THESIS
THE ROSCOE PEGMATITE DIKE
GEORGE A. BENWELL JR.
1900
To The Faculty

of

The Colorado State School of Mines.

Gentlemen;

I have the honor to submit my paper on the Roscoe Pegmatite Dike.

Very respectfully,

George A. Benwell Jr.
The Roscue Pegmatite Dike

by

George A. Benwell Jr.
The subject is discussed under the following heads:

(1) Historical Sketch.
   (a) Definition of the term Pegmatite.
   (b) Occurrence in the United States.
   (c) General Description of Pegmatite.

(2) Origin of Pegmatite.
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Historical Sketch and Definition of the Term

Pegmatite.

The term pegmatite was first suggested by Hauy in 1822 and was limited to that structure variety now known as graphic-granite. In the year 1849 Delesse, and afterward Naumann considered the term to apply to all coarse granites whether graphic in structure or not. (Foot-note, page 675, 15th Annual Report, U.S. geol. Survey.)

Kemp defines pegmatite to be those veins or dikes which are formed of very coarsely crystallized aggregates of the same minerals which constitute granite.

As pointed out by Crosby and Fuller the term pegmatite has been used in two ways. First, the macro- or micro-pegmatic or graphic-granite structure in rocks; second, a distinct type of coarsely crystalline plutonic rocks which are especially characterized, or distinguished by the

(Hand Book of Rock, page 31.)

(American Geologist. Vol. XIX.)
gigantic scale of their crystallization; the graphic structure being only of slight importance.

The authors modify these definitions however by regarding the term, not as applying to a "distinct species or family of rocks, but rather as a possible textural phase of all, or nearly, the plutonic rocks."

In the following general description as well as in the description of the dike or vein that forms the subject of this paper, the word pegmatite will be considered as a structural term and will apply to all plutonic rocks whether acid or basic, which are coarsely crystalline. The graphic appearance of some pegmatites being considered as a textural property only.

**Occurrence in the United States.**

Pegmatites are abundant in the United States, both in the Atlantic states and Rocky Mountain region. The dikes of this rock in the west are mostly, so far as known, of no economic importance. Those in New Hampshire, Maine, Massachusetts, Connecticut, Virginia, Pennsylvania, North Carolina, and
New Mexico furnish most of the mica and feldspar used in this country.

General Description of Pegmatite.

Pegmatites may be acid or basic. In the former they are composed of quartz, alkaline, feldspars, and potash, mica (muscovite), that is, the same minerals which constitute the acid plutonic rocks. The basic pegmatites are aggregates of the same mineral species which go to form the basic plutonic series i.e., Plagioclase feldspar, olivine and pyroxene. The essential minerals in the acid pegmatites are orthoclase, microcline, albite and oligoclase, one or two of the minerals frequently occurring in the same dike; muscovite, biotite, and sometimes lepidolite, the biotite being less common; and quartz. The quartz, as in granite, is especially characterized by the presence of minute cavities, which enclose water or carbon-dioxide gas ($CO_2$), or a mixture of the two. In some cases the carbon-dioxide is liquidfied and floats as a globule in the carbonated water in the cavity. The presence
of liquid carbon-dioxide would indicate that the quartz had been crystallized under pressure, the pressure necessary to produce crystallization increasing directly with the percentage of carbon-dioxide found. The cavities containing gas only, generally assume a geometric form, in which case it will be a form belonging to the same crystal system as the mineral which encloses it. In the case of quartz these negative crystals are hexagonal. The basic pegmatites contain more of the sodium-calcium feldspars (plagioclase) together with members of the pyroxene group and iron oxides, the quartz being the same as that of the acid rock. Another important descriptive feature of pegmatites is that they contain in general numerous rare minerals, not that the mineral species are rare in themselves but that they do not occur in the surrounding region, or at least only in minute quantities. Judging from the literature on the subject, it seems as if the western pegmatites are poorer in these accessory minerals than the eastern dikes; the latter having furnished many interesting minerals.

Crosby and Fuller¹ state that the pegmatites are in

¹ (Origin of Pegmatite, Technology Quarterly, Vol. IX, No. 4. page 329-330)
general independent of the wall rock. "The one important exception to this principal is found in the fact———
that in every pegmatite district there is one normal plutonic rock of essentially similar but slightly less acid composition, with which the pegmatite is most intimately associated into which it may often be traced, and from which it has evidently been derived."

That the pegmatites are closely related to a plutonic rock of more basic character is admitted, but we differ from the authors in considering the parent rock to be present in every pegmatite district. For the region, which is described in this paper, fails to show, so far as known, any rock of the plutonic series.

Williams, in describing the Maryland pegmatites, states that "the size and abundance are directly proportion-
al to their nearness to some eruptive granite mass. At many localities they can be seen to decrease steadily both in

number and size as they recede from such a granitic boundary."

If this rule be applied to the above observations of Crosby and Fuller, then the parent plutonic rock would probably be within a radius of a very few miles, since the region herein described is cut by numerous pegmatite dikes both large and small.

That the pegmatites are in general independent of the wall rock, is brought out by Williams in describing a Maryland dike, which occurs in gneiss and which could be traced into and across a belt of crystalline limestone, the texture of the pegmatite rock remaining the same.

Crosby and Fuller give the following classification of the relationships of pegmatite to the enclosing rocks. These forms are;—First, the more regular masses which occur in rectangular, wall like, vertical dikes. Second, lenticular or tabular, horizontal sheets. Third, all those very

{ (15 annual report, U.S. Geol. Survey. page 683.)

{ (Technology Quarterly, Vol. IX, no.4, page 337.)
irregular dikes or masses which have followed in general the lines of least resistance during the process of injection and solidification. They mention also, another case where the pegmatite is entirely enclosed by the parent plutonic rock.

**Origin of Pegmatite.**

**Aqueous Theories.**

Those deposits which have occurred through the agencies of water circulating through the earth's crusts may be placed under the head of veins.

Considering veins to be, as stated by Le Conte, "the accumulations, mostly in fissures, of certain mineral matters, usually in a pure and more sparry form" than exist in the rock; we may classify them into three divisions according to their mode of formation.

First:- Veins of segregation, in which there is no distinct vein wall, they having been formed not by the filling

!(Elements of Geology. page 243.)
of a preexisting fissure but by the segregation or accumulation of certain minerals in zones and along certain lines in the rock mass. This could have been accomplished by percolating waters or when the rock was in a plastic condition from heat and water. Second;—Veins of infiltration. These veins are characterized by their banded or ribbon structure which necessarily causes the vein to have a distinct and well marked walls. In explanation it is assumed that the rocks in which these veins occur have been subjected to enormous horizontal pressure which causes them to fold and which formed in turn large fissures. In addition to these larger fissures smaller ones were formed in the strata which were caused by the shearing and crushing set up. It was in these smaller fissures that the veins of infiltration were deposited; the deposition being caused by the slowly percolating waters carrying in solution the minerals, or by lateral secretion from the walls. In either case however the banded structure could be formed. The third division embraces the true fissure veins; they are the fillings of the great fissures in the earth's crust caused by pressure and
moving of the strata. The filling is the result of aqueous agencies and may be homogeneous throughout or banded and contain cavaties, and as outlined by Le Conte were probably deposited from hot alkaline solution.

The aqueous theory as applied to pegmatite, was strongly supported by T. Sterry Hunt; from whose work, the following brief outline is taken.

Hunt has classified the granite-like rock into granitic dikes and granitic veins-stones; the latter being called endogenous rocks to indicate the mode of their formation, and to distinguish them from intrusive igneous rocks and sedimentary or indigenous rocks. It is in the granitic veins-stones that pegmatite is placed, the difference between the granite proper and the endogenous rocks may be described as follows;—The eruptive granitic magma in forcing its way through the over lying strata not only absorbed and enclosed portions of the adjacent rock but spread out into many fingers or tongues through it forming small veins or dikes which may or

(Chem. and Geol. Essays, p. 188-189-193-195-200-201-202-213)
may not be traced to the parent mass. Both the veins and main portion are alike in chemical composition however, but differ in texture; the veins being generally of finer grain. The veins follow lines of weakness in the enclosing strata and are not to be confounded with the third class of veins which are the granitic vein-stones or endogenous veins. Hunt considers endogenous rocks to be aqueous in origin and classifies pegmatites as a granitic vein-stones. In support of his theory he states that the banded structure in certain concretionary veins not granitic, are also marked in granitic vein-stones and often appear well developed showing that they have been formed by successive deposition of the constituent minerals. Several cases are pointed out where the graphic structure in endogenous rocks was noticed, the veins being unlike the intrusive rock which was granite, also that the veins occurred alike in gneisses, mica schist, and limestone strata and also in eruptive granites in which case the fissures were small being filled with coarse grained orthoclase, smoky quartz and various micas. Our attention is also called to the fact that the veins
are frequently of very limited extent and occupy short irregular fissures, caused by the shearing and crushing of the rock owing to movements of the earth's crust. The dikes are considered to be dependant upon the same forces which cause the smaller fissures, only in this case the fissures are much deeper and the molten magma forming the igneous dike comes up through them. The endogenous rock requires no deep seated fissure but is distinguished by the banded arrangement of constituent minerals and the fact that the principal constituents are in most cases mineral species common to the adjacent rock.

Further evidence of support are given, such as; the rounded forms of crystals caused by the redesolving of the previously deposited crystallized mineral, by the mineral bearing solution or waters which have undergone a chemical change. The enclosure of one mineral by another, as epidote-allanite intergrowths, also the filling of a complete crystal skeleton, by another mineral.

Sheerer pointed out that some rare minerals such as allanite could not stand a high temperature. A temperature above dull redness would cause the mineral to undergo a
complete molecular change; the chemical properties and density also changing. As many pegmatites contain these rare minerals Hunt points out that the dikes could not have been formed by true igneous fusion since the temperature required for such an origin would be many times greater than allanite could stand.

Geikie in accounting for the origin of pegmatite states that the pegmatite may have originated from a lower still liquid granitic magma, yet the crystalline structure of the rock would seem to indicate a secondary change or rearrangement of the minerals by segregation.

Igneous Theories.

Charpentier (1823) was one of the first to state clearly and satisfactorily the igneous theory as applied to pegmatite. He considered this interesting rock to be the solidified intrusion of the molten granitic mass deep down,


that is the molten portion of an already existing granite rock was thought to have been injected through the surrounding region and solidifying; forming a coarsely crystalline granitic rock. This theory was upheld later by Naumann and also by Brögger who argued strongly in favor of magmatic solidification. He considers the coarse structure crystallization of plutonic rocks to be accounted for by the slow cooling of the deep seated water-bearing magma; the magma being under pressure sufficient to keep the water from separating; and passing to the surface, by the crystallization of the molten rock, but compelling it to pass through the wall rock.

Brögger accounts for the coarse structure of pegmatite, according to the above theory, by stating that when the pegmatite occurs in the parent plutonic or in the surrounding rocks, the region immediately in the vicinity of the pegmatite was heated to a high temperature which would probably prolong the time of cooling of the molten mass thus making the grains of the composing minerals assume the large dimensions so often found. Although Brögger recognized the presence of water in
the magma he has not given it any place in the actual development of the pegmatite, he considered the rock to be formed under more normal igneous conditions.

Elie de Beaumont considered pegmatite to be igneous yet he assumed water to have a very important part in the final crystallization.

Lehmann in considering the origin of pegmatite gives a more important place to the water, which he states is not atmospheric water but water which being highly mineralized and contained in the granite magma, was given up to the surrounding rocks as the mass solidified. He differs also from Brogger in assuming a viscous state of the granitic mass at the time of intrusion. He considers that the wide range of rock formations which might be formed between the gelatinous magma and a saturated aqueous solution would account for the gradual changes often seen between the pegmatite and the parent granite.

Aqueo Igneous Theory.

Although Lehmann first suggested the aqueo-igneous
theory as a possible explanation for the origin of pegmatitic plutonic rocks, it was not until a few years ago (1897) that the theory was set forth in detail; by W.O. Crosby and M.L. Fuller; a brief outline of the most important points of which are here given.

Considering the acid plutonic rocks (granite) to be the product of aqueo-igneous fusion, the order in which the essential minerals were crystallized, and also the presence of vesicles of water and gas in the quartz, which is always the last to crystallize; would show that water played an important part in its growth. The number and minuteness of the water inclusions proves an intimate combination of aqueous vapor and the molten mass. This being the case, the magma when cooling crystallizes, the more basic crystallizing first; and as each mineral takes its form it excludes the water and that portion of the magma not of its molecular constitution. The process of crystallization and exclusion goes on until the portion left is a highly hydrated silica (SiO₂) which is probably in a gelatinous condition, and on crystallizing or solidifying
dehydrates enclosing the water in cavities within it.

Following Sorets principal, ie, the concentration of the salt in a solution, in the cooler portion of it, when we have two parts of a solution of the same salt at different temperatures; the authors point out that in the cooling of a granitic boss, the cooler portion will be the exterior and hence the bases will collect in the outer boundaries of the cooling mass thus leaving the hydrated and more acid interior in a gelatinous condition or in the state of igneo-aqueous solution, from which may be developed on cooling the pegmatitic structure.

The connection between the parent granite and the pegmatite is further explained by considering "a large boss of massive or molten granite to have invaded the crystalline schist at a great depth and undergoing extremely slow refrigeration; crystallization begins on the surface of the mass and gradually extends inward. The rate of cooling diminishes as the crust forms and thickens, but the highly viscous nature of the cooling magma prevents the formation of large crystals."
Finally however as the outer shell of the boss becomes gradually thicker, the rate of cooling and crystallization are sufficiently reduced to enable the quartz as it slowly hardens to exclude a portion of its inclosed water, forcing it inward into the still liquid magma, which is thus rendered more liquid, but not sufficiently so at first, for, the slowness of the process prevents the diffusion of the excluded water through a large volume of unconsolidated magma. The extremely gradual nature of the changes is an essential feature of the explanation. The feldspar and mica probably crystallized, in part at least, far in advance of the quartz forming a sponge-like zone through the meshes of which the silica gradually expells a portion of its water. This process is perhaps favored by the tendency through contraction, to reduce the pressure in the interior of the mass. The magma becomes, although its temperature is slowly falling, more and more liquid passing gradually from the condition of aqueo-igneous fusion to igneo-aqueous solution. And the greater mobility of the later state permits the formation of larger crystals. We may thus conceive a
perfect blending of conditions favoring the formation of normal granite in the exterior portion of the mass with those favoring the formation of giant granite or pegmatite in the central portion? (The American Geologist, vol. XIX, no.3, page 170).

The above named writers also consider the pegmatitic magma to be formed in two ways; in the first the magma separates as it were, both by crystallization and according to Soret's principal, the portions remaining after separation being more acid as the degree of hydration increases. The magma residues may crystallize in place and be entirely surrounded by the already solidified normal granite in which case it is characterized especially by the gradual change between the pegmatite and the granite; or they may crystallize in cavities in the parent rock or in fissures in the surrounding formations.

In the second mode of formation, tongues or jets of the normal granitic magma are considered to pass into the highly heated water bearing formations, from which they obtain water for the hydration of the magma, the pegmatite
being formed than by the slow cooling and spontaneous crystallization of the mineral particles. The high temperature of the wall rock is essential otherwise the mass would solidify before hydration. The hydration is the absorption of water or aqueous vapors by the magma when under enormous pressure; the solidification being due in part to cooling and partly to the spontaneous dehydration of the magma particles. This is substantiated by the fact that no hydrous minerals species are found in the pegmatite dike.

The Roscoe Pegmatite Dike.

The Roscoe pegmatite dike is located about a mile east of Roscoe, Jefferson County, Colorado, and twenty-five miles west of Denver, Colorado, on the line of the Colorado and Southern Railroad.

Placer mining was carried on quite extensively at Roscoe about ten years ago. The flumes used in the mining operations are within a few feet of the dike.
The dike is divided into three portions;—The southern portion out-crops the south side of Clear Creek; the middle, which consists of massive boulders partly in place, lies between the creek and the railroad; while the northern and far the most important part, may be seen on the northern side of the track.

The rocks around Roscoe for many miles consist chiefly of hornblende-biotite gneisses and schists also gabbros, although the latter are rare. Feldspathic dikes intersect them in many places, passing through in all directions. These dikes vary in size from little stringers to masses several feet in width and a few hundred feet in length. In structure they are coarse and fine grained as is the case with the schists. All the rocks in the neighborhood of the pegmatite dike are very much folded and contorted, and are traversed by faults which have so altered the original condition of affairs as to make accurate conclusions very difficult to form.

(Plate 1), shows the southern portion of the dike
which consists of quartz and feldspar in the form of graphic granite. It is of importance only in determining the relative position of that part of the dike north of the track (plates 11 & 111). The dike cuts the bedding of the schists at an angle and hence has forced its way up through a plane of weakness in the surrounding rock. The dip of the graphic granite is 80 degrees west (with the horizontal) and the strike north and south. The schists at contact dip 65 degrees south-west and strike north-west and south-east. Actual dimensions were not attainable, but by estimation, the height is 125 feet and the width at the widest part 25 feet. The dike stands out boldly and hence has been less affected by erosion than the schists. At the upper contact the graphic granite pinches out (plate 1). Immediately above this a fault occurs which has passed through the schists horizontally and intersects the upper portion of the dike on the north side as shown in plates 11 & 111.

The large masses of quartz and feldspar which make up the central part of the dike are several in number. One
or two may be in place, but the rest and larger ones are fragments broken off the northern end of the dike by the action of frost and, by blasting when they cut for the railroad was made. Three of these masses are seen in plate 1. In structure they are very coarse, which is not the case on the south side. They are of interest only as the source of allanite; careful search over the rest of the dike having failed to disclose this mineral.

The northern portion of the dike or that part situated on the north side of the railroad is by far the most interesting and has in consequence received more attention. It is fully pictured in plates 11. & 111; plate 111 showing the north-eastern end of the dike.

On the north side the rocks within a foot or two of the contact are plagioclase and hornblende rocks containing quartz in varying amounts giving a hornblende scist or amphibolite. They are all very fine grained, hard and compact. At the contact the wall rock is acid (quartzose) and contains large quantities of biotite and shows a well developed schistose structure, the hornblende in some cases
being entirely absent. At all favorable points of observation, the schists were very much folded and twisted, yet there were no broken or ragged edges, the schists assuming graceful curves and waves throughout. It is also to be noted that there is no blending of dike and wall rock, the line of contact remaining clear and distinct around the entire mass.

The dike in its present position on the north side outcrops near the railroad, about 200 feet up the creek (west) from the dike as shown in plate 1. It extends in a northerly direction from this point 350 feet, the elevation of the highest point above the track being 230 feet. The southern end of the dike (plate 1) faces the pine tree shown in the lower right-hand corner of plate III, which is the same tree shown in the extreme eastern side of plate II. With this explanation one can imagine the relative positions of the three divisions.

The structure is not uniform in the northern portion, but it is mostly very coarse; the graphic texture is well developed in some places however. The coarsest portion of
the pegmatitic mass is confined to a zone about 20 feet square near the track. In this zone the quartz and feldspar and other minerals have crystallized on a gigantic scale; perfect crystals of microcline from 6 inches to a foot and a half in length having been found. The quartz while not in crystal form, which is not to be expected, since it is the last to crystallize out, assumes very large proportions throughout, all the very coarse regions. One particular piece was 6 feet long and averaged 2 feet wide and was the ordinary white vitreous quartz. Where the dike has a fine structure as near the wall rock or contact, the quartz and feldspar are in small grains massed together in irregular order. Both the pink and white microcline occur, and in many cases both are covered with a black dendritic coat which is probably an oxide of manganese. The quartz has no crystal form except that one very much distorted crystal was found and that in the coarse zone. It measured six inches long and one inch thick.

In order to determine if possible the crystal relationships between the quartz and feldspar, in this graphic granite...
a number of sections were made and examined under the microscope. The results of these experiments are as here stated.

The specimens of graphic granite were first examined to ascertain the position of the quartz staves with reference to the two cleavages of the feldspar. Out of forty-eight samples of the rock, six showed the quartz staves to be perpendicular to the basal cleavage and parallel to the brachy-pinacoidal cleavage of the feldspar, while the quartz staves in the remaining samples were parallel to both the basal and brachy-pinacoidal cleavages. The columnar structure is well developed in the latter case.

The rock sections were used to find out whether the longer dimensions of the quartz staves in the graphic granite were parallel to the principal axes of the quartz crystals; i.e., whether a section perpendicular to the quartz staves would show basal sections under the microscope.

From three samples of rock, exhibiting well developed columnar structure and showing the quartz staves to be parallel to both cleavages, sections were cut in each case as follows:
one parallel to the basal cleavage of the feldspar, a second parallel to the brachy-pinacoidal cleavage and a third perpendicular to both these cleavage planes and therefore perpendicular to the quartz. On examination, the latter only, gave a basal section of the quartz. From three other rock specimens sections cut perpendicular to the quartz staves and cleavage planes showed likewise basal sections of quartz. On the other hand all sections parallel to the basal or brachy-pinacoids failed to do so.

In the six samples containing quartz staves perpendicular to the basal cleavage, sections were cut parallel to the basal-pinacoid, brachy-pinacoid and macro-pinacoid respectively; without obtaining the basal plane of the quartz. A section made parallel to the macro-dome however gave in one case the desired result, but in the same slide there were found quartz individuals which did not approximate a basal plane. Thus we may conclude that in these six samples, the quartz are differently oriented in the same feldspar crystal.

From the results obtained it would seem that, in
graphic granite showing a well developed columnal structure, the principal axis of the quartz is parallel to the longest dimension of the quartz staves, and to the brachy- and basal pinacoids; whereas in cases where the quartz crystallizes in staves perpendicular to the basal cleavage, no definite relation exists.

The strike of the dike on the north side of the creek is north and south, the dip as obtained from various readings on both sides of the creek is 70 degrees to 80 degrees west. The schists at contact strike north-west and south-east and dip on an average of 65 degrees south-west. The fault line is indicated in plates 11 & 111 by the broken line; it passes through the dike 180 ft. above the track, the remaining 50 feet from the fault to the highest is precipitous while the 180 feet has a gradual slope of about 30 degrees. It is probable that the faulting is the principal cause for the perpendicular faces, although frosts and blasting have tended to steepen the eastern face.

Secondary cracks or seams which traverse the pegmatite in a north-westerly and south-easterly direction are of interest.
They slope at an angle of 70 degrees south-west to perpendicularity to 70 degrees south-east and are only noticeable in the thicker parts of the dike.

Commencing at the lowest point and traveling upward along the east face of the dike (plate II), the schists for the first 50 or 75 feet are silicious and very much folded and crumpled, yet exhibit no cracks or broken and ragged edges. The schistose structure is well developed and the biotite in excess of the hornblende. Within this space the dike has changed in structure from coarse crystallization near the bed of the railroad, to rock which is more distinctly graphic and texture. Weathering or erosion is carried on faster in the finer portion, since the graphic granite being composed of aggregates of slender prism-like forms of quartz and feldspar arranged in more or less parallel rows; the water has excess to a greater amount of feldspar surface than it would have if a plane surface of that mineral was exposed to it. The faces of the small quartz columns affording an excellent water coarse. In winter the graphic granite disintegrates rapidly
since the water which saturates it freezes, thus rending a part of the constituent minerals. The effects of erosion can be well studied on the Roscoe dike in many places. In the alteration of the graphic granite the quartz does not change, but the removal of the surrounding feldspar gives the rock a honey-combed appearance.

Immediately under the highest part of the dike on the east face (plate 111) the contact is well shown. The first point you notice was, that while the schists were folded and crumpled yet they had a general bend or trend up the hill as if the dike in the process of formation, or by the action of faulting, had caused the bedding of the schists to change in direction and assume the direction of the forces acting upon them. This property has been noticed in other parts of the dike and also in other localities cut by pegmatite dikes both acid and basic. The schists at the same point are prettily banded black and grey, the black containing more hornblende and biotite than the grey. The large square mass of wall rock higher along the contact and seen in (plate 111) is also much
distorted and may be considered the eastern boundary of the
dike since it becomes smaller and finally pinches out within
the limits of the plate. The pegmatite to the immediate right
of the block of schist constitutes an offshoot which is limited
in extent and lies over the schists which can be well exposed
by removing the slight covering of soil above it.

All dips and strikes of the wall rock were carefully
taken along the eastern face; the variations are small con­
sidering the roughness of the country.
1.---dip 55 degrees south-west. Strike east and west.
2.--- " 75 to 70 degrees south-west. Strike east and west.
3.--- " 80 degrees south-west. Strike east and west.

No contact can be found along the lower boundary
near the railroad track, but on the lower western corner
(plates 11 & IV) the dike disappears through the schists with
its true dip, ie, 70 degrees west. For a distance of 75 feet
along the western side, from the track up, the contact is
fairly well shown and has the characteristics of the eastern
side. The offshoot which starts about 5 feet from the track
extends westward through the schists and disappears at the
gully G. (plate 11.) It varies in thickness from 4 to 10 feet
and contains well developed crystals of microcline; one being
6 inches long and 4 inches wide. It is non-uniform in struc-
ture like the parent dike.

On the surface of the dike, (plate 11) the central
portion below the fault plane and 20 feet above the track,
is covered with large and small lense-like formations of the
schists which at first might be taken for enclosures or parts
of the wall rock which have been broken off and completely
enclosed in the pegmatite during the formation of the latter
into the dike. These masses of schists are all sizes from 8
to 10 inches to 2 feet and more in length and about one foot
wide. They appear on the exposed surface of the dike in approx-
imately parallel rows corresponding exactly to the strike of
the schists on both sides of the creek, ie, north-west and
south-east. Taking this into consideration it is clear that
these lenses are not enclosures but simply exposures caused by
the dike being worn down by water until the underlying schists
are laid bare; and, since the wall rock is so badly crupled, those portions of it which project farthest into the dike are exposed first giving the lense-like form. The whole surface of this portion of the dike is very smooth and has no sharp raises or hollows proving it to be water worn, also in the thickest portions of the dike no schist intrusions or enclosures are to be found; therefore it is probable that the enclosures if any were completely absorbed or desolved by the pegmatite during its formation.

There is a second offshoot which extends west from the northern boundary of the dike, and pinches out in the gully G. It is similar in position to the one shown in plate ill.

The contacts along the northern boundary show the same properties as those just described. The dip and strike were determined in three places giving the same result as before.

As to original position and shape of the dike;—First, judging from the number of offshoots and the varying thickness of the dike it must have occupied an irregular fissure.
It is of later origin than the schists and may have occupied the fissure before the upheaval of the mountain ranges. During this movement which also caused faulting, the pegmatitic mass assumed its position and dip. Although there is nothing to indicate it in the schists, yet it is possible that the dike at this time was cut by a vertical fault which caused the intersected portions to slip east or west as the case may be; the throwing of the dike giving rise to the horizontal fault so clearly shown in plates 11 & 111. The creek cutting the dike as it does would tend to prove rather than disprove the previous existence of the vertical fault, since the creek in the process of leveling seeks the easiest passage on its way to the ocean, which in many cases in the mountainous countries are fault planes.

(Plate 11) shows a section of the dike approximately parallel to the wall rock, proved so by the lense-like exposures of schists and by the fact that the schists along the contact on the eastern side dip under the pegmatite. For the same reason plate 111 shows a section perpendicular to the
wall rock. What has been called the contact on the eastern side then corresponds to the eastern contact of the southern portion of the dike, and the western contact where the dike passes under the track corresponds to the western contact of the south end. (plate 1) The greater portion of the western contact then (plate 11) together with the overlying schist and a great portion of the pegmatite beneath it have been completely removed by erosion. Why the schists and dike on the northern side of the creek should suffer the effects of weathering more than the southern side has yet to be explained.

Magnetite.

The magnetite is the most common of the accessory minerals to be found in the dike. It has a metallic lustre, black streak and is opaque and brittle, attracted by the magnet and non-cleavable but breaks parallel to the octahedron. By tests the hardness is between 5 and 6 and specific gravity 5. A microscopic examination of the powdered magnetite revealed
only three particles of foreign matter. Two of the particles were quartz, the third being a red mineral which was probably hematite.

A chemical analysis gave the following results:

<table>
<thead>
<tr>
<th>Element</th>
<th>Mass Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>FeO</td>
<td>88.11%</td>
</tr>
<tr>
<td>TiO</td>
<td>10.08%</td>
</tr>
<tr>
<td>SiO</td>
<td>1.79%</td>
</tr>
<tr>
<td>Total</td>
<td>99.91%</td>
</tr>
</tbody>
</table>

The mineral occurs in the dike in well developed octahedrons, in crystal aggregates, and singly. The octahedrons will, on slightly tapping them with a hammer, split along planes parallel to their faces forming smaller crystals. According to Dana this is not true cleavage, in as much as the so-called cleavage of magnetite is caused by a pseudo-twinning which necessitates twining planes (and therefore striations on the crystal faces) along which the mineral cleaves. Those striations appear to be entirely absent in the Roscoe magnetite.

The position of the magnetite in the dike is interesting. It occurs sprinkled in the quartz and feldspar in sizes
varying from pieces 1/16 of an inch to 3 and 4 inches in diameter. The mineral is collected in a zone which varies in width from 2 inches to 1 foot and is located near the contact at every point of observation. Sometimes it is right at the contact and again, a little farther along, 2 feet away, yet the zone remains unbroken throughout this change. In some cases as on the western side the zone has followed every little crumple of the contact. On the eastern side near the track the zone starts 1 1/2 feet away from the contact and can be clearly traced for 100 feet up the hill at which point it disappears under the soil. Still farther along where the contact can be seen the zone is again found but not so clear and distinct as below. At a point 75 feet above the track a fragment of the pegmatite about 4 feet square has one surface completely spotted with the titaniferous magnetite, the crystals varying in size from mere specks to 3 and 4 inches in cross section. We see then that the zone has dimensions in both vertical and horizontal planes.

Plate IV was taken at the western contact near the track. It shows a surface of pegmatite similar to the one
just described but in place, completely spotted with the magnetite. The contact is well developed here being 1 1/2 feet below the surface of the rock shown in the plate. Above this point for 50 feet the band or zone is very plain but beyond it dissapears entirely under the soil. Every lense of schist (as described on page 31) on the surface of the pegmatite is completely surrounded by a zone of magnetite also. The zones are separate and distinct and only run into each other when the lenses are close together. The mode of occurrence of the magnetite then proves the magnetite to be collected in a definite zone in the pegmatite dike and also parallel to the dip of the schists.

The collecting of the magnetite over definite areas has been noticed in other localities. About 2 miles below Roscoe a lense of finely combined quartz and feldspar in a very silicious gneiss occurs. A band of magnetite passes through the quartz and feldspar from end to end. An identical occurrence was found at Grand Lake, Colorado, also.
Garnet.

This mineral occurs very much weathered, perfect crystals being unattainable. It has a resinous lustre, fair cleavage and color brown-black to brown-red. The garnets are found scattered over limited areas, imbedded in the dike rock, near the eastern and western contacts above the track. The matrix is quartz microcline or biotite and mixtures of the three.

The largest and greatest number are found on the western contact, here 10 feet above the track, they are sprinkled thickly over an area of surface four by two feet; the largest crystals being $\frac{1}{4}$ inch in cross section. From here up to a point 75 feet above the track are seen large garnets, which are in the coarse part of the dike, some measuring 4 in inches in cross section, the latter showing distinct trap-ezohedral forms. It is here that a curious form of the garnet and black mica is found; a brush-like formation. The garnets while distinctly crystallized, although distorted, have been
pressed together in narrow bands about 1/8 to 1/4 inches in thickness, these bands being protected on each side by a very thin plate of black mica. In some cases the compressed garnets crystals are also separated from each other by the mica. There are a series of such bands which start from a common point and radiate brush-like through the dike. The brushes occur in the coarse quartz and feldspar, and are in most cases 4 inches wide at the small end by 1 1/2 feet long. The space between each bristle is generally filled with feldspar and in some case a with quartz. The brushes are the same in appearance as the mica brushes Fig. 2.

Fig. 1 shows a portion of a band with a section of the black mica covering, on one side, removed thus exposing the garnets.

The garnets on the eastern side are confined to two small areas each 4 feet square. These crystals are all small being only 1/8 inch in cross section.

A rock composed almost entirely of garnets weighing about 25 pounds was found in the creek bottom, at the lower
end of the dike. This rock was made up of very dark red distorted crystals, together with crystals of microcline. Its position in the pegmatite could not be found.

**Black Mica---Sodium Biotite.**

This mineral has a vitreous lustre, black color and good basal cleavage; it is semi-transparent in thin sheets, brittle and does not exhibit much elasticity. It grinds readily into a powder having a grey green color. It weathers to chlorite having a bronze-like color.
A chemical analysis of the mica gave the results shown in (A.)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
</tr>
</thead>
<tbody>
<tr>
<td>SiO₂</td>
<td>34.058%</td>
<td>32.35%</td>
</tr>
<tr>
<td>Al₂O₃</td>
<td>37.466%</td>
<td>17.47%</td>
</tr>
<tr>
<td>FeO</td>
<td>13.406%</td>
<td>24.22%</td>
</tr>
<tr>
<td>Fe₂O₇</td>
<td>0.000%</td>
<td>13.11%</td>
</tr>
<tr>
<td>MgO</td>
<td>4.197%</td>
<td>0.00%</td>
</tr>
<tr>
<td>(1)</td>
<td>0.656%</td>
<td></td>
</tr>
<tr>
<td>K₂O</td>
<td>(2) 0.286%</td>
<td>0.70%</td>
</tr>
<tr>
<td>H₂O</td>
<td>2.200%</td>
<td>4.67%</td>
</tr>
<tr>
<td>MnO</td>
<td>0.000%</td>
<td>1.02%</td>
</tr>
<tr>
<td>CaO</td>
<td>0.000%</td>
<td>0.89%</td>
</tr>
<tr>
<td>(1)</td>
<td>9.618%</td>
<td></td>
</tr>
<tr>
<td>Na₂O</td>
<td>(2) 9.676%</td>
<td>6.40%</td>
</tr>
</tbody>
</table>

It will be seen that the mica is essentially a soda-mica, lithium being entirely absent. Out of 177 analyses of micas described by Dr. C. Hintze (Handbuch Der Mineralogie) one only; tabulated in B. can be found which is low in K₂O and high in Na₂O and which does not contain lithium. This, the 176th analysis, has no MgO but in stead calcium oxide. This mica comes from Auburn, Maine.

A sodium biotite might be produced as follows;—Crosby and Fuller have stated that the pegmatites are more micaceous. !(Technology Quarterly, vol. IX, page 331.)
in the schists than in the granites, also that the muscovite in the acid pegmatites could be formed by the absorption of the schists by the pegmatitic magma. It seems probable then, that the dike in a state of aqueo-igneous fusion, and under sufficient pressure, would in absorbing portions of the Hornblende-biotite schists, which are magnesium-iron-aluminum silicates containing sodium and potassium; cause a mineral rich in soda and containing magnesium, iron and potassium to crystallize out on solidification. The hornblende-biotite schists or amphibolites being richer in sodium than potassium according to Kemp. An aqueo-igneous fusion is assumed since the presence of allanite in the dike would indicate a temperature not sufficient for an igneous fusion.

The sodium-biotite is found in the dike in five different forms.

1st;-On the face of the dike in several places it occurs as a huge dendritic formation, the blades of the mica measuring 6 inches long and 1 to 2 inches wide, the whole tree-like form covering a surface of 2 square feet as is the case near the track, or 7 and 8 square feet as on the cliff! (Hand Book of Rocks, page 102)
Plate V shows a group of these mica blades arranged end to end and side by side giving a surface 5 1/2 feet long with an average width of 1 1/2 feet. The individual 1 by 6 inch mica plates are in general about as thick as bristol board, and seem just to lie on the surface of the rock. The plate or blade form, which probably constitutes a crystal, is the most common occurrence of mica in the dike.

2nd;—The arrow or spear shaped forms from 2 inches to 6 inches long and one to two inches in width at the head. The form of the spear head is marked and occurs mostly in the pegmatite having a graphic texture. These are composed of very thin flake-like sheets having a total thickness of 1/16 of an inch, and cleave parallel to the longest dimension of the form.

3rd;—In the form of a very fine powder covering the rock. The mica in this form occurs mostly sprinkled on the faces of the quartz and feldspar and is not very common in the dike. It was found on one of the large fragments in the central portion, covering quartz and feldspar near the allanite.
crystals.

4th;– In large plates imbedded in the coarse pegmatite near the track. The largest slab was 1 foot square with a thickness varying between 1/8 and 1/2 an inch.

5th;– The brush formation, which is the most interesting, occurs on the western and eastern side and only in the coarse part of the dike. The mica in each band is 1/2 an inch thick by about 1 foot long and spreads out through and around the coarse pieces of quartz and feldspar. The best developed form was found on the west side 5 feet above the track and 20 feet away from the western contact. Quartz and feldspar in irregular order filled the space between bristles of mica, although on the eastern side of the dike quartz alone fills up this space.

Figure (2) is a sketch of a mica brush.

As might be expected the well developed forms and crystals of the accessory minerals have been found to be located in the coarse part of the pegmatite dike near the track. At all points of the contact the soda-biotite is more or less
Figure 2.

disconnected into small flakes blotches, and the large plates are never near the contact. Also it is noticeable that at the contact the mica decreases as the magnetite increases so that at places where the magnetite zone is well developed the mica will be entirely wanting.

Muscovite is very rare. It was found in two places and these were in the coarse pegmatite near the track. In one place, on the western side, a surface 1 foot square was covered with a fine sifting of the mineral and on the other place a piece 2 inches long and 1 inch wide was embedded.
between two large pieces of quartz and feldspar.

**Allanite.**

A chemical analysis was not attempted on this mineral but its physical properties tend largely to prove its identity.

The mineral has a pitch-like lustre, jet black color, concordal fracture, greyish-green streak and is brittle. Its hardness is a little below 6 and the specific gravity determined by testing three specimens gave in each case 3.5. The specific gravity of this mineral, according to Dana, is 3.5 to 4.2.

Before the blowpipe the mineral fuses very easily and becomes strongly magnetic.

A small crystal, (1/4 X 1), evidently monoclinic, was found with faces and angles as shown in Fig. (3).

The faces of this crystal were very much warped making the measurements of the angles with the goniometer very unsatisfactory. The minimum and maximum readings for 5 tests are;—
The allanite, consisting of poorly developed crystal forms massed together, was taken from one of the large fragments in the central portion. The smaller crystals are about 1/8 of an inch thick and 1 inch long, and are found in the finer parts of the rock, but the larger masses of allanite, which consist of bunches of rounded prismatic crystals 1 inch wide and 6 inches long were taken from a very coarse part of the fragment. The mineral is found in the quartz and feldspar, the quartz being the smoky variety although the white vitreous quartz is in abundance, both occurring in masses 2 feet square.
Feldspar develops on a large scale also biotite, which shows again that the large crystals of accessory minerals are always found in the coarse pegmatite. A particular mass of allanite which at first seemed to be a fragment of one large crystal, was found to be made up of at least five crystals which had been pressed together so as to remove all traces of the original crystal faces. The very fine spaces between the crystals were filled in with a fine mixture of quartz and feldspar.

Near the dike a wall built of fine grained quartz and feldspar rock is seen, which is used to shelter the placer workings. In one of these rocks a few small pieces of a dark colored mineral was found which as yet has not been determined nor could its position in the dike be found. The crystal form can not be recognized. The mineral resembles allanite so closely that the difference is only noticed on comparison of the two. The hardness is 6, streak, yellow, color dull pitchy-black, the lustre is resinous and distinctly different from allanite. It is a very brittle mineral and

\[ \text{Gadolinite} \]
specific gravity by testing three specimens 5.7 which is much heavier than allanite.