; Ti=0.0x.
[7] Chip sample from fracture filling cutting gradational layering.

NOTE.—All samples: Pb, Ga, Ti, Sr=0.00x; B=0.0x; LiO_2=<0.01.

as a single type. Most of the plagioclase-perthite-quartz pegmatite rock contains 20 to 50 percent plagioclase, 20 to 35 percent perthite, 20 to 30 percent quartz, and as much as 5 percent accessory minerals. The common accessory minerals are muscovite, tourmaline, biotite, and apatite, with sparse garnet, sillimanite, and yellow lithium mica. Three samples of the pegmatite layers averaged 7.6 percent K_2O and 3.2 percent Na_2O (table 1). The perthite content of the pegmatite was unusually high at the sampled localities; hence the high K_2O content.

Considerable textural variation is found in the pegmatite that occurs as layers, and the diameters of the largest grains range from a few inches in one outcrop to several feet in another. Typically, large crystals of perthite and quartz up to a foot in diameter occur in a finer grained groundmass of plagioclase and quartz. Plagioclase crystals larger than half an inch in diameter are rare. Tourmaline and muscovite crystals occur both in the finer grained groundmass and as large crystals. Biotite, sillimanite, and yellow lithium mica occur in aggregates that rarely exceed a few inches in diameter. Apatite and garnet grains average less than 0.1 inch in diameter.

Analyses of the granite and pegmatite (table 1) show that the granite layers contain more Na, Ca, Fe, and Mn and less K and Ba than the pegmatite layers.

Color layering in the Calamity Peak area is confined to the finer grained or sodic granite layers (fig. 4). The appearance in outcrop is that of numerous thin lines or bands formed by parallel alternating layers of quartz and feldspar grains. Locally, tourmaline and garnet also form layers. The layers are a small fraction of an inch thick and do not have sharp boundaries. In most places the color layers are parallel to the textural layers, but in a few places they are at a large angle to the textural layers. At one locality the color layers appear wavelike in outcrop (amplitude 4–6 inches), but at all others they are planar. The color layering is very similar in appearance to the "multiple banding" described by Staatz and Trites (1955, p. 23–24) and the "line rock" of the Pala district, California, but the composition and occurrence are not necessarily similar enough to justify correlation.

Fracture fillings commonly have sharp contacts, a crosscutting relationship to the host rock, high perthite content, and very coarse grain size. In most occurrences they are very distinctive. They generally consist of a series of parallel to subparallel dikes or segregations of perthite-quartz pegmatite or, less commonly, plagioclase-perthite-quartz pegmatite. Most are roughly tabular and a few inches thick, but they pinch and swell and locally are discontinuous. Some are lenticular and podlike. In areas of prominent textural

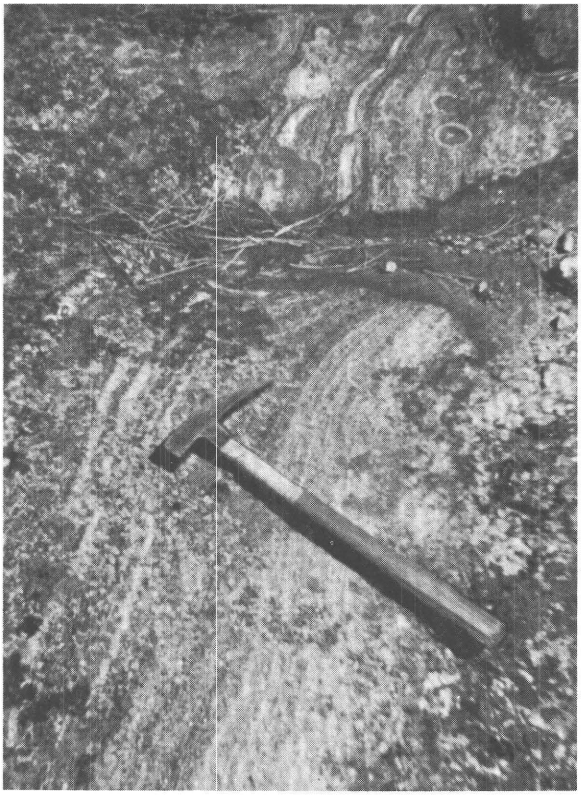

FIGURE 4.—Color layering in a thick textural layer of light-colored sodic granite in the Calamity Peak mass. The dark layers are mostly quartz and the light layers are mostly feldspar. The pick is 14 inches long.

layering they are uncommon, widely spaced, and transgressive. Those that are large and continuous are similar if not identical to unzoned pegmatites. The interest in this paper, however, is in their occurrence in some parts of the complex that are devoid of prominent layering, where they are numerous and parallel and present an appearance similar to that of textural layering. Where the contacts are indistinct, the two are difficult to distinguish. These fracture fillings may be considered a pseudolayering, or they may be the clue to the origin of textural layering.

Of the three types of layering (including pseudolayering), generally not more than one is prominent in any one area, and many areas are devoid of any prominent layering. All three types of layering are well exposed, however, in an area of several acres in the SE¼NW¼ sec. 20, T. 3 S., R. 5 E. The textural layering trends N. 0°–40° W. and dips 47°–90° SW.; the average strike is N. 12° W. and the dip is 70° SW. Fracture fillings in this area are abundant and have variable trends, but the most prominent set, consisting of unzoned plagioclase-perthite-quartz pegmatite, strikes N. 30°–40° E. and dips 50°–90° SE. The closely spaced parallel sheets are a few inches to several feet thick. In one outcrop, color layering is prominent, and strikes N. 10° W. and dips 38° SW., but elsewhere it is less well defined and is probably concordant with the textural layering in the area. The dark-colored layers in the outcrop are principally tourmaline, and this may be a true "line rock" of the Pala type. This is also the location of the wavelike layers previously described.

PEGMATITE

Well-zoned and imperfectly zoned pegmatites occur in the layered complex as dikes and in the metamorphic rocks as sills (parallel to schistosity) or, rarely, as dikes. All gradations can be found from well-zoned pegmatites, through imperfectly zoned pegmatites, to the fracture fillings described previously. The zoned pegmatites are characterized by a distribution of the minerals in distinct concentric zones as described by Cameron and others (1949, p. 16–70). Most of the pegmatites in the metamorphic rock show an imperfect zoning. They generally have a well-defined fine-grained border zone about 1 inch thick in which individual grains are 0.05 to 0.2 inch in diameter. Muscovite tends to be more abundant in the outer part of the pegmatite, and large perthite and quartz crystals are more abundant in the inner part. Table 2 gives details of mineralogy and texture. In naming the pegmatite, the characteristic minerals are listed in order of abundance, with the most abundant minerals first.

The unzoned pegmatite layers in the granite-pegmatite complex are plagioclase-perthite-quartz pegmatite. Most of the pegmatite sills in the schist and many of the fracture fillings in the granitic rock are also plagioclase-perthite-quartz pegmatite. A few graphic-granite pegmatites occur in the schist, but they are much more common in the granitic masses. Small podlike fracture fillings or segregations of perthite-quartz pegmatite are scattered abundantly throughout the granite-pegmatite complex. The well-zoned pegmatites, whether in the schist or the granite-pegmatite complex, have an overall composition similar to the plagioclase-perthite-quartz pegmatite. The outer zones are rich in plagioclase and muscovite, and the inner zones are rich in quartz and perthite.

All the pegmatites occurring outside the granite-pegmatite complex are shown on the geologic map (pl. 1). Only the well-zoned pegmatites and a few other distinctive pegmatites are shown within the granite-pegmatite complex. The various types of pegmatite and their distribution are as follows:

Type	*Name*	*Geologic distribution*
Unzoned or imperfectly zoned.	Plagioclase-perthite-quartz	Coarse-grained layers in complex. Fracture fillings in complex. Dikes in complex. Sills in metamorphic rocks.
	Graphic granite-plagioclase-quartz.	Dikes in complex. Sills in metamorphic rocks.
	Perthite; perthite-quartz	Fracture fillings in complex.
	Quartz-perthite	Dikes in complex.
Well zoned	See table 2	Dikes in complex. Sills in metamorphic rocks.

UNZONED OR IMPERFECTLY ZONED PEGMATITES

Plagioclase-perthite-quartz pegmatite is the most abundant type of pegmatite in the metamorphic rocks of the Calamity Peak area. It occurs as sills and dikes and is similar in texture and composition to the pegmatite that occurs as layers in the granite-pegmatite complex. Individual pegmatite bodies are as much as 1,500 feet long.

Graphic granite-plagioclase-quartz pegmatites occur mainly as dikes in the granite-pegmatite complex. They contain 50 to 80 percent graphic granite in crystals 6 inches to 6 feet in longest dimension. The texture and composition of the remainder of the rock are similar to those of plagioclase-perthite-quartz pegmatite.

Perthite and perthite-quartz pegmatites are numerous in the granite-pegmatite complex as small, irregular, pod-shaped segregation-like fracture fillings. Most of the pods are no wider than the coarsest perthite crystals in them, but several pods may unite to form stringers several feet long. Most of the perthite crystals are between 2 and 10 inches in diameter. Quartz, where present, forms less than 20 percent of the rock. The quartz grains are about one-fourth the size of the perthite crystals.

Rose quartz dikes a few inches to several feet thick can be traced for tens to hundreds of feet through granite-pegmatite complex. Although veinlike in their distribution, most of these bodies consist of massive rose quartz with a few large perthite crystals near the outer edge—a typical pegmatite texture. Some bodies, however, are pure quartz and may represent true veins. Many gradations can be found from rose quartz veins to quartz-perthite pegmatite. In a few places rose quartz veins can be traced along strike into the cores of zoned pegmatites. The rose quartz grades from very pale grayish pink (5*R* 8/1) to clear rose pink (5*R* 6/4).[3]

[3] Munsell numerical color designation.

WELL-ZONED PEGMATITES

The typical well-zoned pegmatite consists of a series of shells or partial shells around a central core. The outermost and thinnest shell is a fine-grained border zone that may be a chilled contact (omitted in table 2). Next is a wall zone in which muscovite and, in places, biotite are concentrated. Next is the intermediate zone, which constitutes the bulk of the pegmatite, although variations are very common. The core in the Calamity Peak area is generally massive rose quartz bordered by very coarse perthite crystals.

Six zoned pegmatites in the Calamity Peak area are described below. Table 2 contains detailed mineralogic data for these pegmatites. The Terry claim (pl. 1) has been described by Page and Pray (Page and others, 1953, p. 195).

L-5 NO. 2

L–5 No. 2 (pegmatite 5, pl. 1) has been sporadically mined by Kenneth Spring of Custer, S. Dak., for minerals to sell to tourists. The pegmatite has been opened by an L-shaped cut 110 feet long and 4 to 12 feet deep.

The L–5 No. 2 pegmatite is shaped like an inverted trough; each limb of the trough is a separate pegmatite, and the wall zones of these pegmatites coalesce. The west pegmatite strikes N. 30° E. for 40 feet and dips 80° NW. The east one strikes N. 37° W. for 70 feet and dips 53° NE. Both are 10 to 15 feet thick. The country rock is granite-pegmatite complex.

The wall zones in the two pegmatites can be subdivided on the basis of minor minerals into three units. These subunits from the contact inward are:

1. Plagioclase-perthite-quartz pegmatite, with tourmaline, muscovite, and biotite;
2. Plagioclase-perthite-quartz pegmatite, with tourmaline and muscovite;
3. Plagioclase-perthite-quartz pegmatite, with tourmaline and beryl.

The core contains massive rose quartz (60 percent), 3- to 6-foot perthite crystals (35 percent), and 2- to 3-foot black tourmaline crystals (5 percent).

PEGMATITE 6

A pegmatite on a low ridge of granite-pegmatite complex (pl. 1) has been prospected by opencuts on both flanks of the ridge. The extremities of the pegmatite have been covered by dump, but the pegmatite seems to be a lenticular pod 50 feet long by 15 feet wide. It is exposed to a depth of 10 feet. The wall zone is composed of graphic granite (95 percent), biotite (up to 5 percent), and traces of tourmaline and muscovite. The biotite occurs as elongate books that average ¼ inch thick, 1 inch wide, and 8 inches long. The long axis of the biotite is perpendicular to the pegmatite contact. The perthite-quartz-muscovite pegmatite intermediate zone contains accessory tourmaline, graphic granite, plagioclase, and apatite and has a medium-grained pegmatitic texture; most of the grains are between 1 and 2 inches in diameter. Some of the perthite and rose quartz crystals are a foot or more in diameter. Badly reeved and soft muscovite occurs as 1- to 4-inch books in clusters or pods 2 feet in diameter. The exposed core of 1- to 2-foot perthite and rose quartz crystals was 6 feet thick, 12 feet wide, and 15 feet long, but three-quarters of its was removed during prospecting.

PEGMATITE 7

Pegmatite 7 (pl. 1), opened by a small prospect pit, is 70 feet long and has a wall zone ½ to 1 foot thick around a core of colorless and rose quartz 3½ feet thick. Black tourmaline crystals ⅛ to 1 inch in diameter and 1 to 4 inches long occur just inside and perpendicular to the contact of the pegmatite with the granite-pegmatite complex. A few perthite crystals 1 foot long occur in the core.

PEGMATITE 8

A series of unprospected discontinuous, lenticular pegmatite bodies occur along a fracture which is 750 feet long, strikes N. 53° W., and dips steeply southwest (pl. 1). The pegmatite is continuous for 150 feet at the west end of the fracture, then it becomes podlike and discontinuous for another 300 feet eastward. The easternmost 300 feet of the fracture contains very little feldspar, just rose quartz. Typical pods contain the following zones:

1. A discontinuous quartz-muscovite-garnet pegmatite border zone 1 inch thick, with accessory feldspar, biotite, and tourmaline;

2(*a*). A perthite-quartz-muscovite wall zone 5 to 30 inches thick, with plagioclase, garnet, and tourmaline;

2(*b*). A perthite-muscovite-quartz pegmatite intermediate zone 5 to 30 inches thick, with tourmaline and biotite; reeved mica books with an average diameter of 2 to 6 inches.

3. A core of rose quartz pegmatite 1 to 3 feet thick, with a few 6-inch crystals of perthite at the edges. The cores of most pods are 2 to 10 feet long.

L-5 OR SPRING PEGMATITE

The Spring pegmatite (pegmatite 11, pl. 1) is owned by Kenneth Spring of Custer, S. Dak. It is opened by a pit 50 feet long, 30 feet wide, and 15 feet deep. The pegmatite is tabular to lenticular and is about 100 feet long and 30 feet thick. The attitude of the pegmatite is not clear, but it appears to strike east and dip 45° S.

The country rock in the neighborhood of the pegmatite includes quartzite, graphitic schist, amphibolitic schist, and quartz-mica schist. The actual contact is exposed at only one point, in the bottom of the northeast corner of the cut, where quartz-mica-tourmaline schist rolls under the pegmatite and plunges 25° W.

The pegmatite consists of three main zones. The wall zone, plagioclase-quartz-muscovite pegmatite, contains 4- to 6-inch crystals of cleavelandite and 1-inch crystals of quartz. The muscovite in this zone is mostly ¼ to 1 inch in diameter, but some books are as much as 3 inches in diameter. The mica is a light ruby, and most of the recoverable sheet would be of no. 2 or no. 2 inferior quality. Crystals of beryl half an inch long are reported to be in this zone.

The intermediate zone, perthite-quartz-muscovite pegmatite, consists mainly of 2- to 10-foot crystals of perthite and quartz. The perthite contains unusual dark streaks along certain planes (crystallographic?) in the mineral, resulting in dark-gray and white layers 0.05 to 0.2 inch thick. Books of muscovite as much as 2 feet in diameter occur in this zone, but the mica is soft, air stained, reeved, and ruled. Only a negligible percentage of this mica could be used for sheet and punch mica. One beryl crystal about 2 feet in diameter and 3 feet long was mined from this zone in 1940.

A quartz core is reported by the owner to have been exposed in the floor of the pit. The floor is now covered by debris, but a small part of the core was observed in the walls of the pit. Its shape is not accurately known.

PEGMATITE 12

Pegmatite 12 (pl. 1) has been mined by an opencut about 15 feet long, 8 feet wide, and 7 feet deep. The pegmatite is 200 feet long and contains a core of rose quartz. The pegmatite has been altered, possibly by hydrothermal solutions, leaving irregular areas of fine-grained perthite, quartz, biotite, muscovite, tourmaline, and clay.

The cut is in a roll on the side of the pegmatite, and the zonal boundaries at this point are very gradational. The outer zone contains mostly ½- to 2-inch muscovite books, but a few books are as much as 8 inches in diameter. The core of the roll is an irregular mass of perthite crystals 4 to 10 feet long. About one-fifth of the perthite crystals are graphically intergrown with quartz.

QUARTZ VEINS

White to gray quartz veins are very common in the schist, and are particularly abundant in the center of sec. 19 and in the northwest corner of sec. 17. They range in size from minute veinlets that follow the minor crenulations in the schist to massive veins 10 feet wide that parallel the schistosity or cut it at moderate angles. Most of the larger veins are in the area mapped by Langen (pl. 1); they contain sillimanite and andalusite. Smoky quartz occurs in many of the veins, and large biotite flakes are common in the adjacent schist.

Many of the quartz bodies in the schist, especially the thin veinlets, contain as much as 30 percent feldspar and may be a transitional phase between typical feldspathic pegmatite stringers and quartz veins.

SEDIMENTARY ROCKS

TERRACE GRAVELS

High-level terrace gravels cap most of the low grass-covered hills in the southwestern part of the Calamity Peak area. The maximum thickness of the deposits is not known, but a 12-foot thickness is exposed in the gravel pit in SE¼ sec. 19 (pl. 1). The edges of the deposits thin to less than 1 foot and become indistinguishable from the finer grained alluvium.

Rounded and subrounded pebbles and cobbles make up half of the gravels. All the bedrock types found in the mapped area are represented among the pebbles; but quartz-mica schist, the most abundant bedrock type, is very rare. Massive quartzite and the amphibolitic rocks are abundant.

The crossbedding of the gravels in the gravel pit suggests a source to the north. The Quaternary age shown on the geologic map (pl. 1) is surmised.

ALLUVIUM AND TALUS

Flood-plain deposits cover the floors of the larger valleys and stand 2 to 6 feet above the present streambeds. Flood-plain deposits and the stream gravels of the larger streams are indicated as alluvium on the geologic map (pl. 1).

Talus is found at the base of all the higher cliffs in the area, but only the talus that obscures significant geologic contacts is indicated on the geologic map (pl. 1).

STRUCTURE

In general, the structure of the Calamity Peak area is that of a series of south-dipping schists cut by large and small masses of granite-pegmatite complex and by many small pegmatites, at least some of which cut the complex and are therefore younger than the complex. The schistosity has been locally deformed. The largest unit of the granite-pegmatite complex—that at Calamity Peak—is a dome-shaped lenticular mass with a schist core. Layering in the complex is also domical. Both the complex and the internal layering are conformable with the schistosity on the south and crosscut it on the north. A smaller mass north of the Calamity Peak mass is less well exposed but is interpreted as sill-like with conformable internal layering.

Three northeast-trending, high-angle, normal-separation faults are interpreted as crossing the area.

SCHISTOSITY

Throughout most of the area schistosity is well developed and bedding is obscured. The attitude of schistosity in the Calamity Peak area is shown by symbols on plate 1. In general, the schistosity dips steeply to moderately southward. A strong probability exists that locally a secondary schistosity has been impressed on the primary schistosity, but more work is needed to properly evaluate the structure.

In the southern part of the area bedding can be observed in several outcrops, and an areal pattern to the bedding can be surmised from the distribution of the various types of metamorphic rock. The bedding appears to follow the general trend of the schistosity, but locally it is contorted (folded?) and irregular. In the rest of the area bedding is obscure, and no relationship between bedding and schistosity can be proved.

In many parts of the area a secondary folding imposed on the main schistosity is suggested by crenulation or wrinkling (fig. 5). Most of the wrinkles have an amplitude of 0.2 to 0.5 inch and a period of 0.5 to 1 inch, but the range in amplitude is from 0.1 to 14 inches.

As a result of the wrinkling, the biotite and muscovite flakes and possibly the other minerals are alined along the wrinkles at an angle to the main schistosity. The result is a lineation on the schistosity that is parallel to the axes of the wrinkles. In some places this lineation occurs where there is no megascopic wrinkling. The plunge of the lineation is southerly.

In the areas where wrinkling is best developed (as in the NE¼NE¼ sec. 20), two sets of schistosity are also commonly present. The older set parallels the regional schistosity and the wrinkles have developed on this set. The newer set parallels the axial planes of the wrinkles.

In many of the areas of intense wrinkling, quartz veinlets conform with the individual wrinkles; the resulting sinuous pattern is very distinctive (fig. 5). In the SW¼NE¼ sec. 17, sinuous quartz veinlets occur in an area of unwrinkled, uniform schists with north-trending (secondary) schistosity. It is believed that this sinuous pattern is a relict structure from the now-obliterated former wrinkling and thus identifies the final stage in the development of secondary schistosity.

A possible third type of schistosity is locally developed around and parallel to the contacts of discordant pegmatites. This schistosity, which obliterates the main schistosity for a few inches outward from

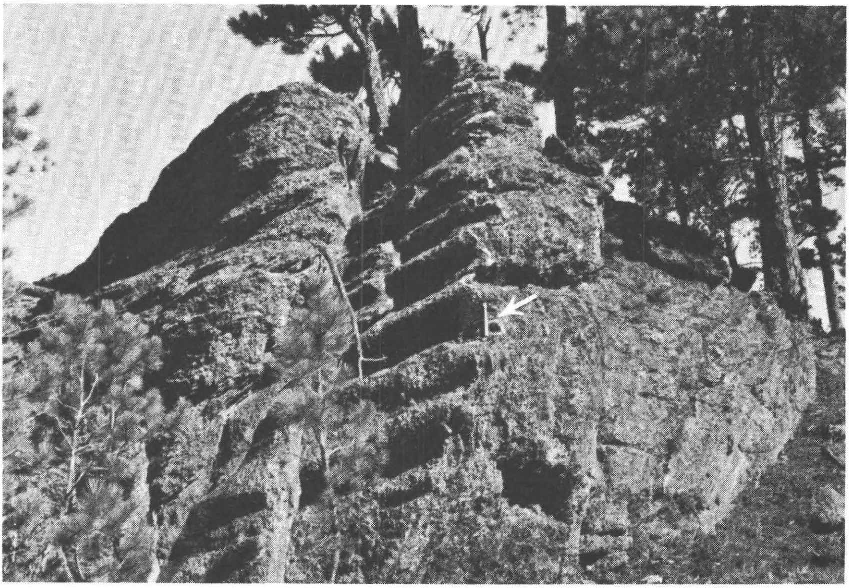

FIGURE 5.—Very large wrinkles (forming stairway in photograph) in schist in the northern part of the area. The main schistosity and the bedding strike N. 60° W. and dip 50° SW. (parallel to the crests of the wrinkles). A second schistosity is developed locally that strikes N. 67° E. and dips 40° NW. (parallel to the axial planes of the wrinkles). The geologic pick rests on a sinuous quartz vein about 1 inch thick that follows the crenulations of wrinkles. The knobby character of the schist is caused by quartz-sillimanite knots.

the pegmatite contact (fig. 6), is considered to be an induced schistosity resulting from the intrusion of the pegmatite.

IGNEOUS STRUCTURE

The area between the large masses of granite-pegmatite complex and the schist country rock consists of an alternating sequence of pegmatite sills and schist screens (septa or tonguelike projections of wallrock in and between pegmatites). The number and concentration of the pegmatites decrease outward away from the main mass as the size and extent of the schist screens increase, so that the change from massive granite-pegmatite complex to schist occurs over a zone several hundred feet thick. At some of the individual contacts within this zone, the same interfingering of the two rock types occurs on a small scale, yet even on the smaller scale each contact is sharply defined and every fragment of rock can be labeled as either schist or granitic rock.

The granitic bodies are divided for purposes of description into 3 structural types, but actually all 3 are members of a gradational series. The large mass of granite-pegmatite complex that crops out in a roughly circular pattern around Calamity Peak is called the Calamity Peak mass in the following discussion and is described first, followed

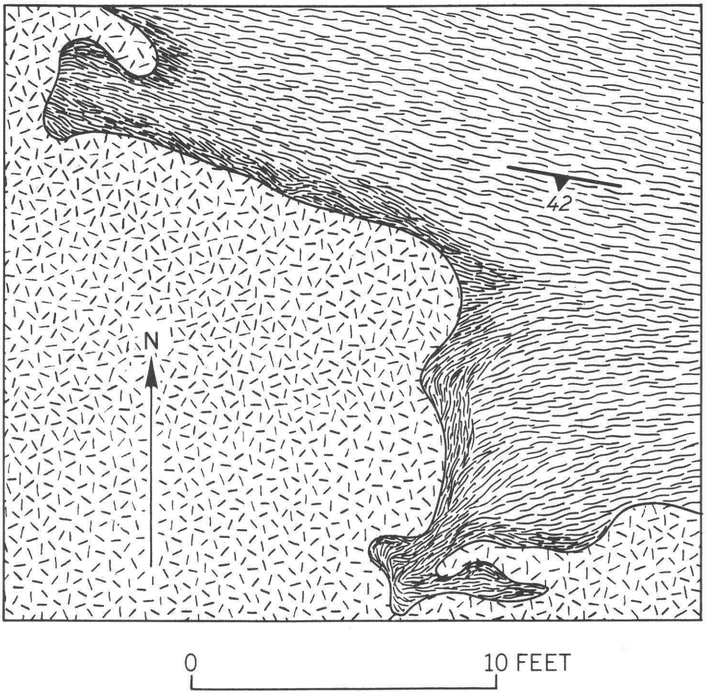

FIGURE 6.—Plan view of contact of pegmatite and schist south of Calamity Peak. The regional trend of the schistosity is locally destroyed and the new schistosity is conformable to the contact.

by the subtabular bodies of the same rock to the north of Calamity Peak, and finally the sills and dikes of pegmatite.

The Calamity Peak mass, a granite-pegmatite layered rock complex, is interpreted as a domical shell with a schist core. The crest of the dome is breached so that the complex is exposed around Calamity Peak as a roughly circular area 1 mile in diameter. The schist core crops out just north of Calamity Peak. The relief is about 600 feet and exceptionally good exposures provide data in 3 dimensions. The layering in the granite-pegmatite complex and the contacts of the mass on the west, south, and east sides are parallel with each other and in general with the schistosity and possibly the bedding. Underneath the mass and all around its north half, however, the schistosity is at a high angle to the contacts and the internal layering (pl. 1).

A deep east-trending valley cuts through the heart of the mass just north of Calamity Peak and exposes a schist core completely surrounded by the granite-pegmatite complex. The schist contains many pegmatites 2 to 20 feet thick; both the pegmatites and the schistosity strike east and dip 40°–70° S. into the granite-pegmatite complex above and on both sides. Ridges, knobs, and cliffs as much as 100 feet high in the area of this schist inlier are capped by an increasing proportion of granite-pegmatite complex upward. Pegmatite dikes branch and thin downward, and schist screens end abruptly upward against the granite-pegmatite complex (fig. 7).

The layering in the granite-pegmatite mass at Calamity Peak, like the mass itself, is domical with dips outward from the schist core. Pendants and inclusions of schist in the granite-pegmatite mass maintain the orientation of the adjacent schist country rock, despite the domical structure of the mass itself.

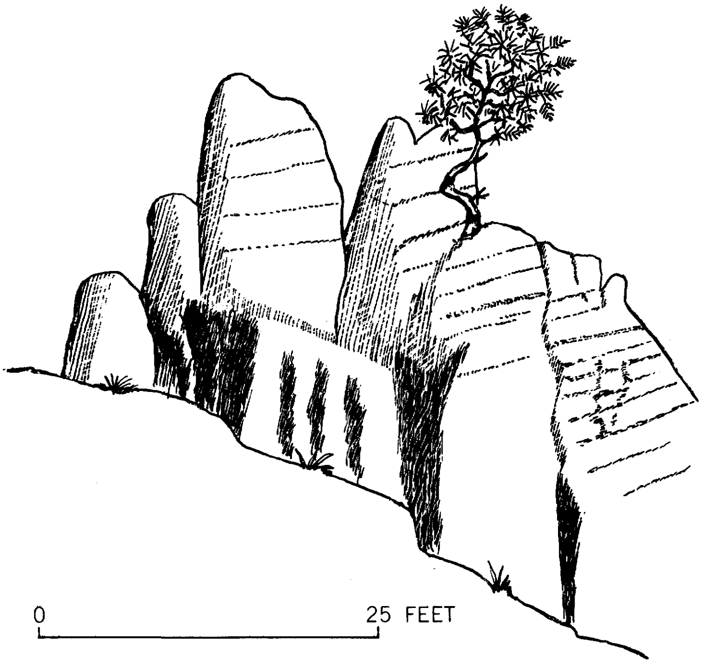

FIGURE 7.—Outcrop in the schist core of the Calamity Peak mass showing schist (dark areas) cutting out upward against layered granite-pegmatite complex. View looking east; schistosity strikes N. 75° E. and dips 65° SE., and layering strikes N. 85° E. and dips 18° NW.

The extreme north contact of the Calamity Peak mass is sharp, without the normal transition zone. It is assumed to be a fault (southeastern fault, pl. 1).

To repeat for emphasis, the granite-pegmatite complex at Calamity Peak is a domed tabular, intrusive, probably cut off on the north by a normal fault. As a crude generalization, the north half of the mass appears to transgress regional structures and the south half parallels them. Where transgressive, the contacts are extremely irregular, and local contacts are at high angles to the more regional contact (fig. 7).

North of the Calamity Peak mass is an outcrop area of granite-pegmatite complex with layering as shown on figure 3. The outcrops show westward-dipping layering that flattens eastward, then a gap, and a few outcrops to the extreme east show eastward dips. This suggests an anticlinal fold. Assuming that the lower contacts of the complex parallel the layering here as they do to the south, this mass is best interpreted as crudely tabular and, neglecting minor irregularities, anticlinal. This interpretation is not in disagreement with the schistosity, layering, or contacts observed. The smaller masses and the pegmatites of the area roughly parallel this trend and suggest that the anticline plunges south. According to this anticlinal interpretation, these tabular masses would be sill-like with respect to the schistosity and about 500 feet thick.

The true pegmatites are characteristically smaller than the complex and are unlayered. A few bodies of granite-pegmatite complex are small, sill-like, and similar to pegmatites (with which they form a gradational series), but they are distinguished by the presence of finer grained sodic granite. Most true pegmatites are either crudely or well zoned. The pegmatites in the schist are generally tabular and concordant with the schistosity. The plunge of the pegmatites and of the minor rolls on the pegmatite contacts is parallel to the plunge of the wrinkling, the folds, and the biotite lineation in the schist.

FAULTS

Three faults have been interpreted as cutting the area (pl. 1), and 1 or 2 other large faults may be present. The evidence for the faults is primarily the abrupt termination of the granite-pegmatite masses against schist in places where the normal gradational contact is absent. Where complex is faulted against complex, the two masses commonly have different structural trends. Some of the evidence is physiographic: The faults all follow valleys and other low areas, even through areas of otherwise massive and resistant complex. Once a fault is recognized, its trend through the schist can be traced by the pattern of the pegmatites. The faults are assumed to be younger than the pegmatites; therefore, undisturbed pegmatites should not cross the fault zones, and none were observed to do so. The possibility that some of the pegmatites might be younger than some of the faults was considered but could not be proved or disproved. No fault surface with striations could be definitely identified, but in places the fault zone could be located within very narrow limits over areas of tens or hundreds of feet and sometimes in three dimensions.

All three faults strike northeast across the area. The middle fault is the best exposed and is composed of two en echelon fractures; the displacement on one decreases as the other increases. The strike is N. 50° E., and the topographic expression suggests a steep southeast dip. The position and structure of the granitic masses on opposite sides of the fault suggest a normal separation of about 500 feet.

The northwestern fault is poorly exposed. Lacking evidence to the contrary, it is assumed to be normal and to dip southeast, like the middle fault.

The presence of the southeasternmost of the three faults is suggested by the abrupt northern termination of the Calamity Peak mass, by the discordance of the internal layering (see pl. 1, section *B–B′*), and by the break in the trends of the schistosity. The direction of movement on this fault is unknown, but it is assumed to be a normal separation fault like the middle fault.

Several minor faults are shown on the map between the middle and southeastern faults (pl. 1). These probably represent the southwest end of a fourth parallel fault, as indicated on section *B–B′* (pl. 1).

MINERAL RESOURCES

Pegmatites in the Black Hills have been mined for beryl, feldspar, mica, spodumene, amblygonite, lepidolite, columbite-tantalite, and for specimens to sell to tourists. In the Calamity Peak area beryl, mica, and feldspar have been produced in the past, but none of the pegmatites were being mined in 1950, probably because they are too small or too low grade. The L–5 No. 2 (pl. 1, pegmatite 5) has been mined for souvenirs: rose quartz, smoky quartz, beryl, mica books, and large black tourmaline crystals have been sold. A limited amount of columbite-tantalite has been reported from the Spring pegmatite (pl. 1, pegmatite 11). The only lithium minerals that have been found in the area mapped are minor traces of yellow lithium mica. The prospects and mines of the area are located on plate 1 and the mineralogy of their pegmatites is tabulated on table 2.

Several pegmatite mines that are just outside the Calamity Peak area have furnished industrial minerals. These include the Victory, Victory No. 1, Custer Mica Lode No. 1 and No. 2, L–5 No. 3 and No 4, Mica Queen, Tin Key, Harback (Lucky Jerry), and Climax mines. They have all been mentioned or described by Cameron and others (1949), or by Page and others (1953). Several small prospects in the Buckhorn area have also yielded some rock for souvenirs.

BERYL

Beryl is known to have been produced from only two pegmatites in the Calamity Peak area. The Spring pegmatite (pl. 1, pegmatite 11) is reported to have yielded 3.4 tons of beryl from 3 crystals.

Crystals of beryl were also reported to have been found in the L–5 No. 2 (pl. 1, pegmatite 5) and sold as souvenirs. In the intermediate zone of the L–5 No. 2 pegmatite I saw one aggregate containing several crystals of beryl; their total weight was about 1 pound. No other likely beryl prospects were noted.

Spectrographic analyses (table 1) indicate that the granite-pegmatite complex contains about 0.001 percent BeO, corresponding to about 0.01 percent beryl; however, beryl was not identified in these samples.

MICA

The Terry claim (pl. 1), a mica mine, is described and illustrated by Page and others (1953, p. 195); its 1943–45 production is given as slightly less than 350 pounds of sheet mica. The Spring pegmatite (pl. 1, pegmatite 11) yielded less than 10 pounds of trimmed sheet and punch mica during the same period (Page and others, 1953, p. 25), but it yielded 75 tons of scrap mica.[4] Pegmatite 6 contains pods of book mica near its borders, and a few pounds of sheet-bearing mica has been stockpiled on the dump. The mica is reeved and soft and none is known to have been sold as sheet mica. Pegmatites 8 and 12 (pl. 1) also contain some large mica books, but not in sufficient quantity to be minable in 1950. Pegmatite 12 has been prospected, but pegmatite 8 has not.

FELDSPAR

Most of the prospecting in the Calamity Peak area has been for feldspar. The coarse perthite crystals in many of the pegmatites could be hand sorted and shipped, but the grade is too low for commercial production at present. The fact that they are not being mined suggests that feldspar is more abundant in other pegmatites in the Black Hills area. The Spring pegmatite (pl. 1, pegmatite 11) is reported to have yielded 675 tons of feldspar.[5] There is no production record for pegmatite 12 (pl. 1), but a small tonnage of feldspar may have been shipped. Pegmatites 1, 5, 6, 7, 8, 9, and 10 (pl. 1) contain feldspar but were not being mined in 1950.

Some parts of the granite-pegmatite complex contain much perthite-rich pegmatite and are potential large sources of feldspar, provided it can be recovered by milling. For example, at sample area H (pl. 1) an exposure of at least 60,000 square feet contains 30 percent feldspar in crystals 2 to 6 inches in diameter.

Graphic-granite pegmatites are potential large sources of potassium feldspar and silica if economic milling and flotation methods could be devised and adopted. To illustrate the order of magnitude of the

[4] Published with the permission of Kenneth Spring, owner.
[5] Published with permission of owner.

tonnages available, 4 pegmatites in an area 1,600 feet wide contain a minimum of 30,000 tons of rock composed of 60 to 70 percent perthite and 20 to 25 percent quartz. There are many such pegmatites in the Calamity Peak area, and all could be treated at a single mill.

GOLD

Small placer and vein deposits are known in this part of the Black Hills. The original gold discovery by the Custer Expedition in 1874 is reported to have been made along French Creek, southeast of Calamity Peak.

The Wild Rose gold mine (pl. 1) in the NW¼ sec. 17 has been described by Allsman (1940, p. 134–135), and I have briefly examined surface exposures at the mine. Gold occurs in quartz and also has been reported in the contorted wallrock schist. Three samples of the vein material and three of wallrock schist assayed [6] 0.01 ounce or less of gold per ton. Two of the samples were taken from a small prospect pit near the shaft, and the others came from the dump.

Placer gold is reported (Allsman, 1940, p. 138–139; Connolly, 1933) in the stream gravels and high terrace gravels of the Black Hills. The groups of clustered prospects in the southwest corner of the mapped area (pl. 1) are small gravel deposits of this type. The gold content is unknown.

GRAVEL

A small gravel pit is in the SE¼ sec. 19 (pl. 1). Additional gravel beds are present in the area, but all are probably thin. Those in the extreme western part of the area are the thickest and therefore the most promising as sources of gravel.

REFERENCES CITED

Allsman, P. T., 1940, Reconnaissance of gold-mining districts in the Black Hills, S. Dak.: U.S. Bur. Mines Bull. 427.

Cameron, E. N., Jahns, R. H., McNair, A. H., and Page, L. R., 1949, Internal structure of granitic pegmatites: Econ. Geology Mon. 2, 115 p., 79 figs.

Connolly, J. P., 1933, Geologic history of Black Hills gold placers: South Dakota Geol. Survey Rept. Inv. 16.

Darton, N. H., and Paige, Sidney, 1925, Description of the Central Black Hills, S. Dak.: U.S. Geol. Survey Geol. Atlas, Folio 219.

Harker, Alfred, 1939, Metamorphism: 2d ed., London, Methuen.

Page, L. R., and others, 1953, Pegmatite investigations 1942–1945, Black Hills, South Dakota: U.S. Geol. Survey Prof. Paper 247, 228 p., 45 pl.

Staatz, M. H., and Trites, A. F., Jr., 1955, Geology of the Quartz Creek pegmatite district, Gunnison County, Colorado: U.S. Geol. Survey Prof. Paper 265, 111 p., 8 pls.

[6] Charles Bently, assayer, Engineering and Mining Experiment Station, South Dakota School of Mines and Technology, Rapid City, S. Dak.