PETROGRAPHY AND PETROLOGY OF THE IGNEOUS INTRUSIVE IN WOODSON COUNTY, KANSAS

by

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B. S., University of Illinois, 1958

A THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Geology and Geography

KANSAS STATE UNIVERSITY
OF AGRICULTURE AND APPLIED SCIENCE

1959

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INTRODUCTION

Purpose of Investigation

The purpose of this thesis is to describe the igneous rocks of the Rose dome intrusive, Woodson County, Kansas; the metamorphic rocks formed by the intrusive; and any effects the intrusive may have had upon the surrounding sedimentary rocks. An attempt was made to determine the character of the parent magma, conditions which prevailed in the magma at the time of the intrusion, and the relationship between the Rose dome intrusive and other igneous rocks reported in nearby areas.

Method of Study

Field Study. Samples of representative rock types were taken from the granitic boulders scattered over the area inasmuch as bedrock exposures were not present. The majority of the specimens were obtained from the westernmost portion of the intrusive body as it was the location of the greatest number of boulders (Plate 1). Several specimens were taken from the soil at depths of one to two feet. Shovels and hand augers were used in an unsuccessful attempt to locate the shale-granite contact described by Twenhofel (1926). Representative samples of the wall rocks were collected from the float. A plane table map was prepared of the intrusive and adjacent areas.

Laboratory Study. The hand specimens of the granite obtained from field work were cut with a diamond saw and thin sections of the various rock types made. A total of twenty-seven thin sections of the rocks were available for study along with their corresponding hand specimens.

A petrographic microscope was used to examine the various thin sections of the rocks. Oil immersion tests were made to determine the indices of several different minerals.

Location

The granite intrusive of Woodson County, Kansas "outcrops" near the crest of the Rose dome approximately eight miles south of the town of Yates Center and one-and-one-half miles west of the town of Rose (Fig. 1). The "outcrop," represented by weathered boulders of granite, covers parts of Sec. 13, T26S, R15E and Sec. 18, T26S, R16E. Another site of igneous activity is located at the Silver City dome about five miles southwest of the Rose dome. Here hydrothermally metamorphosed sedimentary rocks and peridotite outcrops are found (Hambleton and Merriam, 1955).

Topography and Physiography

Granite boulders "outcrop" near the crest of the Rose dome, an anticlinal structure with a surface area of four or five square miles and a closure of approximately 150 feet. While the dome is a topographic high, it is encompassed by other structures of higher elevations. The "outcrops" of boulders are unimpressive as the field in which they occur is relatively flat with little more than twenty feet of relief.

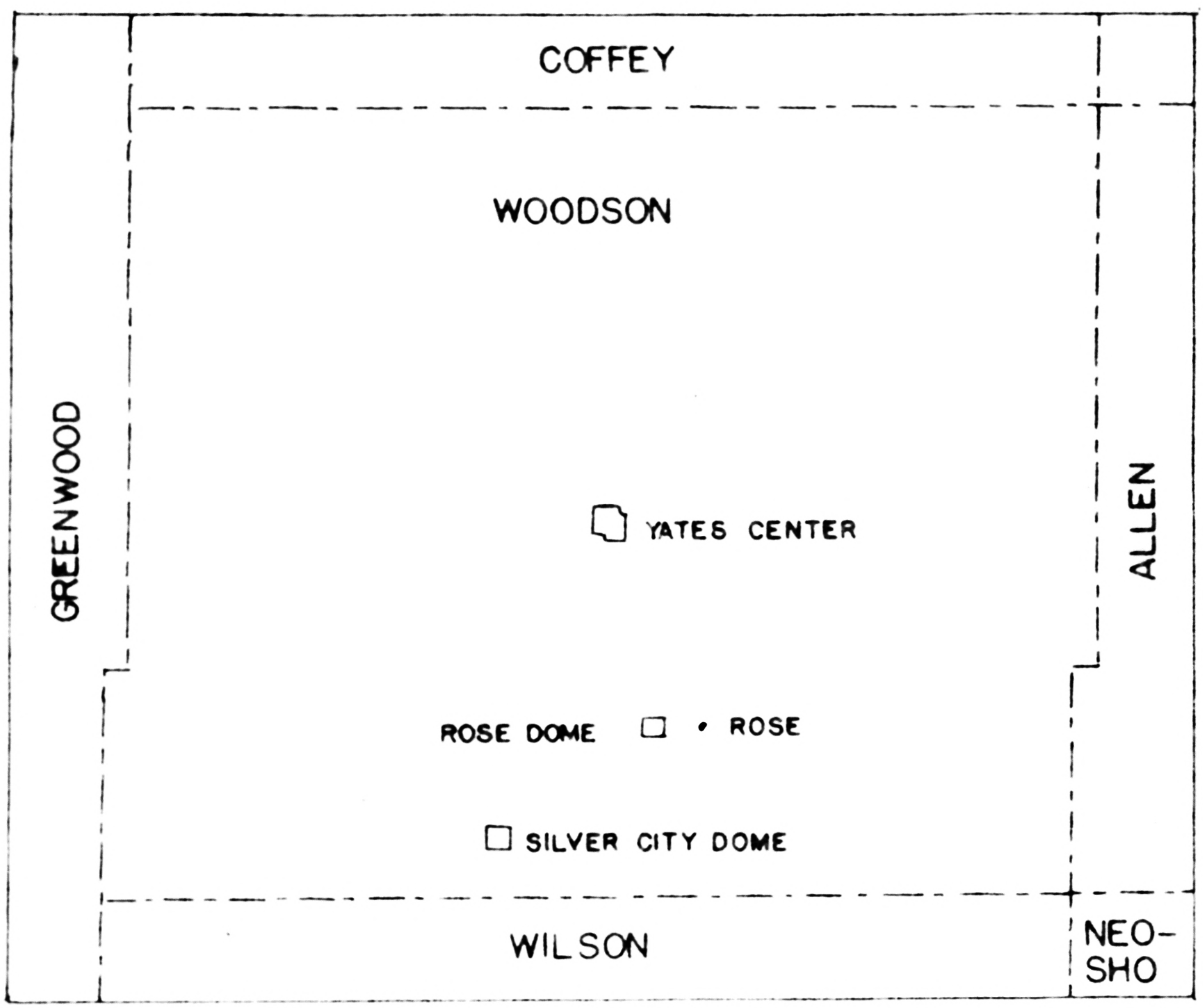

Fig. 1. - Index map of the igneous and metamorphic areas in Woodson County, Kansas, including the area covered by this thesis.

The field has two large mounds and several smaller ones. Each of the mounds, with the exception of one of the larger, is capped by granite boulders ranging from several inches to several feet in diameter. The mounds obviously owe their existence to the more resistant granite. Minor gulleys have been cut in the wallrock adjacent to the granite.

The soil in the immediate vicinity of the intrusive body is rich in highly weathered granite boulders and pebbles. Soil 12 to 18 inches thick has developed above the underlying shales. The soil surrounding the granite body was found to be underlain in several places by clean, unconsolidated sand probably of recent age. The sand overlies either shale or limestone, depending on whether the shale, which is stratigraphically higher than the limestone, is present or not.

Previous Work

The southern part of Woodson County, Kansas, has been a center of geologic interest since the late 1800's. In 1879 the discovery of what was thought to be silver in hydrothermally metamorphosed rocks, near the town of Buffalo, resulted in a silver stampede which proved to be futile.

Mudge (1880) and Hay (1882) had excellent opportunities to study the metamorphic effects on the rocks because of the shafts opened up for mining development at that time. The metamorphic rocks are mainly quartzites and breccias replacing sandstones, shales and limestones. Mudge attributed the metamorphism to "the action of warm mineral siliceous waters." Hay regarded the rocks as the expression of an igneous agency. Twenhofel and Edwards (1921) believed the metamorphism was due to ascending hot solutions possibly related to an intrusive igneous rock underlying the Silver City Ridge.

Granite boulders were recognized near the crest of the Rose dome in 1915 by W. H. Twenhofel (Twenhofel, 1921). At that time Twenhofel postulated four possible methods of origin for the occurence of the boulders;

(1) the cementation of coarse sediments rich in unworn feldspar crystals.
(2) the boulders are weathered products of a sheet, flow or dike which had intruded the sediments.
(3) streams were the transporting agent of the boulders.
(4) the boulders were transported by ice.

Petrographic examination eliminated the cementation of coarse sediments as a possible origin. In view of the lack of evidence of metamorphism in the area, the intrusive theory was discounted. Evidence of metamorphism is scanty at best and the spotty outcrop of boulders could easily lead one to believe that the boulders are in no way related to an intrusive at depth.

Deductive reasoning negated the possibility of stream transportation as a plausible explanation for the boulder's occurrence. Present Kansas streams are not of sufficient gradient to transport material even approaching the size of the boulders and the larger Kansas streams are quite distant from the Rose area.

With seemingly no strong evidence to support the three forementioned hypotheses, Twenhofel favored the ice transportation to account for the boulder's occurrence. Twenhofel (1917) believed "ice could have brought about the transportation either in the form of a glacier or as floating ice." The local distribution of the boulders best supported the ice-rafted theory.

Twenhofel (1921) acknowledges the possibility of metamorphism at the Rose dome but he states that "no such alteration was seen (by him) in the rocks at Rose as occurs at Silver City and he has been inclined to the view that no metamorphism is evident." Twenhofel's concern appears to have been stimulated by reports that evidence of metamorphism had been found in the Rose area.

The area was carefully re-examined in 1924 by Twenhofel (1926) for the express purpose of determining if metamorphic rocks did exist. At this time the contact of the granite in the enclosing shales was observed in a recently widened ditch which parallels the highway running north-south through the area. Adjacent to the granite the shale had lost its lamination and normal black color and had been altered to a grayish yellow. The granite appeared to be slightly finer-grained in the immediate vicinity of the contact.

Twenhofel (1926) discarded the ice-rafting theory with the following statement:

> The conclusion of the intrusive origin is based on the nature of the contact with the enclosing rocks, the presence of contact metamorphic minerals in the rocks penetrated by the well near the northwest margin, and the occurrence of pronounced hydrothermal metamorphism in the Silver City area, four or five miles to the southwest.

In the same article Twenhofel concluded that the granite boulders present at the Rose dome are the weathered equivalent of a granite mass which intruded, and domed, the Pennsylvanian and lower strata.

The report of basic igneous rocks in the samples taken from wells in the vicinity of the Rose dome and the strong evidence of an igneous body below the Silver City dome led Twenhofel (1928) to consider a genetic relationship between the igneous rocks at the Rose dome and those at Silver City. The suggestion was made that the Rose dome granite is compositionally similar to the parent body while the basic rocks are derivatives therefrom.

Knight and Landes (1932) consider three anticlines in eastern Kansas. Two of the anticlines, the Rose dome and the Silver City dome, have igneous phenomena associated with them, and the third, the Neosho Falls dome, is structurally similar. The anticlines are small in areas (four to six square miles) and have closures as large as 140 feet. The resulting dips, unusually large for that part of Kansas, seem to justify the statement that "the apparently casual relationship between the anticlines and igneous intrusions *** suggest that these structures could properly be termed laccoliths."

The hypothesis presented to substantiate this conclusion is as follows:

> A parent body magma first intruded the crystalline shell underlying Woodson and adjacent counties. Cupolas on the top of this deep-seated igneous body broke through the Pre-Cambrian rocks arching the overlying sedimentary strata at the same time sending out dike offshoots. With crystallization of the magma in the cupola, hydrothermal solutions were expelled which worked upward through the rocks causing metamorphism of the shales, sandstones, limestones and some of the dikes (Knight and Landes, 1932).

Lee (1939) casts some doubt upon this conclusion as he had noted thinning of Mississippian limestones amounting to as much as sixty feet in the Rose dome and Silver City dome area. He believes the thinning indicates that the area had been slightly arched long before igneous activity took place. In the same article Lee (1939) notes a similar thinning of the Mississippian rocks in the Neosho Falls area.

Several geophysical studies have been made on the Rose dome area. A magnetic survey was completed in 1935 and a radioactivity survey was made in 1948 (Hambleton and Merriam, 1955). A high radioactivity anomaly was noted at the center of the dome and it was concluded that the granite was responsible for the anomaly. W. W. Hambleton and D. F. Merriam (1955) completed an extensive magnetic survey of the Rose and Silver City domes. It was determined that the magnetometer.

> Was not especially successful in the determination of the character and extent of the intrusive igneous rocks at Rose and Silver City domes owing to lack of contrast between magnetic susceptibility of igneous and sedimentary rocks.

GENERAL GEOLOGY

Rock Description

<u>Sedimentary Rocks</u>. The Pre-Cambrian basement complex of granites and gneisses in the Rose dome area is overlain by the Arbuckle group of Late Cambrian and Early Ordovician age. Dolomites and limestones predominate with cherty and sandy layers common.

Prior to the deposition of the Chattanooga shale, (? Devonian), which unconformably overlies the Arbuckle group, uplift and erosion removed most of the rocks of Middle and Late Ordovician, Silurian and Devonian age from the north flank of the Chautauqua arch (Moore and others, 1951). The Chattanooga shales are overlain by the cherty dolomites and limestones of Mississippian age.

The Pennsylvanian system in Woodson County is represented by the Missourian and Des Moinesian series. Included in the subsurface rocks are the Cherokee, Marmaton, Pleasanton, Kansas City, and Lansing groups. The rocks consist mainly of alternating limestones and shales with a few sandstone members.

Surface rocks outcropping in the vicinity of the Rose dome are the upper formation of the Lansing group, the Stanton limestone, and the lower formation of the Pedee group, the Weston shale. Much of the area surrounding the granite intrusive is covered by the Stanton limestone but in the immediate vicinity of the igneous body only the Weston shales can be found. The shales are thinnly laminated, black carbonaceous rocks with a high degree of induration.

Igneous Rocks. The only exposed igneous rocks in the Rose dome area is the coarse-grained porphyritic granite found as boulders at the surface. The granite is composed mainly of orthoclase and oligoclase feldspars and white to pale blue quartz. The orthoclase has been highly albitized and most of the feldspars show extreme effects of weathering and hydrothermal alteration. Ferromagnesian minerals, predominately biotite are present but have been altered almost beyond recognition. Several specimens have both coarse-grained and fine-grained textures associated together. The finer-grained material probably represents a second stage of intrusion which shattered the coarser-grained rocks and filled in the interstices.

On several occasions the presence of igneous rocks at depth have been indicated in the samples examined from wells drilled at the Rose dome and nearby areas (Twenhofel, 1928). Well samples of very basic rocks through a distance of slightly greater than one hundred feet suggests the presence of a peridotitic dike or sill.

Contact Metamorphic Effects. The most pronounced contact metamorphic effects observed in the Rose dome area are the baking and silicification of the Weston shales. The rocks, on a fresh surface, have a dense, dark, chert-like appearance. The denser portions of the rock have a lenticular or oval shape and are separated from one another by a softer, more porous network. Several of the shales still retain laminations, though somewhat obliterated. The rocks are mottled in whites and grays which form a patchy texture.

Several quartzites were observed in association with the granite boulders. The possibility exists that the quartzites are both igneous and metamorphic in origin. One specimen showed distinct bedding or laminations suggesting a former sedimentary origin. Round, sand sized grains formed stringers throughout a finer groundmass. One small weathered quartzite boulder showed strong effects of differential weathering.

Dense, gray cherts of undetermined origin are associated with the granite boulders.

Structure

The southermost part of Woodson County, Kansas is located between the Bourbon arch and the Chautauqua arch on the northern flank of the Cherokee basin. The Cherokee basin is terminated to the west by the Nemaha anticline.

The Chautauqua arch is a southern extension of the Barton-Ellis arch of Devonian age while the Bourbon arch, the Cherokee basin and the Nemaha anticline are late Mississippian or early Pennsylvanian in age.

The Rose dome is an anticlinal structure, symmetrical in outline, with an axis trending northeast-southwest. The oval shape of the dike-like granite intrusive (Plate I), is outlined by the mounds of boulders found at the surface near the crest of the dome. The surface reflection of the intrusive covers an area of 200 by 1200 feet and trends N80°W.

PETROGRAPHY OF THE IGNEOUS ROCKS

Medium to Coarse-Grained Granite Porphyry. Most of the specimens examined megascopically were placed in the medium to coarse-grained classification, with grain sizes ranging from one to thirty millimeters in diameter. The majority of the coarser grains are phenocrysts embedded in a very fine-grained groundmass. The specimens with similar characteristics will be described collectively, while those with unusual properties will be described individually.

Weathered surfaces are generally light to medium gray in color but iron oxide and clay products commonly tint the rocks with brown, white, and occasionally, black. The surface texture of the rocks may be fairly smooth or quite rough. Those specimens with rough surfaces are the products of differential weathering and/or solutioning. Large phenocrysts stand in relief where the less resistant, finer-grained material has been removed.

Mineralogically, the granites appear quite simple. The minerals identifiable are: feldspar (predominantly perthites), quartz, ferromagnesian minerals, and clay products. The perthites are very light gray in color and highly fractured. Fractures have developed along cleavage planes and were subsequently filled with a light brown material. Thin veinlets of quartz may traverse the grains. Albitization is apparent in the hand specimens represented by alternately light and dark, irregular patches. The grains, usually 10 to 30 millimeter in diameter, are subhedral and anhedral. Many of the feldspars have been highly corroded and embayed. Aggregates of clay minerals, two to fifteen millimeters in diameter, are disseminated throughout the rock and represent highly altered feldspars. Poikiolitic inclusions of quartz and feldspar, one to three millimeters in diameter, are commonly found in perthites. Feldspars comprise 60 to 65 per cent of the rocks.

Quartz is recognizable throughout the rock as aggregates, individual grains, and as poikiolitic inclusion in feldspar. The aggregates are composed of coalesing quartz grains and may exceed 15 millimeters in diameter while the individual quartz grains are anhedral in shape and average one to two millimeters in diameter. Quartz grains appear almost perthitic with alternating clear and cloudy lenses. The overall color may vary from clear to pale blue. Many of the quartz grains are shattered and display slight weathering or alteration along the fractures. The quartz content varies from 25 to 35 per cent of the rocks.

Ferromagnesian minerals are present as varietal accessory minerals (one to two per cent) but their extreme alternation makes definite identification impossible. The majority of the grains appear to be biotite but some magnetite is present. The biotite is olive drab to brownish-black in color with an average grain size of two millimeters in diameter.

In the hand specimens available, it may be noted that as the grain size decreases several changes take place. The rocks remain similar compositionally to their coarser-grained equivalents but there appears to be a lineation of minerals in some of the specimens. Many show excellent flow structure. The groundmass, present in the coarser-grained rocks but masked by the size of the phenocrysts, becomes very apparent.

Those rocks appearing to have a slight lineation of minerals display a brown, rather than gray, color. This is due to the relative increase of the groundmass. The phenocrysts, both quartz and feldspar, exhibit a multitude of shapes. The grains have been subjected to stress and are highly fractured. Some may be well rounded, others prismatic, and still others highly angular with triangular or shard-like shapes. The degree of alteration is similar to

Flow structure is well developed in several specimens. All, with the exception of one small hand specimen, have the flow structure developed around what appears to be inclusions of very fine-grained granite. The flow structure is highly contorted, pinching and swelling in a sinuous pattern, and may bifurcate into nearly perpendicular directions. The individual grains may contact one another or may be separated by a very fine, almost cryptocrystalline groundmass. The feldspars are very highly weathered; some are completely altered to clay.

Microscopic Characteristics. The rocks vary texturally from specimen to specimen. The coarser-grained granites are typically porphyritic but as the grain size of the rock decreases the effects of stress and movement are observable. The rocks remain essentially porphyritic texturally but the phenocrysts have been shattered to tabular, prismatic or anhedral grains which show parallellism. One specimen exhibits medium-sized grains of a highly fractured nature emplaced in a fine groundmass with a resulting cataclastic texture.

Feldspars predominate throughout the rock. Microcline, orthoclase and perthites make up 60 to 75 per cent of the rock. The individual feldspars were classified on optical characteristics and twinning. All of the feldspar phenocrysts have suffered the effects of albitization, often to the extent that the optic sign which was formerly negative is now positive, as in the case of microcline and orthoclase (Fig. 2). Albite replacement has almost obscured the characteristic grid twinning of the microcline. The perthites are of a replacement nature with cloudy blebs of albite irregularly disseminated throughout the grains. The albite patches differed from the potash-rich remainder of the phenocryst both under crossed nicols and in plain light. The albite is relatively unaltered under crossed nicols and in plain light but the remaining fraction of the grains is nearly opaque under crossed nicols. Alteration apparently has taken place along cleavage planes. This is readily seen in plain light. Thin, clear streaks form parallel layers separated by clay-rich bands. This characteristic is reflected throughout the rock in all of the coarse-grained specimens. The feldspar grains are subhedral and anhedral in shape. Corrosion, re-sorbtion and embayments have destroyed the original outline of many of the grains (Fig. 3). Poikiolitic inclusions of quartz, oligoclase and biotite are common in the feldspar phenocrysts. The individual feldspar grains may range from two to 15 millimeters in length with an average of six to eight millimeters in length.

Oligoclase (An(28)) is present in the rocks as pheno-crysts and poikiolitic inclusions in the alkali phenocrysts. All of the oligoclase grains appear to have been twinned but in many grains the twinning has been partially or completely destroyed. The most intense alteration of the oligoclase is concentrated in the center of the grain and decreases towards the margin. Often a thin, twinned skeleton grain will surround an intensely altered interior. The oligoclase grains, like their alkali counterparts, are highly embayed and corroded

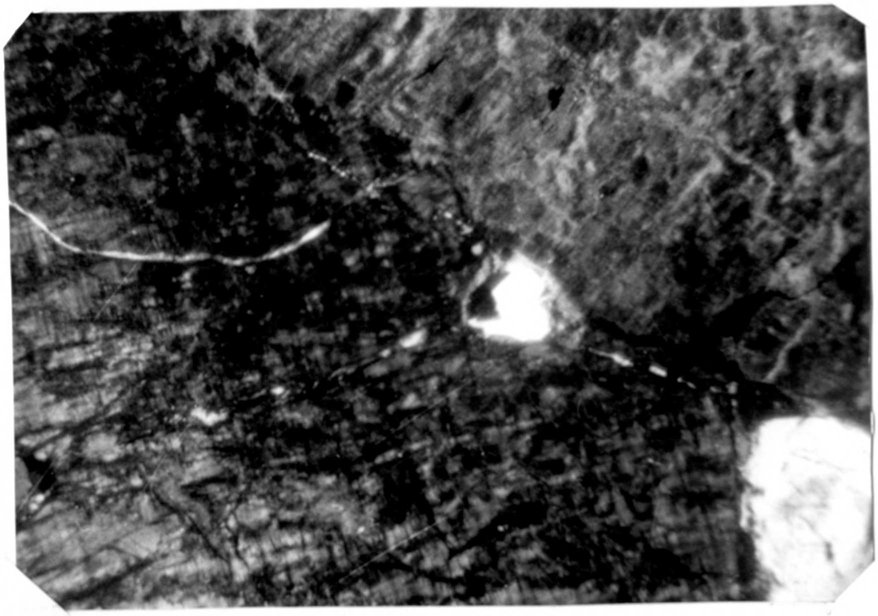

Fig. 2. Perthites showing extreme alteration and albitization. Top. Orthoclase. Bottom. Microcline. Cross nicols. X80.

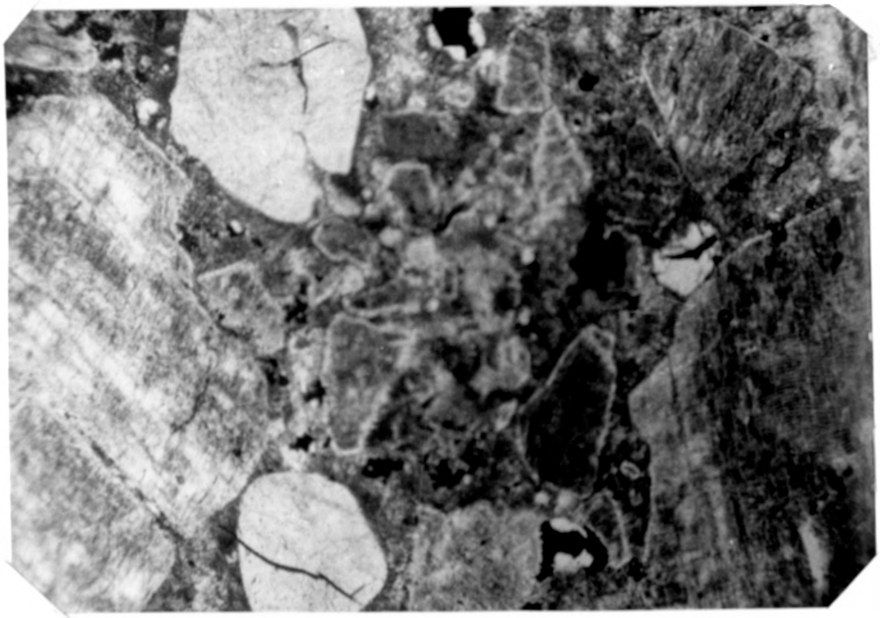

Fig. 3. Rounded feldspar and quartz grains in fine-grained groundmass. Feldspar grains exhibit albite rims. Cross nicols. X25.

near their periphery resulting in subhedral or anhedral grains. The alteration of the oligoclase is distinctive. Sericite is a common secondary product in the oligoclase grains but almost absent in the other feldspars. In plain light the oligoclase appears more altered than the alkali feldspars, but the alteration is much more consistent. The grains have a uniform texture and a homogeneous color. The grains are somewhat smaller than the alkali phenocrysts, rarely exceeding six or seven millimeters in length.

The characteristics of the feldspars described above also apply to the smaller grains encompassed by a fine-grained groundmass. In reality, these grains have probably been separated from the larger phenocrysts during movement and actually comprise a large part of the groundmass (Fig. 4). The feldspars are subhedral or anhedral in shape and have been fractured and crushed. The entire aggregate has been cemented by a very fine groundmass consisting of quartz and albite intergrowths. The larger feldspar grains, 0.8 to 1.5 millimeters in length, may be surrounded partially or completely by a network of clear, prismatic quartz and feldspar crystals oriented perpendicular to the outline of the crystals (Figs. 6 and 7). Where the quartz and albite fill in large voids between grains, the individual minerals lose their prismatic shape and become sutured, shapeless intergrowths.

Quartz comprises a major portion of the rock. It generally is present in amounts of 25 to 35 per cent but in some specimens it may exceed 45 per cent of the rock. The percent-

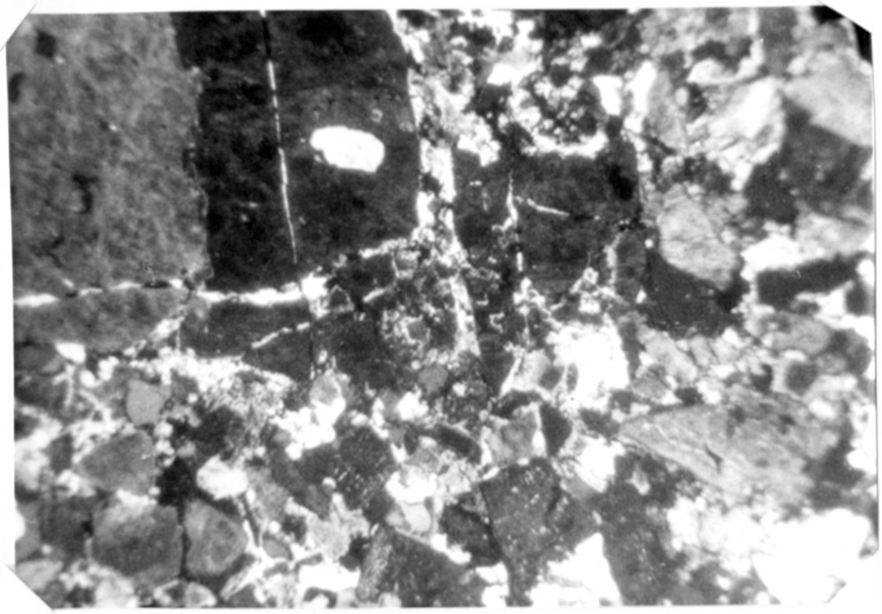

Fig. 4. Photomicrograph of two stages of intrusion. Large feldspar grain surrounded by smaller quartz and feldspar grains encompassed in a fine-grained matrix of quartz and albite. Cross nicols. X25.

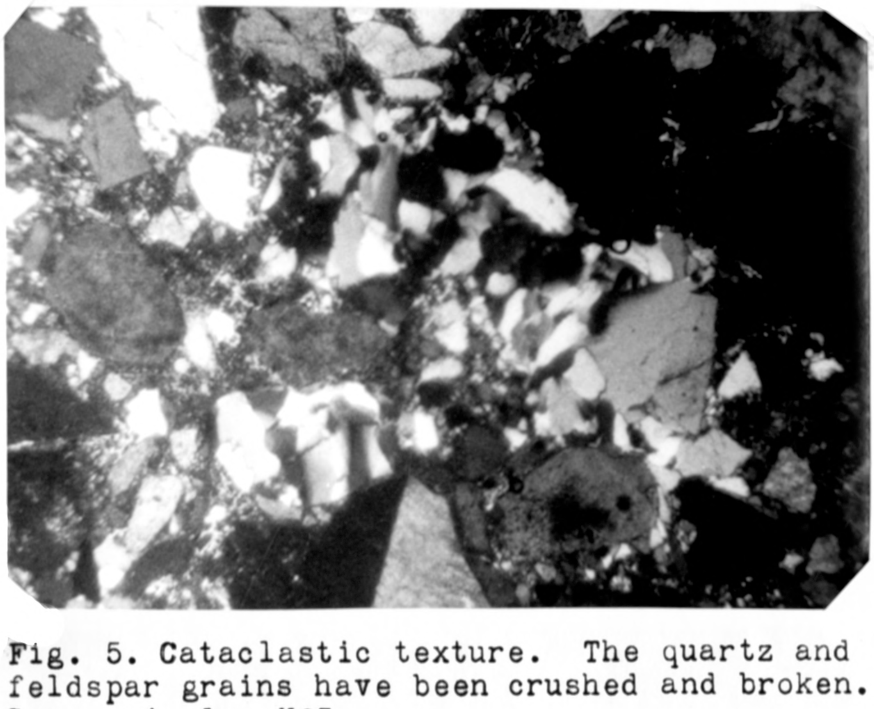

Fig. 5. Cataclastic texture. The quartz and feldspar grains have been crushed and broken. Cross nicols. X25.

age of quartz in a rock may be quickly determined by looking at a thin section of the rock in plain light (Figs. 8 and 9). Quartz is represented in a multitude of sizes, shapes and roles. In the coarser-grained rocks, quartz phenocrysts exceed 10 millimeters in diameter. Aggregates of quartz grains between the larger feldspar phenocrysts commonly exceed 25 or 30 millimeters in length. Individual grains average two to four millimeters in diameter. The quartz and feldspar grains usually show sutured contacts. Commonly, the feldspars are highly corroded and tongue-like extensions of feldspar which appear to penetrate the quartz grains. In reality, the quartz has replaced the feldspar grain in part and the tongue-like extension is a remnant of the former grain (Fig. 11). The majority of the larger quartz grains have a crushed appearance and display undulatory extinction. The quartz is rich in inclusions which have no preferred orientation. Alteration of the quartz is fractured controlled and solutioning of the quartz has taken place along the same zones of weakness (Fig. 10).

Small blebs of quartz (0.2 to 0.5 millimeters in diameter) located in feldspar grains are usually controlled by cleavage or the intersection of two cleavage planes. Quartz is also present as vein quartz emplaced in the voids between shattered fragments of individual feldspar phenocrysts. The veins or veinlets are 0.1 to 0.2 millimeters in width.

Tabular grains of quartz (Figs. 12 and 13), 0.5 to 1.5 millimeters in length, have a preferred orientation with the long axis of the grains in the direction of flow. The tab-

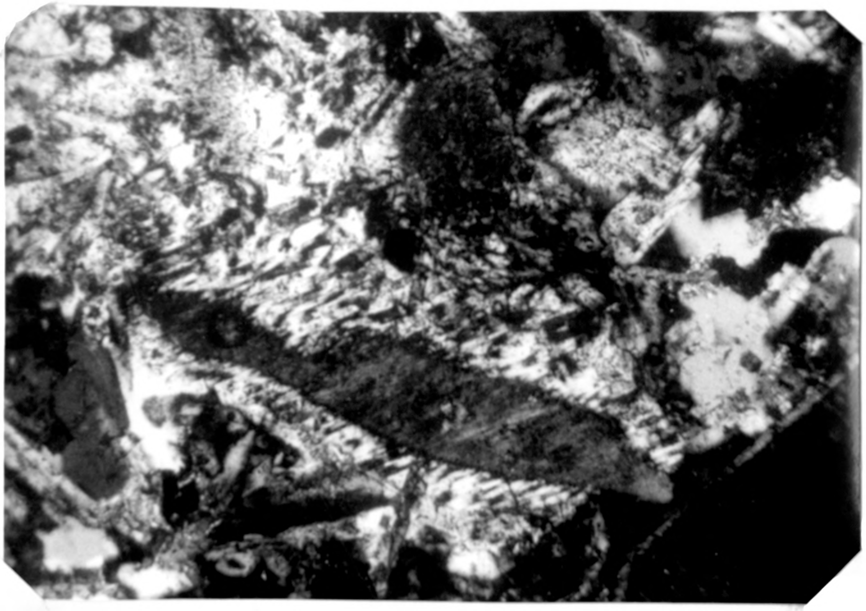

Fig. 6. Partially resorbed feldspar surrounded by intergrowths of quartz and albite crystals perpendicular to outline of grain. Note albite rim on large feldspar phenocrysts. Cross nicols. X25.

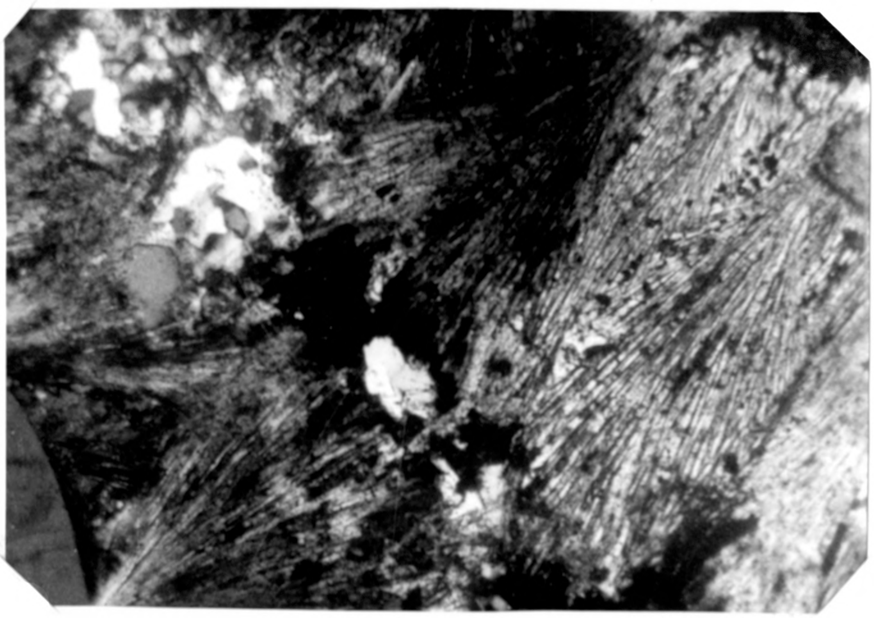

Fig. 7. Radial intergrowths of feldspar and quartz. Growth took place in a veinlet in feldspar phenocryst. Later filled with vein quartz. Cross nicols. X 200

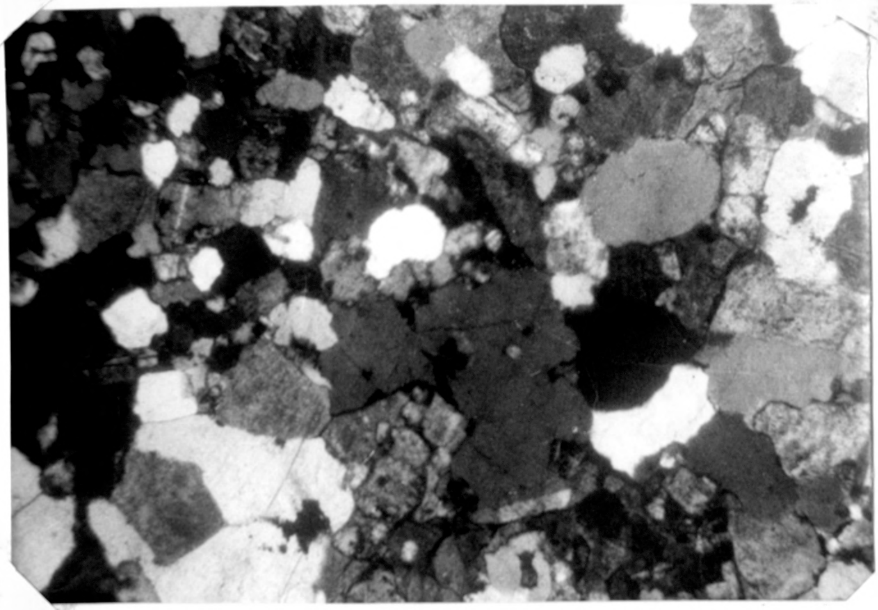

Fig. 8. Aplite. This rock has an unusually high oligoclase content. Cross nicols. X25.

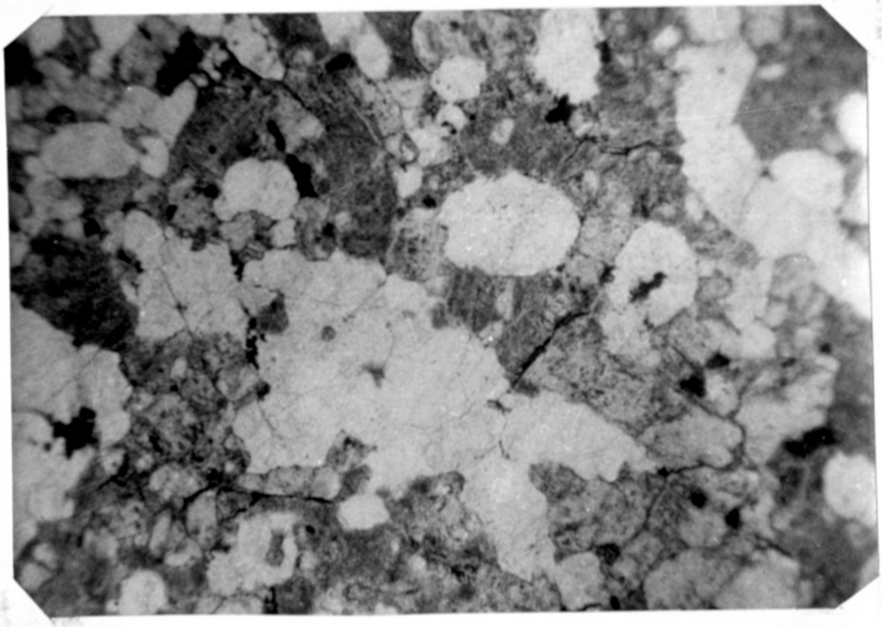

Fig. 9. Same rock as above but plain light. Quartz (clear) content is very high. Feldspars (dark gray) moderately altered. X25.

ular or prismatic shape of the grains is due to fracture and growth during movement. The grain shapes, due to fracture, are spear or shard-like while those due to growth are tabular with small extensions developing perpendicular to the direction of movement.

The very fine-grained groundmass observed in the thin sections of the rocks fills in the fractures between shattered phenocrysts, completely surrounds many of the medium and fine sized grains, and has in part, resorbed and replaced the earlier formed feldspars (Figs. 4 and 6). The fine-grained groundmass is predominantly intergrowths of quartz and albite. The intergrowths may consist of radiating or spherulitic growths, parallel laths of quartz and albite, or a combination of quartz and albite grading into nearly pure cryptocrystalline and vein quartz (Figs. 6 and 7). Larger, individual grains of quartz may be partially or completely surrounded by lath-shaped quartz and albite grains perpendicular to the contact. In the case of feldspar, the intergrowths parallel to the cleavage of the feldspar tend to resorb and replace it, while the intergrowths perpendicular to the cleavage form a sharp contact (Fig. 7). The spherulitic intergrowth of quartz and albite resemble chalcedony in structure, but differences in extinction, relief, and degree of alteration, when viewed in plain light, quickly distinguishes between the two.

Ferromagnesian minerals make up a very small percentage of the rock, usually less than two per cent. The crystals have been partially or completely altered to magnetite, clay

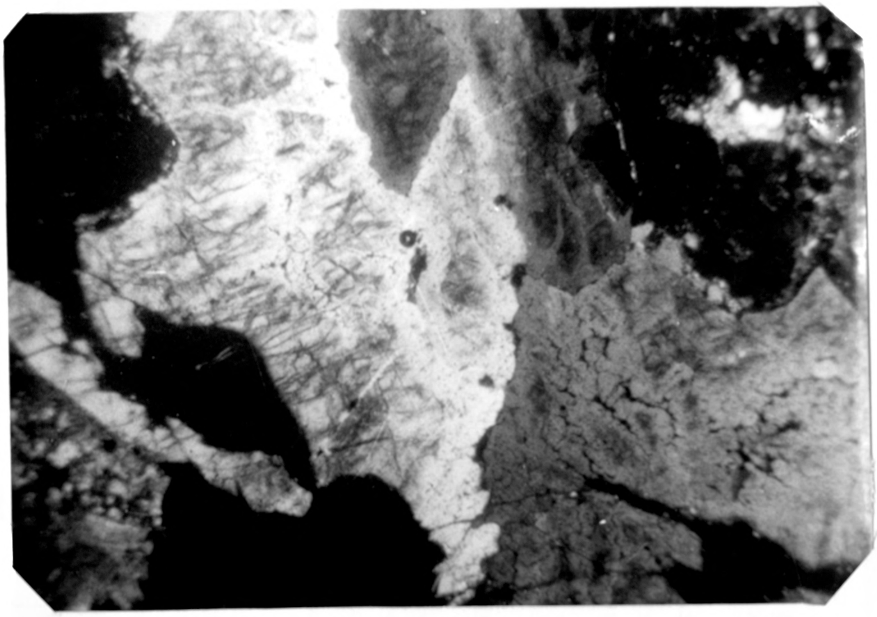

Fig. 10. Fracture controlled alteration of large, anhedral quartz grain. Cross nicols. X25.

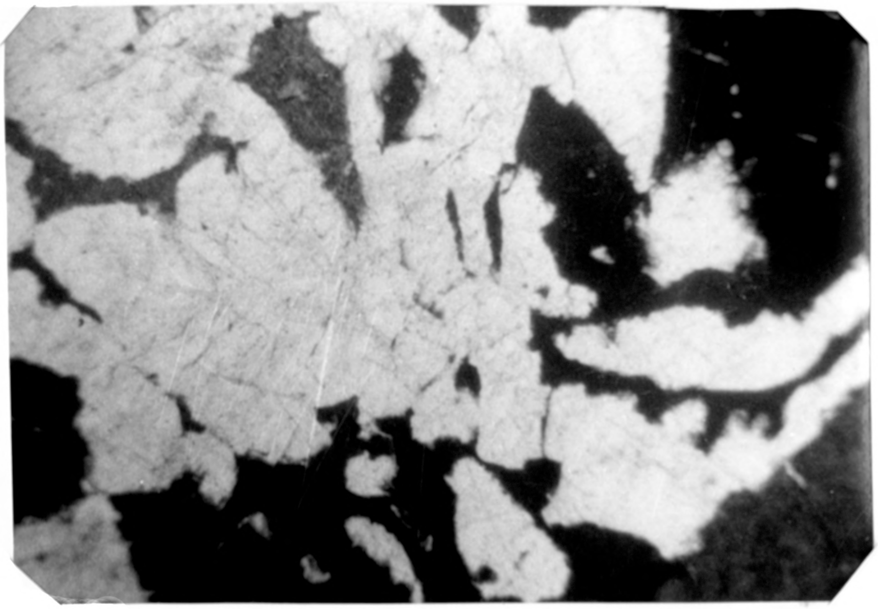

Fig. 11. Anhedral quartz grains (white) replacing feldspar. Cross nicols. X25.

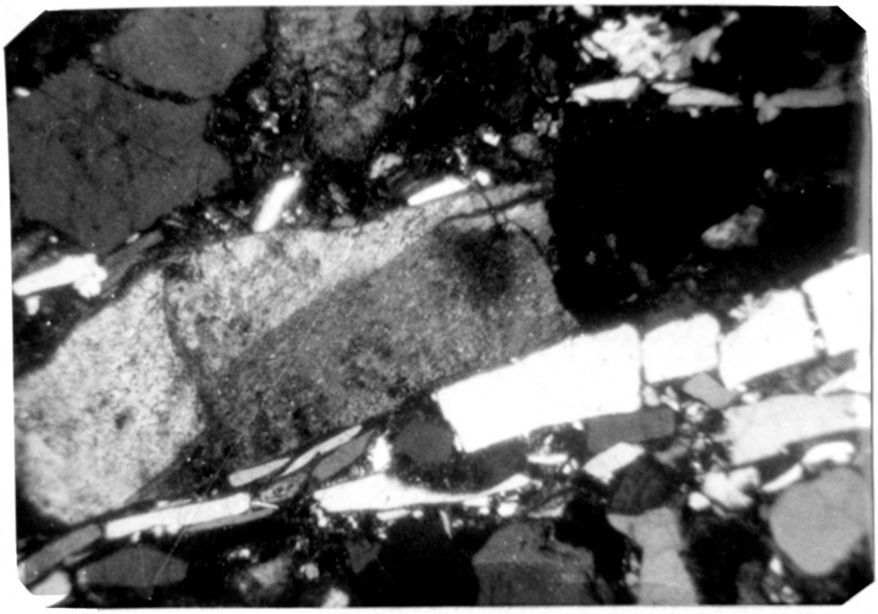

Fig. 12. Flow structure. Note crushed grains, tabular quartz (white) and feldspar. Cross nicols. X25.

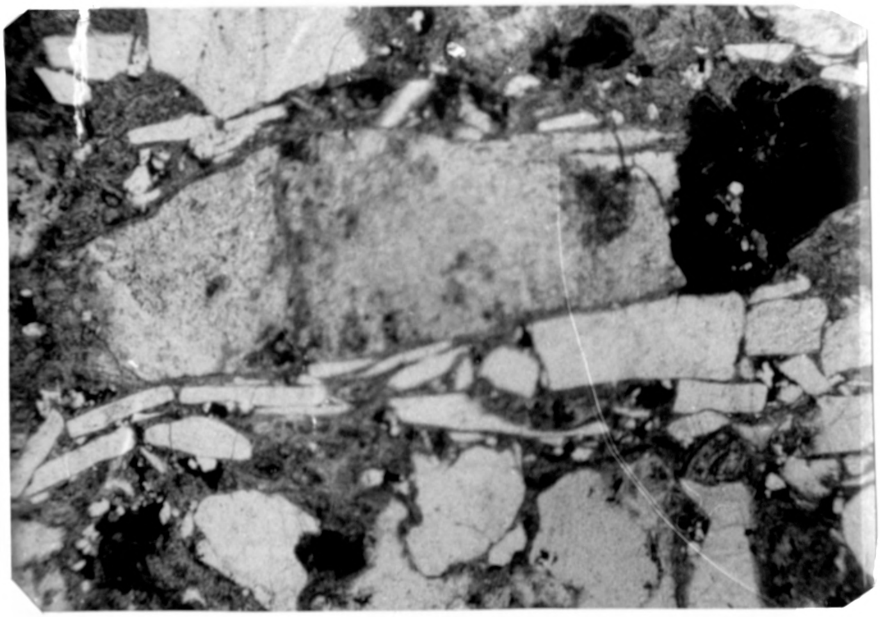

Fig. 13. Same as photomicrograph above but plain light. Note the moderately intense alteration of the feldspars. X25.

and chlorite. Precise determination of the minerals is impossible, but the structure of the prismatic, subhedral grains indicates that the former mineral was biotite. The grains range from less than 0.1 to 3 millimeters in length. Magnetite is a secondary products of alteration and weathering. Clays and iron oxides are disseminated throughout the rocks, both as cloudy masses and as pseudmorphs after feldspar or ferromagnesian minerals. Very fine, euhedral grains of zircon, apatite, sillimanite and tremolite (?) are disseminated throughout the rock in minute quantities.

Pegmatitic Granites. Mineralogically and compositionally the pegmatitic rocks are identical to the coarse-grained granites. The only distinction between the two is that of grain size. Several of the specimens collected and many of the boulders observed at the Rose dome contained phenocrysts in excess of 30 millimeters in length. The largest phenocryst measured, a perthitic feldspar, was 43 millimeters in length. Rocks containing phenocrysts of this size are termed pegmatitic.

The megascopic and microscopic description of the coarse-grained granites will suffice for the pegmatitic rock. A further discussion of this rock type will not be continued as it will add nothing new to the petrography.

Aplites. Sugary-textured rocks with a grain size generally less than 0.5 millimeters in diameter have been classified as aplites. On weathered surfaces the rocks have a light gray to brown color. On a fresh surface the rocks are speckled white and gray. The "inclusions" which have been described as aplitic in texture are similar in appearance to fine-grained stages which have been observed in contact with coarser-grained rocks. The contact between these two stages is somewhat gradational but, within the distance of a few millimeters the grain sizes change from an average of 0.5 to five millimeters in diameter.

The aplitic rocks are composed mainly of quartz and feldspar. Quartz is more abundant in the finer-grained rocks, often comprising 45 to 50 per cent of the rock. Many of the quartz grains are highly embayed and interfinger with anhedral feldspar grains, but, if the texture of the rock is considered as a whole, it is more correctly described as mosaic. The feldspar grains may be partially or completely altered to clay.

One specimen, strongly weathered in the outer portions, exhibited a dark gray core which appeared only slightly altered. While aplitic in texture, the grains of feldspar and quartz interfinger in a sutured pattern. The rock is unusually porous and many of the former voids are filled with pyrite. The pyrite may make up as much as 10 per cent of the relatively unaltered rock, but in the weathered zone it has apparently been altered to iron oxide.

Texturally the aplitic and fine-grained rocks are hypautomorphic-granular to xenomorphic-granular. Subhedral grains represent a very small fraction of the rock. This characteristic is reflected throughout the aplitic-textured rocks and the fine-grained "inclusions." Notable differences exist between the finer-grained rocks and those that are coarser-grained. The finer-grained rocks lack the groundmass and the predominance of subhedral crystals present in the coarser-grained rocks; the finer-grained rocks may contain as much as 50 per cent quartz as contrasted with an average of 25 to 35 per cent quartz in the coarser-grained rocks.

Feldspars make up approximately 50 per cent of the rock by volume. This includes orthoclase, oligoclase (An_{28}) and minor amounts of microcline. The ratio of potash-feldspars to oligoclase is extremely variable, ranging from a high potash feldspar-oligoclase ratio of approximately two to one to a low where oligoclase is almost absent. Corrosion has strongly embayed and altered the majority of the feldspar grains, but a few oligoclase crystals retain a relict, prismatic habit. Orthoclase and microcline grains are generally anhedral grains 0.4 to 0.7 millimeters in diameter. Rarely does a feldspar grain exceed one millimeter in length.

Alteration varies from rock to rock both in degree and mode of alteration, but the alteration of an individual specimen is quite homogeneous. The rock may display a high degree of alteration which is uniform in intensity from the periphery to the center of the grain (Fig. 9) or it may be controlled by cleavage and the grain to grain contact. Many of the grains are altered along the periphery with the center free from such effects (Fig. 15).

Quartz grains may make up 50 per cent of the rock by volume (Figs. 8 and 9) and are evenly distributed throughout the rock. The grains are anhedral corroded and embayed masses contacting the feldspar grains with a sutured or mosaic texture. Only one rock proved to be an exception. Euhedral quartz grains, 0.5 to 0.7 millimeters in diameter, are relatively abundant. Many of these euhedral grains have developed overgrowths (Fig. 14). It should be noted that the euhedral grains with overgrowths are in every case surrounded by pyrite. The quartz is clear, rich in inclusions, and free from the crushed and altered appearance of the quartz characterizing the coarser-grained rocks. Quartz with undulatory extinction is not common in the aplitic rocks.

Chalcedony is much more common in the finer-grained rocks. Aggregates 0.1 to 0.5 millimeters in diameter often consist of a radial interior surrounded by a fine outer band of feathery chalcedony (Fig. 15). The chalcedony is usually partially surrounded by pyrite in a manner similar to the euhedral quartz grains. Pyrite makes up six to eight per cent of one rock (Fig. 15) but is restricted to the less altered core. The intensely weathered outer portion of the rock is free of pyrite. Biotite grains, 0.1 to 0.8 millimeters in length, comprise less than one per cent of the rocks. Alteration has reduced the biotite grains to magnetite and iron oxide. The degree of alteration and the amount of clay products and iron oxide present may be readily observed by examining figures 8 and 9.

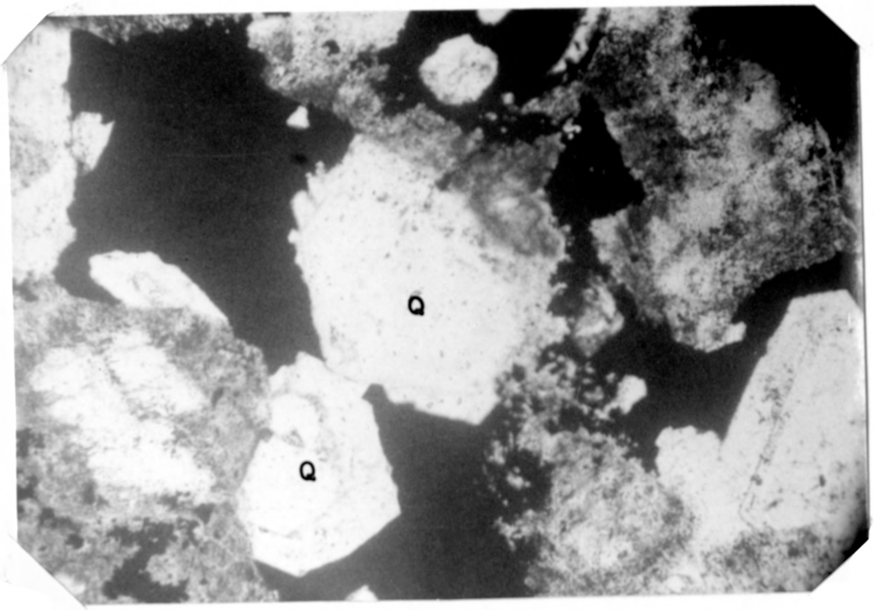

Fig. 14. Quartz crystals (Q) with overgrowths in aplitic rock. Opaque material is pyrite. Plain light. X25.

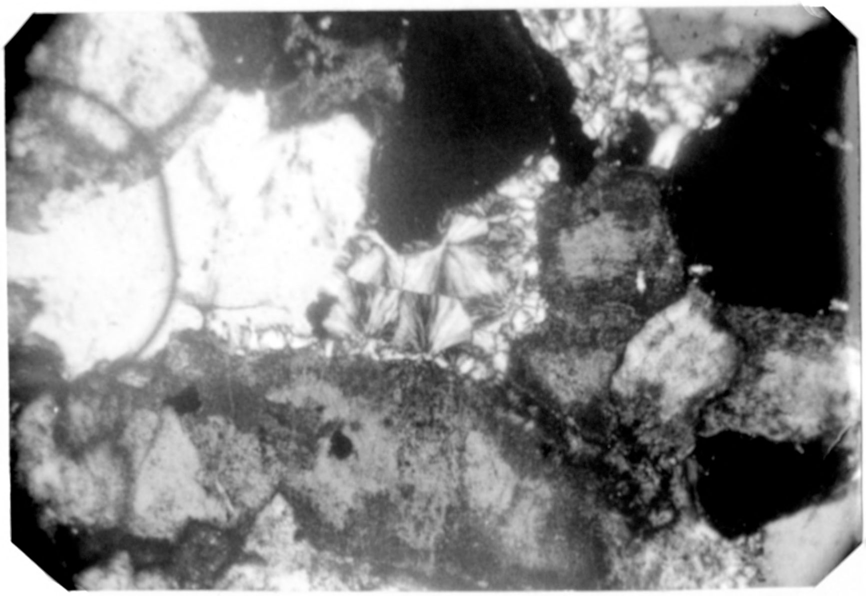

Fig. 15. Radial chalcedony in aplitic rock. Opaque material is pyrite. Cross nicols. X80.

Metamorphic Rocks

Shale. Several altered and unaltered shales were examined megascopically. The unaltered shales are dense, fissile rocks, dark gray to black in color. The altered shales vary widely in texture and possibly composition but this cannot be determined megascopically or microscopically..

The altered shales weather light gray to brown. On a freshly exposed surface the colors may be gray, grayish blue, powdery white and buff. Laminations are apparent in restricted areas but for the most part they have been obliterated.. Former structure is best represented by alternating color bands of grayish-blue and white which pinch and swell in a manner suggestive of the lenticularity of the unaltered shales.

Rocks of doubtful origin, but most aptly classified as silicified shales, were found only near the granite boulders. The color of the weathered surfaces was extremely variable in reds and browns. On a freshly cut surface the rocks showed oval or lense-shaped layers of a dense, hard chert-like material. These layers are separated by a lighter colored network of soft, porous material. The stratigraphic position, the position in relation to the intrusive body, and the general resemblance to the unaltered shales in the same area seem to substantiate the shale classification.

Two thin sections of the shales were examined microscopically. The shale which appeared least altered was homogeneous in color and texture. The more highly altered shale was very fine-grained and the determination of individual minerals was impossible except where recrystallization was evident. Quartz could be recognized both as individual grains and in round to lenticular aggregates of cryptocrystalline quartz as large as 0.2 millimeters in diameter.

The thin section showed the rock to be composed of tongue-shaped patches interfingering with one another. Color varied from patch to patch, perhaps governed by the degree of oxidation and recrystallization, and grain size, generally homogeneous throughout the patches, varied from patch to patch. Under plain light, a large percentage of chlorite was distinguishable by the pale green color it imparted to the rock.

Chalcedony or cryptocrystalline quartz filled small veins in the shale. A few spheroidal grains of chalcedony, less than 0.1 millimeter in diameter, were also present. A small percentage of very fine magnetite grains were disseminated throughout the shale.

<u>Quartzite</u>. Quartzites found in the Rose dome area are interesting in character and content. Megascopically the quartzites varied in color from light gray to light brown on a fresh surface but on a weathered surface iron stains may impart a rusty color to the rock. One specimen revealed its former sedimentary origin by wavy, sub-parallel layers of rounded quartz grains. The original bedding has been destroyed but a variation in color and texture shows its approximate former position. The individual laminae range from one to eight millimeters in thickness. This is readily observed in cross sections by the distinctive iron oxide film distributed along the bedding surface.

One thin section revealed the rock to consist of 95 per cent quartz. For the most part the quartz grains were equant, anhedral grains averaging 0.1 to 0.2 millimeters in diameter but grains exceeding two millimeters in diameter were distributed throughout the rock. The articulation of the grains was variable with both mutual contacts and highly embayed sutured contacts present. Most of the grains appeared to have overgrowths which were incorporated into the individual grain during metamorphism.

The rock contained a small amount of feldspars. All the feldspars observed displayed excellent twinning. Microcline and oligoclase grains average 0.2 to 0.3 millimeters in diameter. A few chert or cryptocrystalline quartz grains reached 0.1 millimeters in diameter.

One other quartzite was examined microscopically. This rock contained 97 to 99 per cent quartz, excluding the clay content. The individual quartz grains were not unusual in any respect. The grains had low first order color, good extinction. Quartz grains ranged in size from 0.3 to 1.1 millimeters in diameter with an average of 0.5 millimeters in diameter.

The unusual aspect of the quartzite rested upon the clay content. Throughout the thin section of the rock the content varied from 15 to 35 per cent clay. The clay usually formed a patchy, porous network throughout the rock. The quartz displays no preference in its mode of replacement, and the clay, as often as not, transects the center of a grain rather than following the contact of the grains (Fig. 16). Euhedral

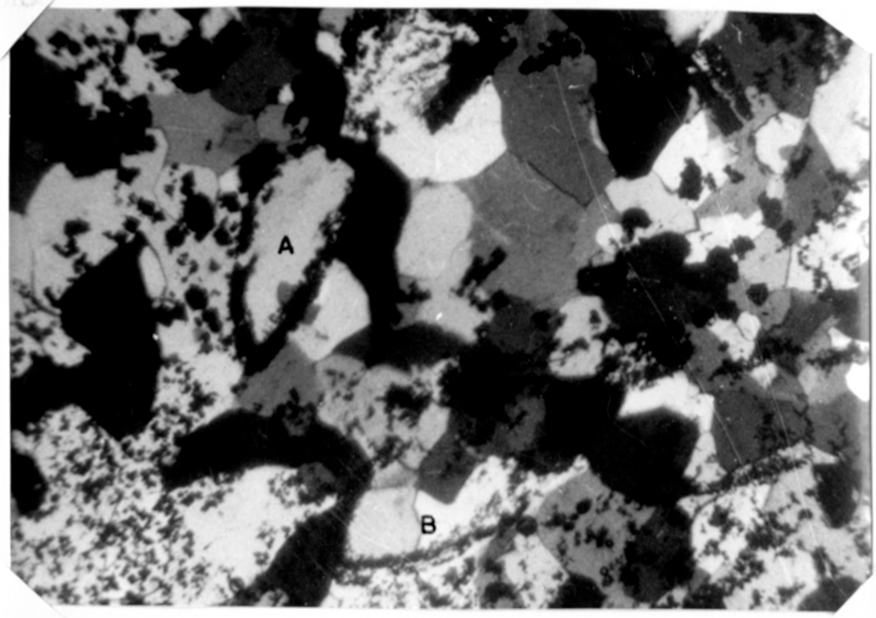

Fig. 16. Unusually high clay content in quartzite. A. Replacement along contact of grain. B. Replacement cutting across grains. Cross nicols. X25.

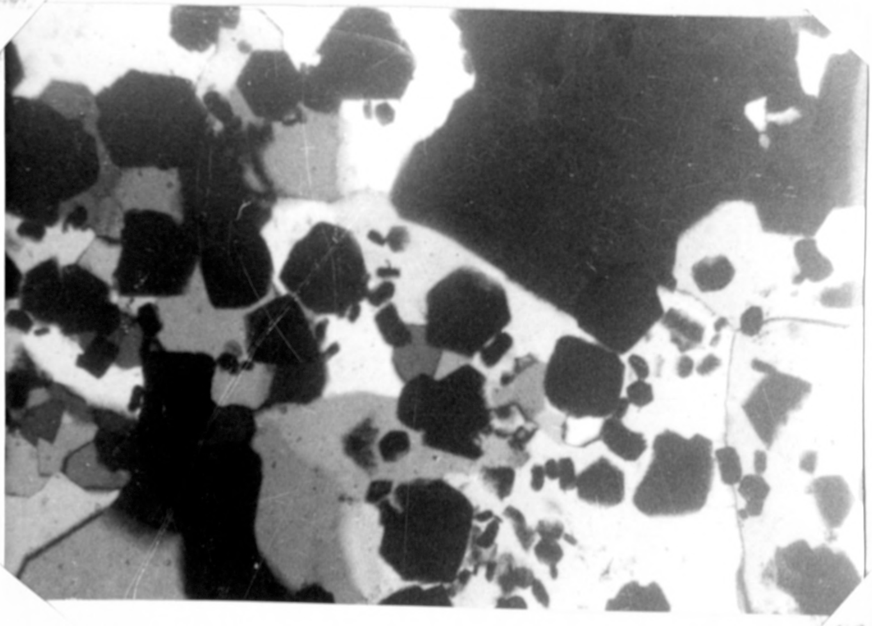

Fig. 17. Euhedral and subhedral crystals of dickite replacing quartz in quartzite. Cross nicols. X80.

dickite crystals, approximately 0.1 to 0.2 millimeters in diameter, followed a rather sinuous pattern suggesting a fracture or vein filling. These crystals are cubic, rectangular, or hexagonal in shape and are relatively isolated to limited sections of the rock (Fig. 17).

Less than one per cent of the rock is composed of both altered and unaltered biotite. The unaltered grains are pleochroic in greens and prismatic in shape.

Chert. Chert boulders of varying sizes and shapes are associated with the granite boulders. Several of the larger chert boulders exceeded a foot in length and eight inches in diameter. The rock is extremely dense and is mottled in colors of black, gray and white. White, cloudy patches and veins form an intricate network throughout the rock.

The chert has been brecciated into fragments of various sizes and these fragments have been cemented together by a dark brown aggregate of sand and silt size grains. The cementing material gives the appearance of having flowed into the voids as the larger detrital quartz grains form sinuous layers with sub-parallellism. It is this cementing material that is the most interesting part of the chert. It is extremely hard and well indurated. When the boulders were broken the fractures showed no preference for the cementing material but cut across both chert fragments and the cementing aggregate. The material filling the voids between the chert fragments bears a strong resemblance to several quartzites found in the area.

Microscopically, the rock is a typical chert composed of cryptocrystalline quartz. Occasionally individual grains attain sizes of 0.05 millimeters in diameter. The veins between or traversing the chert fragments are rich in chlorite. The fine groundmass encloses shattered, prismatic quartz grains which display a subparallellism to the vein walls. Still other quartz grains may be rounded or equant ranging in size from 0.05 to 0.8 millimeters in diameter. Vein quartz commonly forms a thin veinlet between the chert fragment and the cementing material.

PETROLOGY

The Woodson County intrusive, represented by granitic boulders resting in the Weston shale at the crest of the Rose dome, was formed by a series of multiple injections at depths along a zone of weakness. The series of late magmatic injections were individually and/or collectively altered by post-magmatic and hydrothermal activity. Weathering was the last process to affect the rocks. The character of the parent magma from which the granitic rocks have been derived may be the product of magmatic differentiation due to fractional crystallization. The possibilities existing for the composition of the parent magma are:

1) a parent magma of granitic composition or
2) a parent magma with a composition ranging from that of an ultrabasic rock to one of a monzonitic rock.

The feasibility of these alternatives will be discussed later in respect to the regional relationship between the Rose dome intrusive and other igneous rocks reported in the area, both at the surface and at depth.

Petrologic inferences have been drawn from petrographic examination of the rocks and from observation made in the field of the relationship between the boulders. Because of the lack of true outcrops of igneous rocks and their contact with the enclosing wall rock a portion of this petrology will be subject to speculation and a certain amount of conjecture will necessarily be introduced. Where concrete evidence is lacking, reference will be made to geologic situations where the normal sequence of events is well understood.

In the initial stages preceeding the first injection of the granitic material, normal crystallization took place in a magma rich in potassium, sodium, silica and some calcium. Large crystals of orthoclase, microcline, oligoclase and quartz developed (Figs. 2 and 10). As crystallization continued, the residual liquid became richer in free silica, soda and water. Vapor pressure increased rapidly in this stage. The partially crystallized melt was then forced upward and injected into the country rock to its approximate present position. In this first stage of intrusion, the medium to coarse-grained and pegmatic rocks formed. A slight decrease in grain size at the contact. The heat present in the melt then "baked" the shales at this point for a distance of 12 to 18 inches from the contact.

The residual liquid then permeated the coarse-grained rocks with notable effects. Orthoclase and microcline phenocrysts were highly albitized and much of their former structure destroyed (Fig. 2). Next followed a high temperature hydrothermal or deuteric stage in which silica-rich solutions altered and partially replaced the crystallized feldspars (Fig. 11).

An aplitic or fine-grained stage of small magnitude resulted from the second injection of silicate melt. This intrusion was the result of tremendous pressures forcefully thrusting an uncrystallized mass along fractures into the previously intruded coarser-grained rocks. The uncrystallized melt, injected with no systematic order or pattern, cooled rapidly with the resulting aplitic texture. Release of pressure at the time of intrusion resulted in the loss of volatiles. Water, therefore, was not available as a transporting agent for soda and consequently, the effects of albitization are not apparent in this stage.

Continued crystallization at depth preceeded the third recognizable injection of igneous material. As crystallization proceeded in an essentially closed chamber, the temperature decreased and a corresponding increase in pressure developed. Release for the pressure was found in the tremendous injection of a medium-grained stage (Fig. 12). Many of the early formed crystals were broken and shattered. Flow structure is well developed at this stage. Temperatures may have fluctuated at this point and many of the feldspars were partially resorbed and rounded (Fig. 3). Albite rims were well developed in the phenocrysts of this stage.

Post-magmatic activity followed the third stage of intrusion. Residual liquids, rich in silica and soda, moved along interstices throughout the composite body formed by multiple injections of silicate melt and crystallized in a eutectic mixture. Crystallization of this mixture in open spaces developed parallel or radiating intergrowths of quartz and feldspar (Fig. 7). Vugs may have been left between the intergrowths which grew from either side of a vein or veinlet.

The eutectic mixture developed a very fine-grained groundmass throughout much of the rock. Earlier formed minerals were resorbed or destroyed. Metasomatic replacement of the feldspar phenocrysts resulted in corroded anhedral masses. Coincident with, or slightly later than this stage was the filling of fractures and vugs with vein quartz. Blebs of quartz were disseminated throughout feldspar phenocrysts along cleavage planes.

Hydrothermal activity marked the final stages of igneous activity in the Rose dome area. Petrographic examination indicates that, during this silica-rich phase, previously emplaced feldspars may have been replaced by quartz (Fig. 14). The presence of abundant chalcedony (Fig. 15) probably indicates the dying phase of the final stages. It may have been at this time that silicification of the shales and sandstone took place. Quartzites and cherts were formed from the former sedimentary rocks. Pyrite was probably the last mineral introduced into the rock.

The parent magma for the Rose dome intrusive was probably dioritic in nature. The granite found at the Rose dome was the end product of magmatic differentiation. The igneous and metamorphic activity found at the Silver City dome is probably directly related to the same parent magma responsible for the Rose dome intrusive - the only difference being the contrast in composition of the rocks found in the two areas. The basic rocks at the Silver City dome are the result of gravitative settling while the acid rocks at the Rose dome are from a residual magma derived by fractional crystallization. The basic rocks reported at considerable depths from wells in nearby areas are probably sills of basic material injected between strata similar to the occurrence of the rocks at Silver City.

The intrusion at the Rose dome was probably of a passive nature with very little arching or doming. As Lee (1939) has noted, thinning of the Mississippian rocks at the Rose dome indicates doming in this area preceeded the emplacement of the granite intrusive.

ACKNOWLEDGMENTS

The author wishes to express his gratitude to Mr. H. D. Pilkington for his unselfish contribution of time and effort towards the completion of every aspect of this thesis. Thanks are also due to William Grossnickle for his aid in the field and in the preparation of this thesis and to my wife, Betty for her tireless efforts in the numerous typings required to complete the thesis.

The author also wishes to express his thanks to Dr. J. R. Chelikowsky and the staff of the Department of Geology at Kansas State University for the use of the laboratory facilities.

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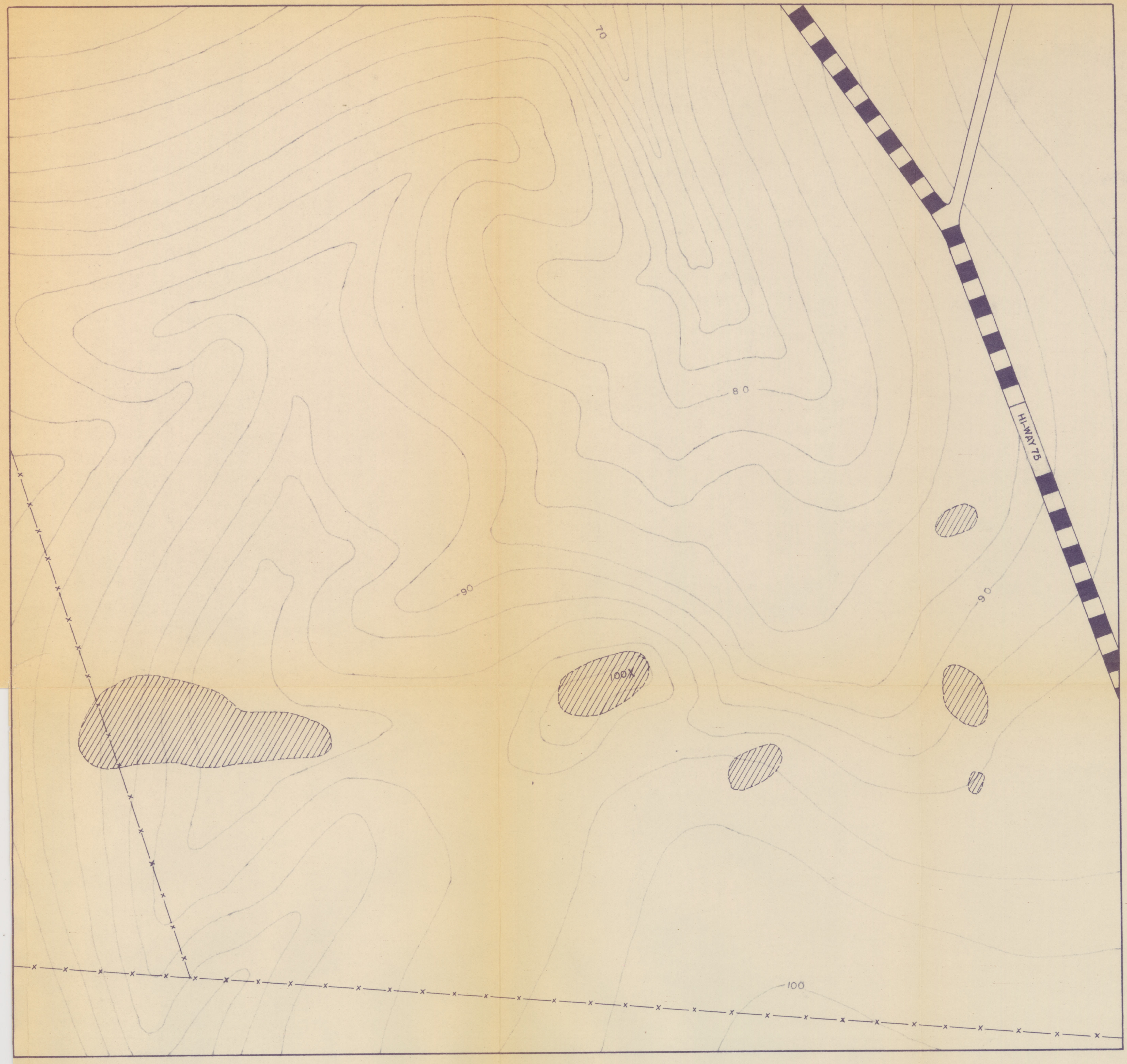
TOPOGRAPHIC MAP OF ROSE DOME INTRUSIVE

WOODSON COUNTY, KANSAS



SCALE 1:1200

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CONTOUR INTERVAL 2 FEET

LEGEND

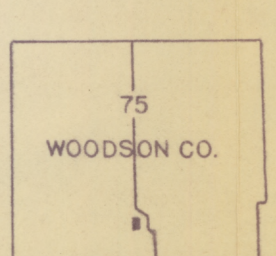
GRANITE BOULDERS

FENCE

ROADS

HEAVY DUTY

IMPROVED DIRT



INDEX MAP

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MAPPED BY L.H. SLEEMAN AND
ASSOCIATE, W.E. GROSSNICKLE
MAY 27, 1959

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PETROGRAPHY AND PETROLOGY OF THE IGNEOUS INTRUSIVE IN WOODSON COUNTY, KANSAS

by

LYLE HERMAN SLEEMAN, JR.

B. S., University of Illinois, 1958

AN ABSTRACT

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Geology and Geography

KANSAS STATE UNIVERSITY
OF AGRICULTURE AND APPLIED SCIENCE

1959

The granite boulders resting on the Weston shale near the crest of the Rose dome, Woodson County, Kansas, represent a surface reflection of the only known outcropping acid igneous rocks in Kansas. It is the purpose of this thesis to describe the granitic rocks; the effect the intrusion has had upon the enclosing host rocks; and conditions which prevailed in the parent magma at the time of intrusion.

Field and laboratory studies were undertaken to obtain the desired information. Hand specimens and thin sections of the rocks were examined megascopically and microscopically with the aid of a petrographic microscope.

W. H. Twenhofel previously examined the boulders at the Rose dome as early as 1915. Because of the absence of a granitic body immediately below the boulders, and at that time, the lack of evidence of metamorphism, Twenhofel believed the boulders to have been ice-rafted. Later findings of metamorphism and the granite-shale contact caused the acceptance of an igneous theory for the origin of the intrusive.

The surface reflections of the intrusive indicate that the body is dike-like in nature, being greatly elongated in an east-west direction. The intrusive was formed by a series of multiple injections of which the first was a coarse-grained stage. This was subsequently followed by an aplitic stage, then a medium-grained stage, and finally a major post-magmatic hydrothermal stage which introduced fine intergrowths of quartz and albite, chalcedony, and pyrite. The enclosing shales were "baked" during the first intrusion then later silicified in the final stages.

The parent magma for the Rose dome intrusive was dioritic in nature. Gravitative settling and normal fractional crystallization gave rise to the basic rocks found at depth and at the Silver City dome and to the granite at the Rose dome, respectively.