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The Geology of the South Mountain Area, Bernalillo, Sandoval, and Santa Fe Counties, New Mexico

Tommy B. Thompson

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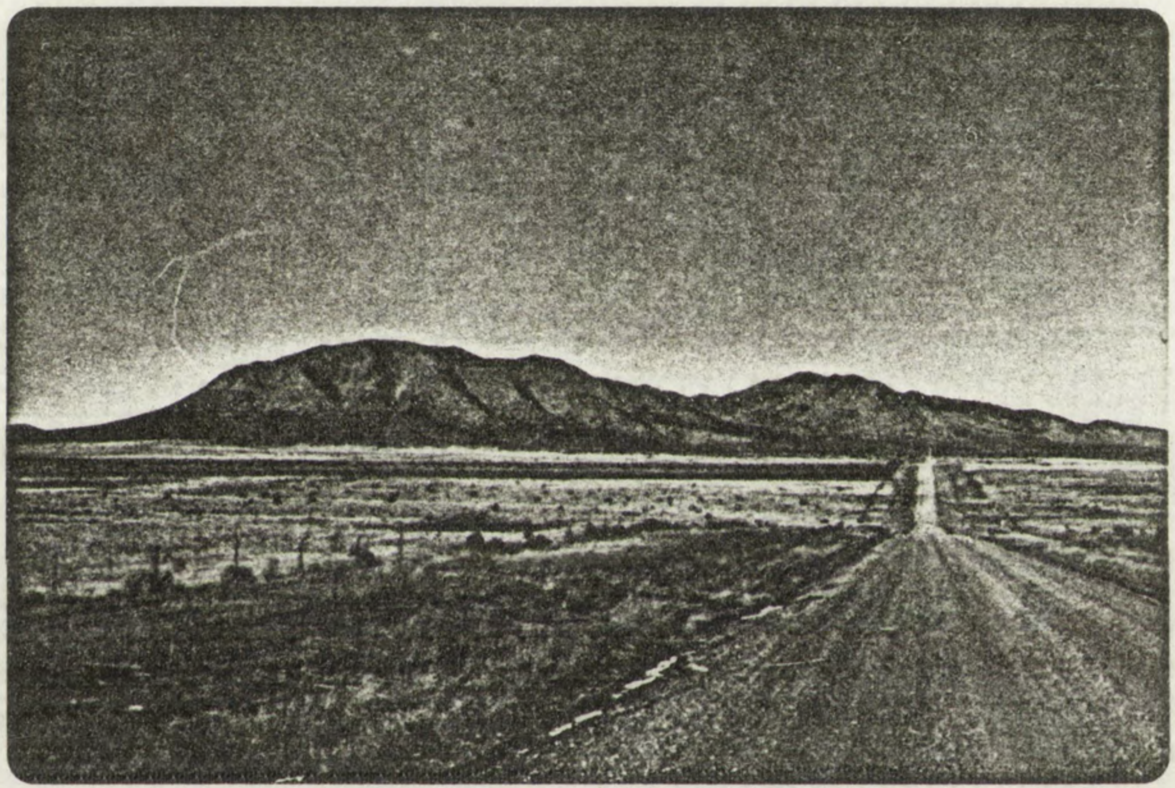

South Mountain from State Road 344. View north.

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THE GEOLOGY OF THE SOUTH MOUNTAIN AREA, BERNALILLO, SANDOVAL, AND SANTA FE COUNTIES, NEW MEXICO

By

Tommy B. Thompson

A Thesis

Submitted in Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Geology

The University of New Mexico

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MASTER OF SCIENCE

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Dean

May 28, 1963
Date

Thesis committee

Vincent C. Kelley
Chairman

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Wolfgang E. Elston

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ABSTRACT

South Mountain is approximately 30 miles northeast of Albuquerque in the southern end of the San Pedro-Ortiz porphyry belt. It is a Tertiary monzonite laccolith that intrudes the Permian Abo and Yeso Formations and, in places, the Permian Glorieta Sandstone. The base of the laccolith lies on the Abo except in the southeastern part where it overlies the Meseta Blanca Member of the Yeso. The incompetence of the Yeso appears to have allowed the monzonitic magma to spread laterally throughout the stratigraphic interval up to the Glorieta Sandstone which was more resistant and broken only locally by the intrusion. The Yeso was apparently shoved aside by magmatic forces and, at the same time, added to the doming of overlying sediments caused by the intrusion. The Abo and underlying formations were folded into a basin apparently by the intrusion. In the southwestern part of the laccolith a small circular quartz monzonite stock intruded the monzonite with little shattering or brecciation along the contact. This seems to indicate that crystallization of the monzonite had not been completed.

Northwest of South Mountain a latite-andesite porphyry laccolith intruded the Pennsylvanian Sandia Formation. It overlies a conglomerate at the base of the Sandia Formation and is overlain by massive limestone of the Madera Limestone.

North of South Mountain a series of rhyolite sills intrude the Madera Limestone. The sills can be traced to the San Pedro Mountains. The feeder for the sills appears to be a dike around which there is zoning of mineral deposits.

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There appear to be at least two periods of faulting: 1) contemporaneous with intrusion, and 2) post-intrusion. The dominant trend of faulting is to the northeast while minor trends are northwesterly and easterly. Most of the faults belong to the Tijeras fault system which is of regional extent.

Mineral deposits include: 1) a small contact-metasomatic magnetite deposit, 2) many small supergene iron deposits, 3) a fissure vein of magnetite-specularite, and 4) a fissure vein of galena, sphalerite, chalcopyrite, and pyrite. These deposits are small and not economically important. Ground water is usually available in the Madera Limestone or in Quaternary alluvium at a depth no greater than 200 feet.

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INTRODUCTION

Location and Accessibility

South Mountain lies in the southwestern corner of Santa Fe County, New Mexico, immediately south of the New Placers mining district (Fig. 5); the mapped area also includes parts of Bernalillo and Sandoval Counties. Included in the mapped area are secs. 2, 3, 4, 5, 8, 9, 10, 16, 17, T. 11 N., R. 7 E., secs. 28, 29, 32, 33, 34, 35, T. 12 N., R. 7 E., and the southeastern part of the San Pedro Grant.

South Mountain is 30 miles northeast of Albuquerque by paved road and 2 miles south of Golden. New Mexico State Road 10 is the northwestern boundary of the area. State Road 344 runs along the northern, eastern, and southeastern boundary of the area. There is access to the area through the San Pedro Grant, but much of the mapping required 2 to 3 miles of walking to gain access.

Topography and Drainage

South Mountain rises as much as 1,500 feet above the surrounding plains and has three peaks more than 8,500 feet elevation along a northeasterly trend. The mountain is dissected by many canyons which have extensive pediments where they open to the plains. Several topographic shoulders near the high peaks may be either remnants of former pediments or due to structural layering of the igneous body.

The northwestern part of the area is of lower relief and consists of north-trending parallel ridges dissected in a trellis pattern. South Mountain is at the southern end of the north-trending San Pedro-Ortiz porphyry belt (Pl. 4-A).

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[illegible]

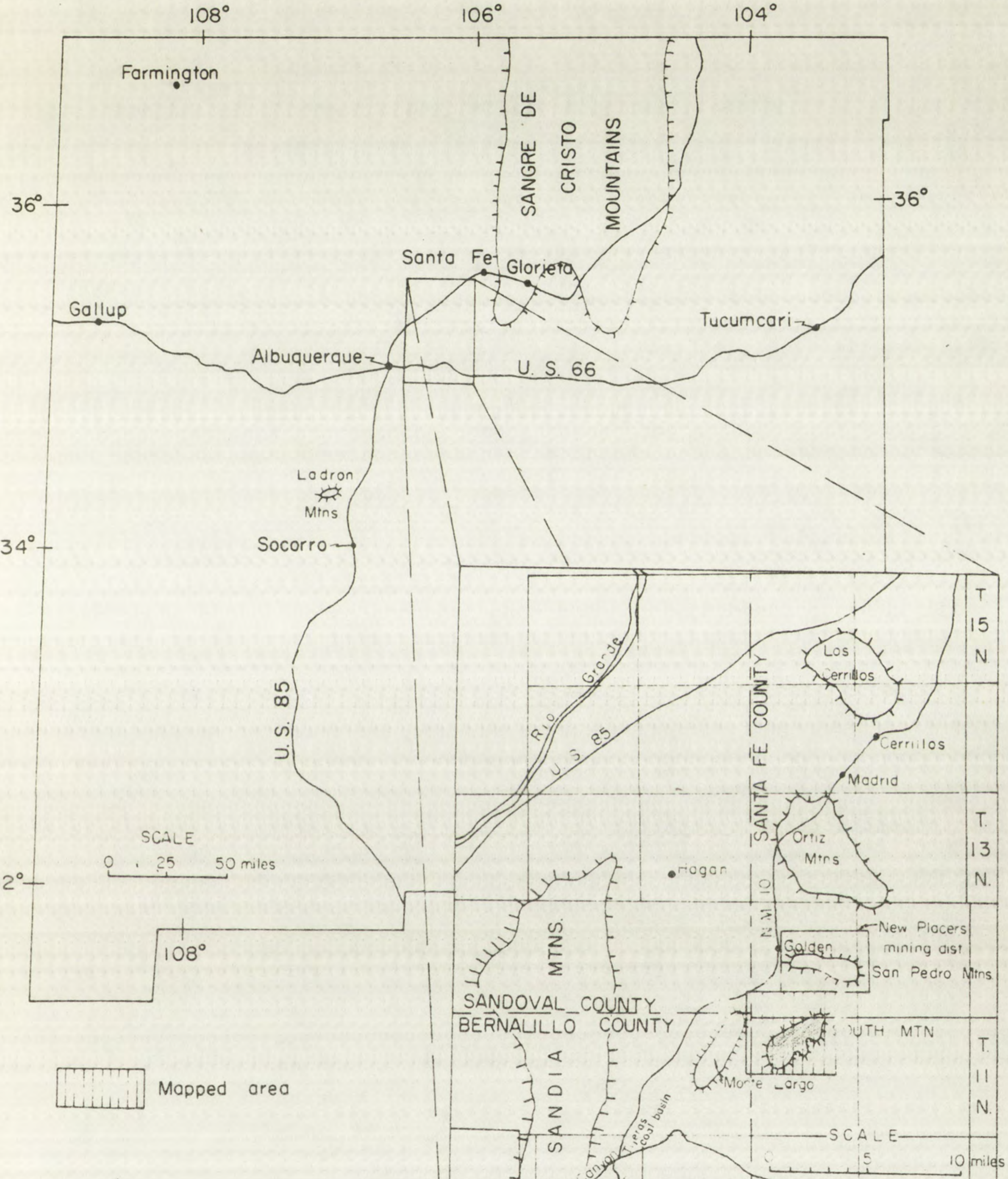

Figure 5. Index map showing South Mountain area.

Climate, Vegetation, and Animal Life

The climate of the area is semiarid with about 16 to 20 inches of precipitation annually. Most of the precipitation is derived from snow which covers the northern slopes from November to April and from thundershowers in early August. The temperature is seldom aobve 90°F. in the summer and may be as low as 10°F. during the winter for short intervals.

The mountain is thickly covered with juniper and pinon trees, but along the high ridges and northern slopes ponderosa pine is abundant. Oak brush grows profusely on the northern slopes and on the ridges in the northwestern part obscuring many outcrops. The southern slopes are less abundantly vegetated and prickly pear cactus is very common. There are spotty patches of thorny bushes in places.

Deer, bobcats, coyotes, porcupines, skunks, cottontails, rattlesnakes, pack rats, and field mice were noted during the field work.

Previous Investigations

In 1903 (p. 353) Yung and McCaffery illustrated South Mountain as a stock. They described the general areal geology, but there was no map. Johnson (1903, p. 457) in a study of the Cerrillos Hills briefly commented on the intrusive belt. An Oil and Gas Investigation Map (Read and others, 1944) provides the first geologic map of the area and subsequent investigations have come from field course mapping at the University of New Mexico (Stevenson and Hayes, 1948) and from the U. S. Geological Survey (Dane and Bachman, 1957).

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Two compilation maps have recently been published (Northrop and Hill, 1961, and Kottlowski and others, 1961) which show the mapped area. There have been numerous theses from students at the University of New Mexico that deal with adjacent areas (Emerick, 1950; Atkinson, 1961; Lambert, 1961). A New Mexico Bureau of Mines and Mineral Resources map by V. C. Kelley (1963) deals with the geology of the Sandia Mountains and vicinity. It is the most detailed work of South Mountain that is in print. Much of the San Pedro-Ortiz porphyry belt has been mapped in detail (Disbrow, 1957; McRae, 1958; Peterson, 1958; Atkinson, 1961), and South Mountain is one of the last remaining areas of the belt that has not been mapped in detail.

Present Investigation

The object of this study is to provide a detailed geologic map of the South Mountain area, interpret the geologic structure, and provide a petrographic study of the igneous rocks.

The mapping was done on aerial photographs at a scale of about 2.2 inches to the mile. This information was transferred to the U. S. Geological Survey topographic sheet of the San Pedro, New Mexico, quadrangle which has a scale of 1 inch equals 2,000 feet. Two small areas required detailed mapping and these were done by plane table surveys. Distortion on the aerial photographs required some preliminary radial line triangulation projections in order to locate accurately some critical points on the topographic sheet. This was accomplished by making overlays of each photograph on clear acetate showing the critical points. A tracing of the topographic base on clear acetate

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Approximately 200 rock specimens were collected from which 32 thin sections were made and studied. Eight polished sections were also made and studied to determine texture and paragenesis of the mineral deposits.

Acknowledgments

The author would like to thank Dr. Vincent C. Kelley for advice and suggestions on the field work as well as for critical reading of this report. Thanks are due to Dr. W. E. Elston and Dr. J. Paul Fitzsimmons for critical review of this report. William G. Gustafson assisted the author in the plane table surveys. Financial assistance for thin sections was provided by the New Mexico Geological Society. Permission by C. B. Read to use the projecting equipment of the U. S. Geological Survey proved invaluable in map compilation.

SEDIMENTARY ROCKS

Pennsylvanian System

Sandia Formation.

The Sandia Formation is subdivided into a Lower Limestone Member and an Upper Clastic Member. The Lower Limestone Member is now considered Mississippian in age (Noble, 1950, p. 37-44, and Montgomery and Sutherland, 1960, p. 6), and its occurrence closest to South Mountain is in Cedro Canyon (Szabo, 1953, p. 15) (Fig. 5, p. 4). In the vicinity of Ferryboat Hill the Upper Clastic was also made on the cores of each [illegible] photographed [illegible]. This photograph [illegible] were all taped to the back of the [illegible] with clear tape and [illegible] was easily [illegible].

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Member of the Sandia Formation nonconformably overlies Precambrian rocks. It consists of a basal conglomerate of 10 to 30 feet thick overlain by brown micaceous sandstone and siltstone. In the upper part the sandstone beds are less micaceous and intercalated with thin fossiliferous limestone. No sections were measured because the formation is disturbed by a Tertiary intrusion and by faulting. In cross section the Sandia Formation appears to have a thickness of approximately 670 feet. In the Golden area Emerick (1950, p. 17) considered the Sandia Formation to be only 5 feet thick, but this seems to be greatly in error. Along the crest of the Sandia Mountains the Sandia Formation ranges from 175 to 300 feet due to the irregularity of the erosional surface on which it lies (Catacosinos, 1962, p. 23). At the northern end of the Sandia uplift the Sandia Formation was subdivided by Harrison (1949, p. 21) into three members with a total thickness of 265 feet. In the southern Ladron Mountains the Sandia Formation varies from 402 to 642 feet (Noble, 1950, p. 49-53). These thicknesses refer to the Upper Clastic Member and it is apparent how irregular the Precambrian terrain was in Pennsylvanian time although some of this may be due to inconsistent choosing of the upper contact due to rapid lateral variations.

The contact between the Sandia Formation and the overlying Madera Limestone was chosen arbitrarily at the base of the lowermost limestone cliff of a series of massive limestone cliffs. The Sandia Formation is primarily a slope former.

Madera Limestone.

A complete section of the Madera Limestone is not present due to

faulting and Tertiary intrusive rocks. The Madera Limestone crops out in the northwestern part of the area and consists of massive- to thin-bedded gray, fossiliferous limestone with much intercalated gray-to-black shale. The limestone in places is rather cherty and one zone was noted in which silicified foraminifera occurred in gray to black chert. One unit of medium-grained brownish-gray sandstone with calcic cement was noted throughout much of the area and appeared to be a good marker bed.

To the northwest Harrison (1949, p. 33) measured 1,261 feet in the Madera Limestone whereas to the south in Cedro Canyon Szabo (1953, p. 55) found 1,026 feet.

Permian System

Abo Formation.

The Abo Formation crops out over much of the area, but a complete section is absent due to faulting and igneous intrusions. Normal contact between the Abo Formation and the underlying Madera Limestone is not present on the surface because faulting has placed them in juxtaposition.

The Abo Formation consists of reddish-brown to maroon sandstone, siltstone, and shale units that are extensively cross-bedded. Spherical (circular on the bedding plane) white spots due to reduction of iron by carbonaceous matter and subsequent leaching are abundant.

The Abo Formation is 900 feet thick in the Hagan coal basin (Harrison, 1949, p. 44), and in the San Pedro Mountains the thickness is believed to be approximately 975 feet (Atkinson, 1961, p. 6). The thickness in faulting and Tertiary intrusive rocks. The Madera Limestone crops out in the northwestern part of the area and consists of massive- to thin-bedded gray, fossiliferous limestone with much intercalated gray to black shale. The limestone in places is rather cherty and one zone was noted in which silicified foraminifera occurred in gray to black chert. One unit of medium-grained brownish-gray sandstone with calcite cement was noted throughout much of the area and appeared to be a good marker bed.

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Exposures of the Abo Formation and Madera Limestone on U. S. Highway 66 just south of the area show a transition from marine environment during the Pennsylvanian period to continental environment in the Permian period.

Yeso Formation.

The Permian Yeso Formation consists of two members, the lower Meseta Blanca Sandstone Member and the upper San Ysidro Member. Of these, only the Meseta Blanca Sandstone Member is fully exposed in the mapped area, and it is present only in the southern and southeastern parts. The upper member is limestone, in some places overlain by a shale. The thickness of the upper member in the South Mountain area is never greater than 10 feet.

The Meseta Blanca Sandstone Member consists of massive, cross-bedded, coarse-grained, white-to brown sandstone beds which grade upward into thin, cross-bedded, reddish-brown sandstone and siltstone. The massive sandstone part of the Meseta Blanca Sandstone Member is 62 feet (Stevenson and Hayes, 1948, p. 12) while the thickness of the entire member present is probably 200 feet. It is possible that some of the San Ysidro member was mapped with the Meseta Blanca member. This is evident when the thickness of the Meseta Blanca is noted in cross section (Fig. 1).

In the San Pedro Mountains the entire Yeso Formation was found the South Mountain area [illegible]

1968, p. 11).

Exposures of the [illegible]

Highway 80 just south [illegible]

movement during the [illegible]

in the Permian period.

Earp Formation.

The Permian Earp [illegible]

[illegible] Sandstone [illegible]

Of these, only the [illegible]

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eastern parts. The [illegible]

overlain by a shale. The [illegible]

South Mountain area [illegible]

The [illegible]

bedded, coarse-grained [illegible]

upward into thin, [illegible]

slope. The [illegible]

Member is 82 feet [illegible]

thickness of the entire [illegible]

possible that [illegible]

[illegible]

[illegible]

In the [illegible]

graphically to be 400 feet thick (Atkinson, 1961, p. 6) and no massive sandstone unit was found.

The outcrop pattern of the massive sandstone unit indicates that it is a channel deposit which wedges out within one or two miles north and west of the thickest section. Alternatively, the wedging may have been produced by the overlying "nonconformable" intrusive (Fig. 1). Without this sandstone unit, the Meseta Blanca Sandstone Member would be almost indistinguishable from the reddish-brown sandstone, siltstone, and shale of the Abo Formation.

San Andres Formation.

The San Andres Formation consists of three members, the lower Glorieta Sandstone Member, the San Andres Limestone Member, and the upper San Andres Sandstone Member. All are present in the mapped area but they are incompletely exposed and repeated by faulting. The San Andres Formation crops out only in the northeastern part of the area.

The Glorieta is a gray siliceous quartzose sandstone, in places extensively epidotized. It is probably up to 100 feet thick in the South Mountain area but is less than 50 feet in many places owing to erosion. In the Hagan Basin Harrison (1949, p. 69) found 70 feet of Glorieta Sandstone of similar lithology.

The San Andres Limestone Member is gray limestone which weathers differentially to resemble a "worm-eaten" weathered surface. It was impossible to determine its thickness because contacts are obscure and faulting caused repetition of the section.

gradually to be 400 feet thick (Atkinson, 1962, p. 41) and no massive sandstone unit was found.

The outcrop pattern of the massive sandstone unit indicates that it is a channel deposit which wedges out within one or two miles north and west of the thickest section. Alternatively, the wedging may have been produced by the overlying "nonconformable" intrusive (Fig. 2). Without this sandstone unit, the Meseta Blanca Sandstone Member would be almost indistinguishable from the reddish-brown sandstone, siltstone, and shale of the Abo Formation.

San Andres Formation.

The San Andres Formation consists of three members, the lower Glorieta Sandstone Member, the San Andres Limestone Member, and the upper San Andres Sandstone Member. All are present in the mapped area but they are incompletely exposed and repeated by faulting. The San Andres Formation crops out only in the northeastern part of the area.

The Glorieta is a gray siliceous quartzose sandstone, in places extensively brecciated. It is probably 50 to 100 feet thick in the South Mountain area but is less than 50 feet in many places owing to erosion. In the Hagan Basin Harrison (1949, p. 49) found 70 feet of Glorieta Sandstone of similar lithology.

The San Andres Limestone Member is gray limestone which weathers differentially to resemble a "worm-eaten" weathered surface. It was impossible to determine its thickness because contacts are obscure and faulting caused repetition of the section.

The upper San Andres Sandstone Member is present in only a few places and is very incompletely exposed. Except for less cementing, it is very similar to the Glorieta Sandstone Member.

Harrison (1949, p. 69) found a total thickness of 257 feet for the San Andres Formation in the Hagan coal basin while Atkinson (1961, p. 7) graphically determined a thickness of about 200 feet in the San Pedro Mountains. This is probably of the same order of thickness as at South Mountain.

Quaternary Alluvium, Talus, and Landslide Debris.

Erosion of South Mountain has caused the accumulation of alluvium in arroyos, and along the southern and eastern parts of the area pediments have been formed. The alluvium is no thicker than 150 feet and consists of fragments derived from the igneous and sedimentary rocks.

Gravity, jointing, and, in places, shearing played the major roles in the formation of talus. The talus occurs on steep slopes of igneous rocks and generally does not occur very extensively below the igneous-sedimentary contact since the slopes are less inclined in sedimentary rocks. For this reason the talus in many places is a good guide to the contact between igneous and sedimentary rocks expecially along the southern flanks of the area.

Landslide debris consists almost entirely of Glorieta sandstone blocks which originally capped the igneous rocks. It was mapped as a separate unit in sec. 10, T. 11 N., R. 7 E. (Fig. 1). The blocks are as much as 6 to 8 feet in diameter.

The upper San Andres Sandstone Member is present in only a few areas and is incompletely exposed. Except for less cementing, it is very similar to the Glorieta Sandstone member.

The present [illegible] for the San Andres Formation in the Hagan coal basin [illegible] Albuquerque (1961, p. [illegible]) [illegible]

San Pedro Mountains. This is probably [illegible] order of [illegible] [illegible] South [illegible]

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IGNEOUS ROCKS

Precambrian Granite, Pegmatite, and Vein Quartz

Precambrian igneous rocks crop out only in the southwestern part of the South Mountain area. The igneous rocks are very minor and are dikes and sills enclosed in foliation planes of Precambrian metamorphic rocks. Time did not permit a detailed study of the granite, pegmatite, or vein quartz; however, in the Monte Largo Hills immediately to the west petrographic analyses have been made.

Lambert (1961, p. 58) indicated on the basis of "abraded" zircons, lenticularity of granite, and the control of the host rock on the granite that the granite was metasomatic in the Monte Largo Hills. On the other hand, the pegmatites represent the last stages of crystallization of a granitic magma. Quartz veins are either crosscutting or foliation-controlled and may be either igneous or metamorphic in origin (Lambert, 1961, p. 61). It is possible that the veins are hydrothermal in origin.

Tertiary Intrusive Rocks

Monzonite

Monzonite forms the main igneous mass of South Mountain. In hand specimen the monzonite is gray on fresh surfaces and brownish-gray on weathered surfaces. It is resistant to erosion and forms steep slopes (Fig. 1). Talus slides of monzonite are made up of angular blocks and, in some cases, concave-convex exfoliation plates. In most places there is no evident lineation of minerals except adjacent to xenoliths.

Microscopically, the monzonite contains mostly plagioclase, orthoclase, and dark-green hornblende. Accessory minerals include magnetite, ilmenite, hematite, apatite, and sphene. Often the hornblende is partly altered to chlorite and the feldspars epidotized or kaolinized. The quartz content is seldom more than 5 percent; feldspars account for 80-85 percent and hornblende up to 15 percent. The plagioclase content varies from one to three times that of the orthoclase. The average plagioclase composition is An_{36} although cores of zoned crystals are as calcic as An_{57} (see Appendix).

Plagioclase occurs as roughly equidimensional, euhedral crystals while the orthoclase is intersertal, anhedral, and smaller in size. Twinning and normal and oscillatory zoning are quite common in the plagioclase, and calcic cores of zoned crystals are usually saussuritized.

The ferromagnesian minerals are usually intersertal although sometimes completely enclosed in the plagioclase. Hornblende is usually in elongate, ragged, anhedral grains, but apatite and sphene are subhedral to euhedral. Magnetite is anhedral to euhedral and usually is intergrown with ilmenite. Locally, the magnetite-ilmenite content is as great as 8 percent. Hand specimens from locality SM-26 (Fig. 2) passed slowly within 2 inches of a magnet will cause the magnet to jump to them. There seems to be no set pattern for the extent of these high-percentage magnetite zones.

Xenoliths are common and are almost exclusively dark-green, elongate to equidimensional hornblende aggregates up to 4 inches long. Most of the monzonitic rocks of the Colorado Plateau and adjacent areas including the San Pedro-Ortiz porphyry belt contain

Macroscopically, the [illegible] porphyry [illegible]

sizes, and dark-green hornblende. Accessory minerals [illegible]

ilmenite, hematite, apatite, and zircon. Often the [illegible]

partly altered to chlorite and the plagioclase sericitized [illegible]

The quartz content is seldom more than [illegible]

[illegible] percent and hornblende up to 15 percent. The plagioclase

content varies from one to three times that of K-feldspar. The

average [illegible] composition is [illegible] although some [illegible]

[illegible] are as calcic as [illegible] (see Appendix).

Plagioclase occurs as equidimensional euhedral crystals

while the orthoclase is interstitial, anhedral, and smaller in size.

Twinning and normal and oscillatory zoning are quite common in the

plagioclase, and [illegible] of zoned crystals are usually [illegible]

The ferromagnesian minerals are usually interstitial although some

occur completely enclosed in the plagioclase. Hornblende is usually

elongate, ragged, anhedral grains, but apatite and sphene are subhedral

to euhedral. Magnetite is subhedral to euhedral and usually is inter-

grown with ilmenite. Locally, the magnetite-ilmenite content is as

great as 6 percent. Hand specimens from locality [illegible] (Fig. 2)

passed slowly within 2 inches of a magnet will cause the magnet to

jump to them. There seems to be no set pattern to the extent of

these high-percentage magnetite zones.

Xenoliths are common and are almost exclusively dark-green,

elongate to equidimensional hornblende aggregates up to 4 inches

long. Most of the [illegible] of the [illegible]

[illegible]

this type of xenolith and it has been postulated that they were derived from: 1) segregations of mafic constituents formed either in the feeder pipes or magma reservoirs, 2) fragments of wall rock which reacted with the magma to produce minerals in equilibrium with the magma, or 3) derived from earlier intrusive differentiates of the magma (Hunt, 1953, p. 160). At South Mountain the hornblende xenoliths have the same optical properties as the smaller hornblende grains found throughout the monzonite; however, reaction rims around the xenoliths indicate disequilibrium with the magma while the small grains appear to be crystallization products of the magma. There are small intergrowths of zoned plagioclase in the xenoliths with a composition range of An_{49} to An_{57}. This is slightly more calcic than the plagioclase of the monzonite, but it indicates that the xenoliths possibly are segregations formed in the magma chamber.

Slight metamorphism of overlying and underlying sediments indicates that the temperature of formation of the monzonite was relatively low. In the Henry Mountains the temperature of formation was determined by duplicating the degree of coal metamorphism and shale metamorphism in the laboratory, which indicated a temperature of formation of approximately 600° C. (Hunt, 1953, p. 165).

At SM-27 (Fig. 2) the monzonite is strongly altered hydrothermally in a four-foot-wide zone to a leucomonzonite in which all the hornblende is chloritized and the feldspars are kaolinized. The original hornblende content was unusally low in comparison with the normal monzonite of South Mountain (see Appendix). The this type of xenolith and it has been postulated that they were derived from: 1) segregations of mafic constituents formed either in the magma chamber or a magma reservoir, 2) fragments of wall rocks which reacted with the magma to produce minerals in equilibrium with the magma, or 3) derived from earlier intrusive differentiates of the magmas (Hunt, 1953, p. 160). At South Mountain the hornblende xenoliths have the same optical properties as the smaller hornblende grains found throughout the monzonite; however, reaction rims around the xenoliths indicate disequilibrium with the magma, while the small grains appear to be crystallization products of the magma. There are small intergrowths of zoned plagioclase in the xenoliths with a composition range of An_{35} to An_{45}, which is slightly more calcic than the plagioclase of the monzonite, but it indicates that the xenoliths possibly are segregations formed in the magma chamber.

Slight metamorphism of overlying and underlying sediments indicates that the temperature of formation of the monzonite was relatively low. In the Henry Mountains the temperature of formation was determined by duplicating the degree of coal metamorphism and shale metamorphism in the laboratory, which indicated a temperature of formation of approximately 500° C. (Hunt, 1953, p. 165).

At SM-2T (Fig. 6) the monzonite is strongly altered hydrothermally in a 100-foot-wide zone to a leucomonzonite in which all the hornblende is chloritized and the feldspars are kaolinized. The original hornblende content was [illegible], but in comparison with the normal monzonite of South Mountain (see Assay [illegible]), the feldspars show replacement by kaolin along crystallographic axes giving rise to a grid-like texture.

The monzonite shown in Figure 3 is extensively saussuritized due to hydrothermal action, and some of the magnetite shows hematite rims. At SM-21 (Fig. 4) the rock is leucocratic and is herein called a leucomonzonite. The mafic minerals constitute approximately 10 percent of the total rock (see Appendix). There are no hornblende or quartz crystals, and lath-shaped feldspars, apatite, sphene, magnetite, hematite, and chlorite are the rock constituents. The entire rock is saussuritized and shows an abrupt contact with the monzonite to the west and with the Glorieta Sandstone to the east. The leucomonzonite represents hydrothermal alteration in which the hornblendes were chloritized and the feldspars kaolinized. The original hornblende content appears to have been low. It appears that the leucomonzonite represents one of the early crusts (Fig. 9) in the crystallization of the monzonitic magma and that with injection of more magma, the crust and its overlying domed beds were tipped on end. This relationship will be discussed more fully under structure. With the sharp contact between the later monzonite and the leucomonzonite there is more evidence of a low-temperature magma of low stoping and assimilating power.

In Figure 4 the monzonite is in contact with Precambrian metamorphic rocks and there is a definite chill zone in the monzonite and with lineation of hornblende crystals. The chill zone is 6 inches wide in the monzonite and the crystals grade from 1/8 mm. to the feldspars [illegible] kaolin along crystallographic direc- tions giving rise to a grid-like texture.

The monzonite shown in Figure 3 is extensively saussuritized due to hydrothermal action, and some of the magnetite shows [illegible] rims. At SX-39 (Fig. 3) the rock is leucocratic and is herein called a leucomonzonite. The mafic minerals constitute approximately 15 percent of the total rock (see Appendix). There are no [illegible] quartz crystals, and lath-shaped feldspars; apatite, sphene, magne- tite, hematite, and chlorite are the rock constituents. The entire rock is [illegible] and [illegible] at its [illegible] contact with the monzonite to the west and with the Clarissa Sandstone to the east. The leuco- monzonite represents hydrothermal alteration in which the hornblende were chloritized and the feldspars sericitized. The original hornblende content appears to have been low. It appears that the leucomonzonite represents one of the early crusts (Fig. 9) in the crystallization of monzonitic magmas and that with injection of more magma, the crust and its overlying domed beds were lifted on end. This relationship will be discussed more fully under Structure. With the sharp contact between the later monzonite and the leucomonzonite there is more evidence of a low-temperature magma of low stoping and assimi- lating power.

In Figure 4 the monzonite is in contact with Precambrian meta- morphic rocks and there is a definite chill zone in the monzonite and with lineation of hornblende crystals. The chill zone is 3 inches wide in the monzonite and the crystals grade from 1/8 inch to [illegible] normal grain size of 1/2 mm. Immediately adjacent to large xenoliths of Precambrian rocks the hornblende content of the monzonite is high, and because of the lineation the rock appears gneissic. This is only a narrow two- to three-inch zone. The quartz content is as great as 20 percent in the contact zone and is probably derived from high-quartz metamorphic rocks or from late-stage emanations from the magma chamber. The blocks of Precambrian rocks are up to 170 feet in length and required a very viscous and forceful magma to float them upward.

Locally, the monzonite is miarolitic with small quartz crystals in the vugs coated by limonite; however, no definite pattern or areal extent could be distinguished.

Quartz Monzonite.

Quartz monzonite is identical mineralogically with the monzonite except that it contains round, anhedral quartz phenocrysts up to 1/4 inch in diameter. On weathered rock surfaces quartz phenocrysts appear as white "eyes" in the gray matrix. Hornblende is somewhat different in color from that of the monzonite, being light-green to brownish-green in thin section.

The quartz monzonite is exposed on a nearly level surface in the southern end of South Mountain (Fig. 1). Because of soil, vegetation, and float the contact between the monzonite and the quartz monzonite is difficult to trace. There are structural features which indicate the contact and these are discussed below. No flow structure is evident in the field or in thin sections of the quartz monzonite. The quartz monzonite is definitely later than the monzonite although there probably was not much lapse of time between the two phases. No stoping of the monzonite is evident and large hornblende xenoliths are present in the quartz monzonite.

The plagioclase is slightly more sodic than that of the monzonite with the average of An_{32}; however, calcic cores of zoned crystals are as calcic as An_{37}. The orthoclase to plagioclase ratio varies from 1:1 to 1:2. Quartz makes up as much as 15-17 percent of the rock with the feldspars contributing 70-75 percent and hornblende up to 15 percent. The texture is very similar to that of the monzonite except for the quartz phenocrysts (see Appendix).

Latite-Andesite Porphyry.

In hand specimen and under the microscope the latite-andesite porphyry is seen to contain white to greenish-gray feldspar phenocrysts which appear to be stained by kaolin. The phenocrysts are in a green, fine-grained groundmass of feldspars and ferromagnesian minerals. The latite-andesite porphyry is exposed along the western part of the South Mountain area (Fig. 3). On aerial photos this rock type is distinguished by the dendritic drainage patterns as compared with the trellis drainage pattern of the Madera Limestone. It is principally a slope former.

Under the microscope the feldspars are seen to be replaced largely by epidote and kaolin, and because of the saussuritization plagioclase compositions were indeterminate. Of the accessory minerals magnetite is commonly euhedral and commonly contains apatite inclusions. The apatite is anhedral and constitutes as much as 2 percent of the rock mass. Practically no quartz is present but when present it constitutes less than 1 percent.

Microscopically, the groundmass is very fine grained, like a salt and pepper texture, and consists of hornblende, plagioclase, and accessory minerals (Pl. 2-C). Hornblende is usually equigranular although some elongate crystals up to 3 mm were observed. A marked feature of this rock is the complete saussuritization.

Plagioclase phenocrysts constitute 10-15 percent of the rock with the remaining 85-90 percent made up of groundmass and occasional phenocrysts of magnetite and hornblende.

Rhyolite.

Hand specimens of rhyolite appear white to light gray on a fresh surface but on a weathered surface they are brownish gray. Phenocrysts of quartz, orthoclase, and magnetite are apparent. The rhyolite crops out in the north-central part of the area in the form of sills in the Madera Limestone. It is moderately resistant to erosion, forms steep slopes, and weathers to angular fragments.

Under the microscope, the quartz phenocrysts appear rounded and slightly corroded (Pl. 2-B), and the orthoclase phenocrysts are partly to completely kaolinized. The groundmass is all crystalline though very fine grained, and the rock could be classified as a nevadite (Moorhouse, 1959, p. 210). It consists of quartz, orthoclase, is colorless, subhedral and corroded, contains sparse inclusions of mag- apatite is anhedral and constitutes as much as 1 percent of the rock- mass. Paramorphic magnetite is present but when present it constitutes less than 1 percent.

Macroscopically, the groundmass is very fine grained and has a salt- and-pepper texture, and consists of sanidine, plagioclase, and access- ory apatite (Pl. 2-C). Hornblende usually occurs as [illegible] some elongate crystals up to 3mm were observed. [illegible] marked feature of this rock is the complete saussuritization.

Plagioclase phenocrysts constitute 10-15 percent of the rock with the remaining 85-90 percent made up of groundmass and occasional phenocrysts of magnetite and hornblende.

Rhyolite.

Hand specimens of rhyolite appear white to light gray on a fresh surface but on a weathered surface they are brownish gray. Pheno- crysts of quartz, orthoclase, and magnetite are apparent. The rhyo- lite crops out in the north-central part of the area in the form of sills in the Madera Limestone. It is moderately resistant to erosion, forms steep slopes, and weathers to angular fragments.

Under the microscope, the quartz phenocrysts appear rounded and slightly corroded (Pl. 2-D), and the orthoclase phenocrysts are partly to completely kaolinized. The groundmass is [illegible] very fine grained, and the rock could be classified as a porphyry (Moorhouse, 1959, p. 210). It consists of [illegible] magnetite, and some hornblende. Occasional elongate leucoxene phenocrysts are associated with the magnetite from which it was derived. The quartz content is as high as 20 percent with orthoclase, plagioclase, hornblende, and magnetite comprising most of the remainder. Orthoclase dominates completely over the rest of the mineral constituents. There is some epidote alteration of feldspars and hematite alteration of magnetite, but the rock is exceptionally unaltered when compared with most of the other igneous rocks in the South Mountain area.

Summary of Igneous Rock Types and Age Relationships in the San Pedro-Ortiz Porphyry Belt.

In 1903 (p. 353) Yung and McCaffery described the rocks of the South, Tuertos (San Pedro), and Ortiz Mountains as syenite porphyries, and Lindgren (1910, p. 36) noted that the rocks in the San Pedro-Ortiz porphyry belt become more acidic to the south. Detailed studies since these early workers have given a truer picture. The rocks become comparatively more sodic and show a decrease in pyroxene content to the south. For any individual intrusive complex along the porphyry belt differentiation produces much the same effect.

Most of the rocks in the San Pedro-Ortiz porphyry belt are saturated although in one stage in the Ortiz Mountains, nepheline is quite abundant (McRae, 1958, p. 48). The last stages of igneous rocks at South Mountain and in the Ortiz Mountains show moderate quartz content.

At South Mountain only monzonite and quartz monzonite are magnetite, and [illegible] occasional [illegible]

phenocrysts are associated with the magnetic [illegible]

deposits. The quartz content is as high as [illegible] percent [illegible]

clase, plagioclase, hornblende, and magnetite [illegible]

the remainder. Orthoclase constitutes completely [illegible]

[illegible]

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rocks in the South Mountain area.

Summary of Igneous Rock Types and Age Relationships in the San Pedro-Ortiz Porphyry Belt

In 1905 (p. [illegible]) Yung and McCaffery described the rocks of the South, Tuertos (San Pedro), and Ortiz Mountains as monzonite porphyries, and Lindgren (1910, p. 39) noted that the rocks in the San Pedro-Ortiz porphyry belt [illegible] to the [illegible]. Detailed studies since these early workers have given [illegible] time. The rocks become comparatively more [illegible] and show [illegible] decrease in pyroxene content to the south. For any individual intrusive complex along the porphyry belt [illegible] much the same effect.

Most of the rocks in the San Pedro-Ortiz porphyry belt are saturated alkali [illegible] Ortiz Mountains [illegible] is quite abundant (Lee, [illegible], p. [illegible]). The last stages of [illegible] dike rocks at South Mountain and in the Ortiz Mountains show moderate quartz contents.

At South Mountain early monzonite and [illegible] closely related. The quartz monzonite appears to be a differentiation product of the monzonitic magma (p. 18). The rhyolite can be traced to the San Pedro Mountains along the same stratigraphic horizon and for this reason it is believed to have had its origin there or from a nearby feeder pipe. The latite-andesite porphyry has been considered to be derived from the San Pedro area (Atkinson, 1961, p. 17), but to the author it appears to be a separate body unrelated either to the San Pedro or South Mountains.

A possible correlation of rock types is compiled on the following page. It has been assumed that the magma reservoirs in the entire San Pedro-Ortiz porphyry belt are closely related. The San Pedro Mountains appear to have had one of the earliest stages of igneous activity although Los Cerrillos and possibly the Ortiz Mountains had volcanic equivalents.

METAMORPHIC ROCKS

Precambrian Gneiss, Quartzite, and Schist

Precambrian metamorphic rocks are most extensively exposed in the southwestern part of the South Mountain area. They consist of quartz-microcline gneiss, hornblende gneiss, and quartzite. The quartz-microcline gneiss is the most abundant type and is a pinkish to light-red, poorly banded rock. Time did not permit detailed petrographic studies, but in the Monte Largo Hills immediately to the west detailed work on the Precambrian rocks has been done by Lambert (1961). He believed that quartz-feldspar gneiss is a metamorphosed feldspathic closely related. The quartz porphyry appears to [illegible]

tion product of the monzonite magma (p. 48). [illegible]

tended to a San Pedro-Ortiz [illegible] the [illegible]

margin of the mass. It is believed to have [illegible]

or from a nearby feeder pipe. The latite-andesite porphyry has

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METAMORPHIC ROCKS

Precambrian Gneiss, Quartzite, and Schist

Precambrian metamorphic rocks are most extensively exposed in the southeastern part of the South Mountain area. They consist of quartz-microcline gneiss, hornblende gneiss, and quartzite. The quartz-microcline gneiss is the most abundant type and is a pink to light-red, poorly banded rock. Time did not permit detailed petrographic studies, but in the Monte Largo Hills immediately to the west detailed work on the Precambrian rocks has been done by [illegible]

He believed that quartz-feldspar gneiss is a [illegible]

SOUTH NORTH

	South Mountain Thompson, this report	San Pedro Mountains Atkinson, 1961	Ortiz Mountains Southern Peterson, 1958	Ortiz Mountains Northern McRae, 1958	Los Cerrillos Disbrow and Stoll, 1957
OLDEST ↓	4) quartz monzonite		3) latite porphyry with minor plugs of quartz monz.		4) augite-biotite monzonite
		5) augite-bearing monzonite porphyry	2) nepheline-augite monzonite	3) nepheline-augite-monz.	3) hornblende-augite monz. porphyry
	3) latite-andesite porphyry	4) monzonite assoc. with latite porphyry	1) latite-andesite porphyry	2) latite-andesite porphyry	2) hornblende-augite monz. porphyry
	2) rhyolite	3) rhyolite			1) hornblende monz. porphyry
	1) monzonite	2) monzonite			
		1) diabase porphyry		1) trachyte-latite vent rock	

Figure 6. Possible correlation of rock types in the San Pedro-Ortiz porphyry belt.

sandstone or subgraywacke, hornblende gneiss, a metamorphosed graywacke, and quartzite, a metamorphosed pure quartz sandstone. In the South Mountain area some conglomeratic quartzites were noted.

In the northern part of the area (Fig. 4) several large blocks of Precambrian rocks were found included in monzonite (Pl. 4-B). The metamorphic rocks included leucogneiss and biotite schist. The dike-like leucogneiss appeared to have sheared the monzonite, and it was originally mapped as pegmatites. However, more detailed work resulted in finding a biotite schist (see Appendix) as well as leucogneiss fragments included in the monzonite. The leucogneiss is very similar to gneisses in Tijeras Canyon.

Tertiary Metamorphic Rocks

Intrusion of Tertiary igneous rocks in the South Mountain area was accompanied by little metamorphism of the country rock. The base of the monzonite mass rests on the Meseta Blanca Member of the Yeso Formation and the Abo Formation, which are red-beds. Hornfels along this contact is never greater than 4 to 6 inches thick. In places the sandstone and shale of the red-beds were leached in zones perpendicular to the bedding to a gray color and slightly indurated. In Figure 4 part of the Glorieta Sandstone (Psg_1) is indurated and the bedding contorted, but it is otherwise intact.

In places Glorieta Sandstone overlies the monzonite. Locally the sandstone is extensively epidotized; elsewhere it appears to have been indurated for only a narrow zone along the contact. In the Henry sandstone are subgraywacke, intermediate between graywacke [illegible] graywacke, and quartzite, and [illegible] quartz sandstones. In the South Mountain area some conglomeratic materials were noted.

In the northern part of the area (Fig. 4) several large blocks of Precambrian rocks were found included in monzonite (Pl. 4 B). The metamorphic rocks included leucogneiss and biotite schist. The schist-like leucogneiss appeared to have sheared in monzonite, and it was originally mapped as pegmatites. However, more detailed work resulted in finding a biotite schist (see Appendix), as well as [illegible] fragments included in the monzonite. The leucogneiss is very similar to gneisses in Tijeras Canyon.

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In places Glorieta Sandstone overlies the monzonite. Locally the sandstone is extensively epidotized; elsewhere it appears to have been indurated for only a narrow zone along the contact. In the [illegible]

Mountains metamorphic effects are slightly greater along the roof than on the floor or sides of the igneous bodies (Hunt, 1953, p. 165), and this is true at South Mountain. The small amount, grade, and extent of metamorphism is strongly suggestive of relatively low temperature of the monzonitic magma. Hornfels is found as float in many parts of the area especially on the topographic shoulders in the southern part of the area.

GEOLOGIC STRUCTURE

Regional Setting

Kelley (1955) has shown that the Colorado Plateau has three principal northwesterly-trending regional lineaments which, from northeast to southwest, are: 1) the White River lineament, 2) the Uncompahgre lineament, and 3) the Zuni lineament. They divide the Plateau into three northwesterly belts which are, from northeast to southwest, the Uinta, San Juan, and Mogollon segments. All the porphyry laccolithic intrusions on the Colorado Plateau occur within the San Juan segment and within this segment the porphyry centers lie on three straight lines. The South Mountain laccolith appears to lie on the Ute porphyry line which extends through the Abajo and Ute centers, the Temple Mountain breccia pipes in the San Rafael Swell, and small minette intrusives near the Colorado-New Mexico line. Most of these regional trends appear to begin in the Eastern Rockies (Sangre de Cristo Mountains). Most of the porphyry centers of the San Juan segment are on or near sedimentary or structural basins, or on platform areas, but none is on a

Mountains metamorphic effects are slightly greater along the roof than on the floor or sides of the intrusions (Hunt, 1958, p. [illegible] and [illegible] [illegible] accounts for [illegible] [illegible] absent of [illegible] is strongly suggestive of relatively low temperature of the [illegible] magmas. [illegible] is [illegible] [illegible] many parts of the area especially on the topographic [illegible] in the [illegible] part of the area.

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In New Mexico Lindgren (1910, p. 35) noted that the early Tertiary intrusives were distributed along a south-southwest line through the State which followed the Rio Grande along its eastern boundary. Even more locally, Johnson (1903) noted that the Ortiz, San Pedro, and South Mountains occur possibly along one great fracture which died out before reaching the surface, so that the rising magma spread out laterally arching the overlying beds and forming laccoliths. Figure 7 shows the northerly trend of the San Pedro-Ortiz porphyry belt and the echelon basins of the Rio Grande depression. Kelley (1952, p. 102) explained that this pattern could be developed if tangentially directed forces of a couple acted upon a deep-seated shear zone.

The late Tertiary tectonic pattern is dominated by northerly to northeasterly trends (Kelley, 1952, p. 102) while Laramide structures trend northerly in the Eastern Rockies possibly along deep-seated lines of weakness (Kelley, 1955). Figure 8 shows a tectonic map of the porphyry belt and the dominant northeasterly trends with subordinate northwesterly trends. The northerly trend of the porphyries is quite evident, yet this is not parallel to the dominant Tertiary trends in the area. The South Mountain intrusive is elongate northeasterly and, if extended in this direction, would not cross the rest of the porphyry belt. It seems that Tertiary trends alone could not have controlled the emplacement and alignment of the entire porphyry belt. Possibly the porphyry belt represents intersections of northeasterly Tertiary trends with an older tectonic uplift (Kelley, 1955, p. 58), and this holds true for the San Pedro-Ortiz porphyry belt.

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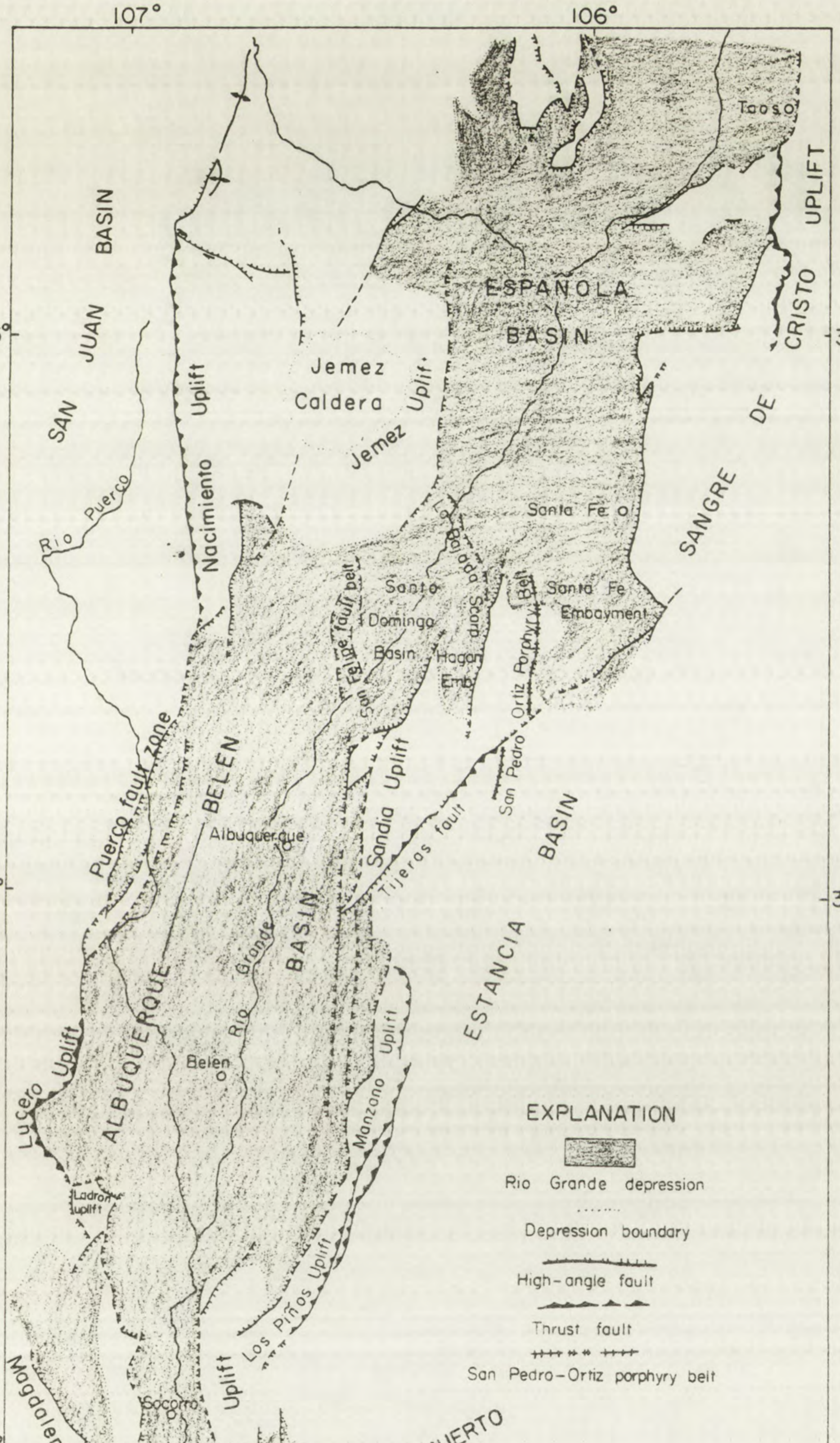

Figure 7. Tectonic map of the middle Rio Grande depression (adapted from Kelley, 1961).

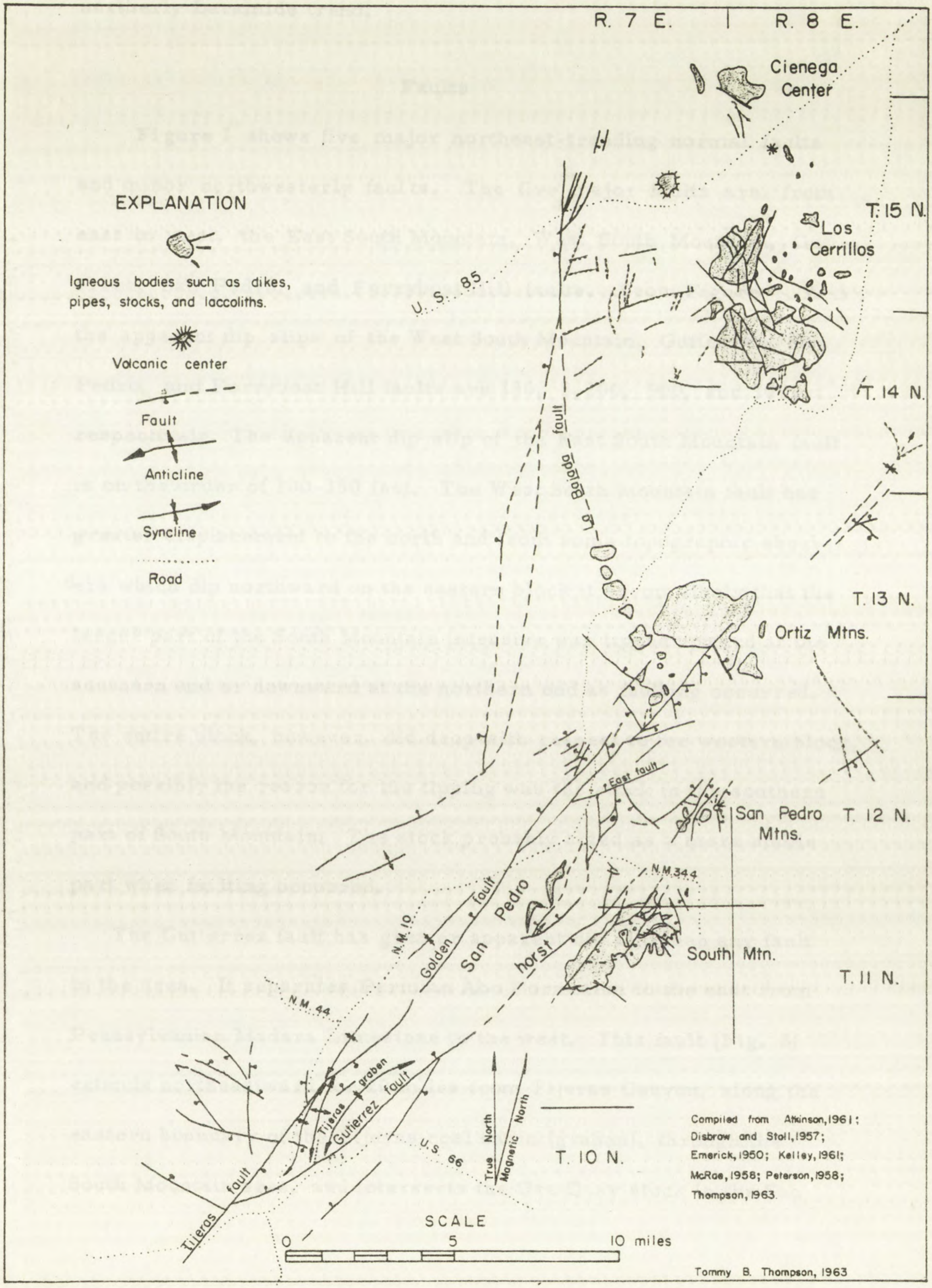

Figure 8. Tectonic map of the San Pedro–Ortiz porphyry belt.

northerly Laramide trend.

Faults

Figure 1 shows five major northeast-trending normal faults and minor northwesterly faults. The five major faults are, from east to west, the East South Mountain, West South Mountain, Gutierrez, San Pedro, and Ferryboat Hill faults. From Figure 1, A-A', the apparent dip slips of the West South Mountain, Gutierrez, San Pedro, and Ferryboat Hill faults are 130, 2,200, 900, and 30 feet respectively. The apparent dip slip of the East South Mountain fault is on the order of 100-150 feet. The West South Mountain fault has greater displacement to the north and from some topographic shoulders which dip northward on the eastern block it seems likely that the larger part of the South Mountain intrusive was tipped upward at the southern end or downward at the northern end as faulting occurred. The entire block, however, did drop with respect to the western block, and possibly the reason for the tipping was the stock in the southern part of South Mountain. The stock probably acted as a more stable part when faulting occurred.

The Gutierrez fault has greater apparent dip slip than any fault in the area. It separates Permian Abo Formation to the east from Pennsylvanian Madera Limestone to the west. This fault (Fig. 8) extends northeastward for 20 miles from Tijeras Canyon, along the eastern boundary of the Tijeras coal basin (graben), through the South Mountain area, and intersects the Oro Quay stock in the San northerly Laramide trend.

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Pedro Mountains. Its greatest displacement is in the Tijeras coal basin and appears to die out north of the San Pedro Mountains. In the Tijeras coal basin it causes the western block to drop while in the South Mountain area the southeastern block is dropped relative to the northwestern one. This scissor action is similar to that of the Tijeras-Golden fault. The Tijeras coal basin is a graben while the Ferryboat Hill-Monte Largo Hills area is part of a horst that extends northward to the San Pedro Mountains. The horst is known as the San Pedro horst.

Drag folding is associated with many faults, especially those through Ferry boat Hill. The fault zones are sharply defined and the Gutierrez fault has a brecciated zone as wide as 200 feet due to incompetence of the Abo Formation.

There appear to have been two periods of faulting in the South Mountain area: 1) contemporaneous with intrusion, and 2) post-intrusion. Possibly there was movement along some of the faults prior to intrusion. The Tijeras-Golden fault, if extended, would intersect the Ortiz intrusives and the Gutierrez fault intersects the San Pedro Mountains. Other buried faults may control the rest of the porphyry belt. The Tijeras fault appears to have been active even in Precambrian time (Kelley, 1952, p. 102). The faulting contemporaneous with intrusion is better explained when discussing the igneous bodies and their treatment is deferred to that section.

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Folds

Folding appears to be simple in the South Mountain area, but the observed features may not give the entire picture. The South Mountain laccolith appears to have been intruded into a structural basin while sediments capping the intrusive are slightly domed. This results in an anticline superimposed above a syncline. Stevenson and Hayes (1948, p. 20) considered the area to be "a large southward-plunging syncline," but this does not appear to be the case. Localization of the intrusive body appears to have been controlled by a small structural basin, but it appears that the basin was formed during the time of intrusion. The origin of the basin is discussed in the section on igneous bodies below. To the northwest of the Gutierrez fault a series of homoclinal ridges dip southeastward, and faulting on the southern end of Ferryboat Hill has resulted in the formation of a small northward-plunging anticline.

Repetition of quartzite in Precambrian rocks may indicate isoclinal folding similar to that postulated by Lambert (1960, p. 79) in the Monte Largo Hills to the west. An area larger than that of this study would be needed to determine the presence of folding.

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Igneous Bodies

Yung and McCaffery, (1903, p. 353) pictured the porphyry belt as syenite porphyry stocks which were remains of enormous laccoliths. Lindgren (1910, p. 171) recognized their laccolithic nature and the most recent works show them to be complexes of dikes, sills, laccoliths, and stocks (Disbrow and Stoll, 1957; McRae, 1958; Peterson, 1958; Atkinson, 1961).

The main igneous mass of South Mountain is an asymmetrical, doubly convex laccolith (Fig. 1, D-D', E-E'). It is elongate to the northeast, indicating that the feeder might be an elongate vent rather than one central pipe. To the northeast the laccolith appears to penetrate out beneath Glorieta Sandstone causing formation of small monoclinal and anticlinal folds. The laccolith does not extend north of State Road 344.

The structural basin and the domed sediments appear to be the only evidence of folding in the South Mountain area. However, stratigraphic relationships and the nature of the intrusive magma indicate that as much as 600 feet of Yeso Formation and some of the Abo Formation are unaccounted for. The only way to account for the missing section would be through folding and "shoving-aside" by magma. Intrusion was by forceful injection into incompetent Yeso and Abo beds. Figure 9 represents how the laccolithic emplacement and growth may have occurred at South Mountain. Resistant units no doubt existed in the Yeso Formation particularly in the Meseta Blanca Member. The intrusion appeared to bypass above and below these, so that with erosion of the laccolith indentations (Fig. 9-D) were formed. The inden-

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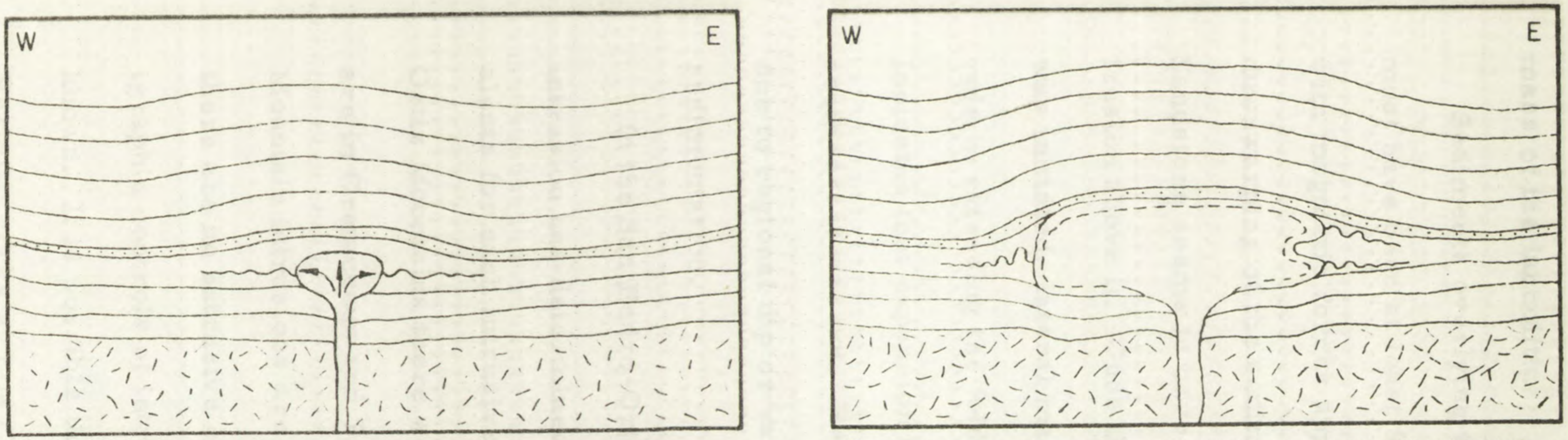
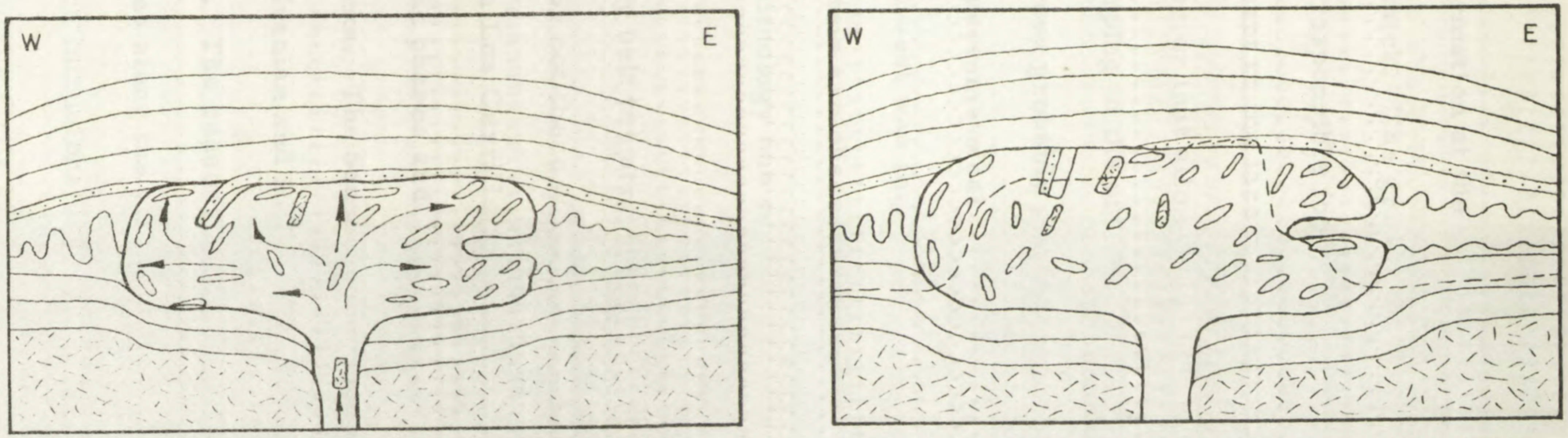


A. Intrusion of monzonitic magma through zone of weakness until incompetent zone is reached at which place lateral and vertical expansion occurs. Incompetent unit shoved away from feeder zone accompanied by doming of overlying sediments and downwarping of underlying sediments.

B. Intrusive expands upward until contact is made with competent sandstone. Lateral expansion becomes restricted by zones of competent sandstone that are bypassed. Followed by period of magmatic quiescence during which time a crust (blue) forms.



C. Reactivation of magmatic intrusion with fracturing of resistant sandstone and crust which sink into the melt. Concurrent uplift and lateral folding (except for competent sandstone that is bypassed). Continued downwarping of underlying sediments.

D. Final stage of intrusion and crystallization with xenoliths floating in various positions. Note that throughout development the highly folded unit appears to thicken due to folding. Dashed line represents the present surface.

Figure 9. Diagrammatic representation of intrusion for the South Mountain laccolith.

tations are represented by shoulders on the laccolith and are evidence of sedimentary units that were more easily eroded than the monzonitic mass of the laccolith.

Sediments overlying the Abo Formation at the time of intrusion must have been at least 6,000 feet thick. The great overburden along with magmatic forces appear to be responsible for the doming and downwarping of the sediments adjacent to the laccolith. The Glorieta Sandstone seems to have been a barrier that allowed very little intrusion above it. Once the downwarping of the underlying sediments was initiated, lateral magmatic forces probably played an important role in extending the folding. The asymmetrical form of the laccolith indicates that expansion to the northwest was impeded while to the southeast it was not. Reasons for this are obscure but it may have been due to regional dip or variation in lithology due either to faulting or sedimentation.

In the San Pedro-Ortiz porphyry belt the stratigraphic level of intrusion has determined whether or not there were extrusive equivalents for each intrusive phase. In Los Cerrillos and possibly the Ortiz Mountains there were volcanic phases and the intrusives there are in Cretaceous and Tertiary rocks. The San Pedro and South Mountain intrusions are in Pennsylvanian and Permian rocks, and there are no extrusive equivalents. The reasons for different stratigraphic controls of intrusive bodies along the porphyry belt are not known. It is possible that there are intrusions in Pennsylvanian and Permian rocks at Los Cerrillos and the Ortiz Mountains, but the

depth of erosion is greater at the southern end of the porphyry belt than in the northern end. Evidence at South Mountain indicates that intrusion above the Glorieta Sandstone was limited.

Interpretation of the mechanics of intrusion necessitates some sort of a cyclical intrusion rather than development in one stage. Cyclic emanations would tend to force the magma and sediments upward and outward. Evidence for this is shown in Figure 4 where a leucomonzonite is in contact with Glorieta Sandstone to the northeast and monzonite to the southwest. This leucomonzonite is interpreted as having once been a crustal layer of the laccolith which, in its early stages, was overlain by Glorieta Sandstone. The crustal layer with its overlying Glorieta cap was broken by further magmatic injection which in places rotated the border blocks to near vertical attitudes. At the same time beds were being shoved back from the feeder zone. Assimilation was at a minimum.

The laccolith of South Mountain is not completely concordant along its base, as is usually the case with laccoliths. In the Henry Mountains the laccoliths cut across several hundred feet of strata to higher levels away from the feeder (Hunt, 1953, p. 90).

Most of the faulting contemporaneous with the intrusion of the laccolith is due to fracturing of a crustal layer of the monzonite. Apparently some of the crustal layers of monzonite with the overlying Glorieta Sandstone floated while others sank or were tipped up. A very dense magma would be required to support these blocks and support for this appears near the Fuzzy Jim claim where large depth of erosion is greater at the southern end of the porphyry belt than in the northern end. Evidence at South Mountain indicates that intrusion above the Glorieta Sandstone was limited.

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Following intrusion of the monzonite laccolith a quartz monzonite stock intruded through the laccolith in its southwestern part. Since there was little shattering or brecciation the two intrusions must have occurred before complete crystallization of the monzonite. A pronounced concentric set of joints is strongly developed in the quartz monzonite stock and to a less extent in the monzonite laccolith. They probably represent planes along which movement occurred during the intrusion of the stock.

Rhyolite sills and dikes and a latite-andesite porphyry laccolith intruded northwest of South Mountain. Rhyolite sills are not entirely concordant and appear to move down in the Madera Limestone to the north. They are continuous with sills in the San Pedro Mountains, but a small dike (SW1/4 sec. 28, T. 12 N., R. 7 E.) shown in Figure 1, C-C', appears to be the feeder pipe. This is supported by zoning of mineral deposits around the dike.

The latite-andesite porphyry laccolith of Ferryboat Hill intrudes the Pennsylvanian Sandia Formation. The same conglomerate bed is at its base throughout its extent. A lens of the Sandia Formation is included in the laccolith. The laccolith wedges out on the southern edge of Ferryboat Hill and does not show in the upthrown block of the San Pedro fault where the Sandia Formation is exposed. This indicates that the feeder for the South Mountain laccolith was not the source for the latite-andesite porphyry laccolith. Atkinson (1961, p. 17) thought

that the San Pedro Mountains were the source area for this laccolith, but it appears to become too thin as it approaches the San Pedro Mountains. It seems possible that the feeder for this small laccolith might have been along the Golden fault.

TERTIARY GEOLOGIC HISTORY

At the end of the Cretaceous period, the first broad upwarping of the Rocky Mountains began and from this the Laramide orogeny developed. River deposits formed during the Eocene were unconformable with the Upper Cretaceous rocks in a broad basin in the area of the porphyry belt (Stearns, 1953, p. 467). Volcanics overlie conformably the Eocene river deposits and fossils collected from a bentonite clay indicate an Oligocene age (Disbrow and Stoll, 1957, p. 11). The Oligocene Espinaso Volcanics have been shown by Disbrow and Stoll (1957, p. 11) to be extrusive equivalents of intrusives in Los Cerrillos. There were several episodes of intrusion and extrusion in the northern end of the porphyry belt.

Structural evidence in the South Mountain area indicates only that the monzonitic laccolith is post-Permian. The proximity, alignment, and similarity of rock type and texture of the intrusives in the San Pedro-Ortiz porphyry belt indicate that they are all probably of the same age. No age determinations by radioactive decay methods have been made, but assuming that the porphyry belt intrusive stages occurred at approximately the same time, an Oligocene age seems likely.

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Following the intrusive stages of the porphyry belt, the Rio Grande depression began to subside and the late Miocene to Pliocene Santa Fe Group of beds accumulated in the trough. The Santa Fe Formation contains contact metamorphic rocks which could have come only from the Ortiz, San Pedro, or South Mountains (Stearns, 1953, p. 473). This indicates uplift of the porphyry belt during that time.

Since the late Miocene to Pliocene uplift of the porphyry belt minor adjustments have occurred as indicated by deformation of the Santa Fe deposits (Read and others, 1944). Some faulting has occurred in the South Mountain area which probably represents adjustments along major trends. The Tijeras fault system was active after the laccolithic intrusions.

Erosion of the South Mountain area has continued to the present with deposition of pediment gravel and alluvium on the plains.

ECONOMIC GEOLOGY

Mineral Deposits

General.

Numerous prospects in slightly mineralized areas are present in the South Mountain area yet little or no mining has been done. Lindgren (1910, p. 170) noted some prospects at South Mountain but no deposits of importance. A few shafts are 50 to 75 feet deep and have one or two levels along the mineralized zone. Most of them are inaccessible or have bad air. There are no records of mineral production from South Mountain, yet it is probable that small shipments were made to San Pedro and the smelter there.

The lack of deposits, such as are present in the San Pedro area, in South Mountain is due to at least two possible reasons. One important factor is the lack of carbonate host rocks. Secondly, and most importantly is that there must not have been a concentrated introduction of ore-forming elements in the South Mountain intrusive stage or subsequent hydrothermal stages. The San Pedro intrusives and the South Mountain intrusives are much more closely related than any other intrusive bodies in the San Pedro-Ortiz porphyry belt. It seems possible that these two closely related bodies may have a common magma chamber and that the ore-forming fluids were introduced only in the San Pedro area after the South Mountain conduits were sealed off. This is further supported when it is noted that most of the mineralization in the South Mountain area is in the northern part nearest the San Pedro bodies. Most of the deposits are iron-bearing and suggest a zoning effect around the San Pedro-South Mountain areas. Atkinson (1961, p. 38) noted in the San Pedro Mountains that magnetite veins were within or adjacent to stocks and that specularite, copper, and lead-zinc deposits, in that order, were farther away from the stocks. In the South Mountain area the magnetite deposits are related to the laccolith-sediment contact while there are minor occurrences of magnetite, specularite, copper, and lead-zinc minerals near rhyolite sills in fissure veins (Fig. 10). There appears to be some zoning in part of the South Mountain area (Fig. 10) and a comparison with Atkinson (1961, pl. 3), shows a similar type of zoning which is to be expected. In the northernmost part of the area zoning

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in South Mountain [illegible]
portant factor is the [illegible]
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lead-zinc deposits [illegible]
in the South Mountain area [illegible]
laccolith-sediment contact [illegible]
magnetite, specularite, [illegible]
[illegible] in fissure veins [illegible]
in part of the South Mountain [illegible]
Atkinson (1961, p. [illegible]
is to be expected [illegible]

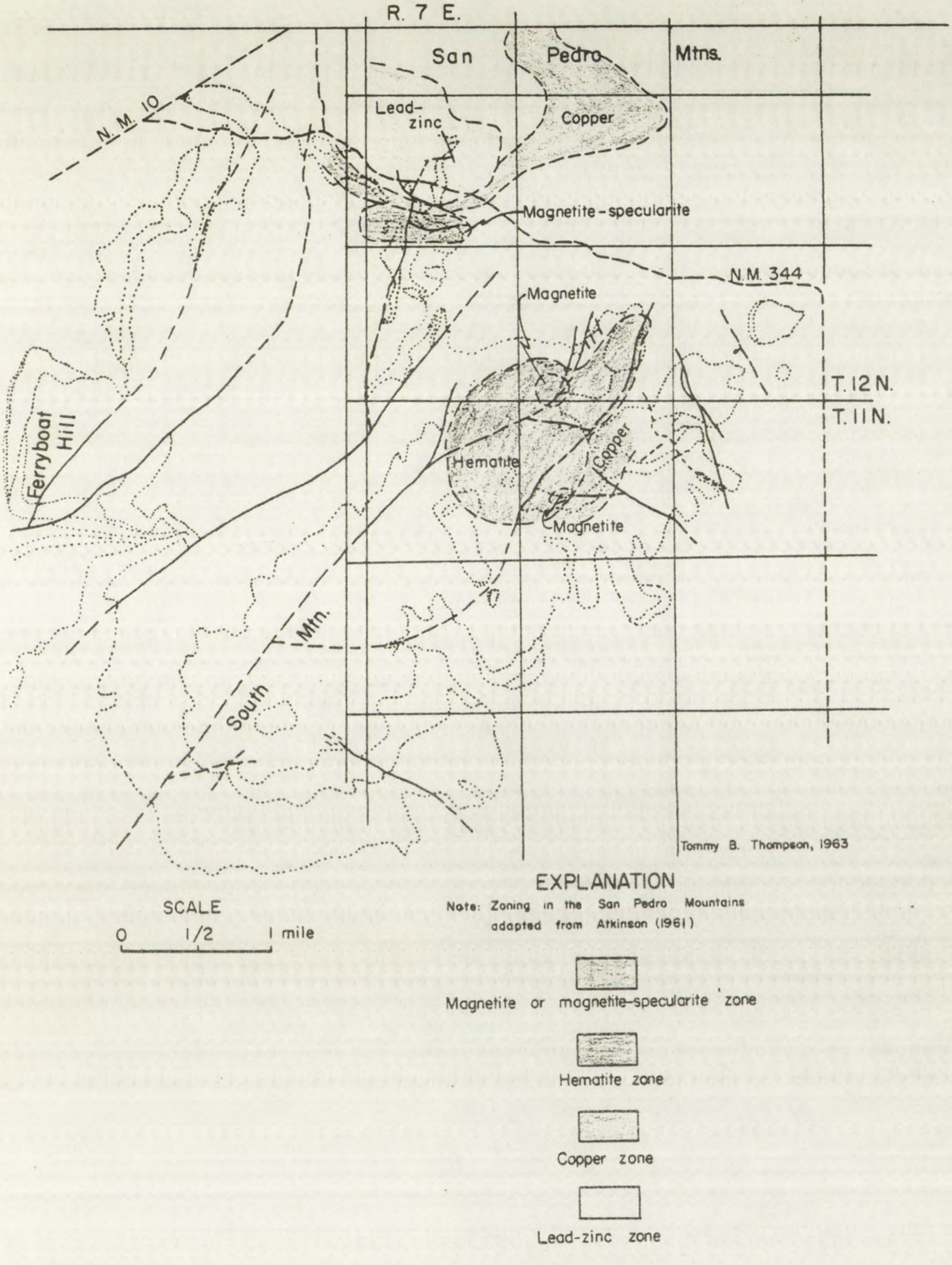
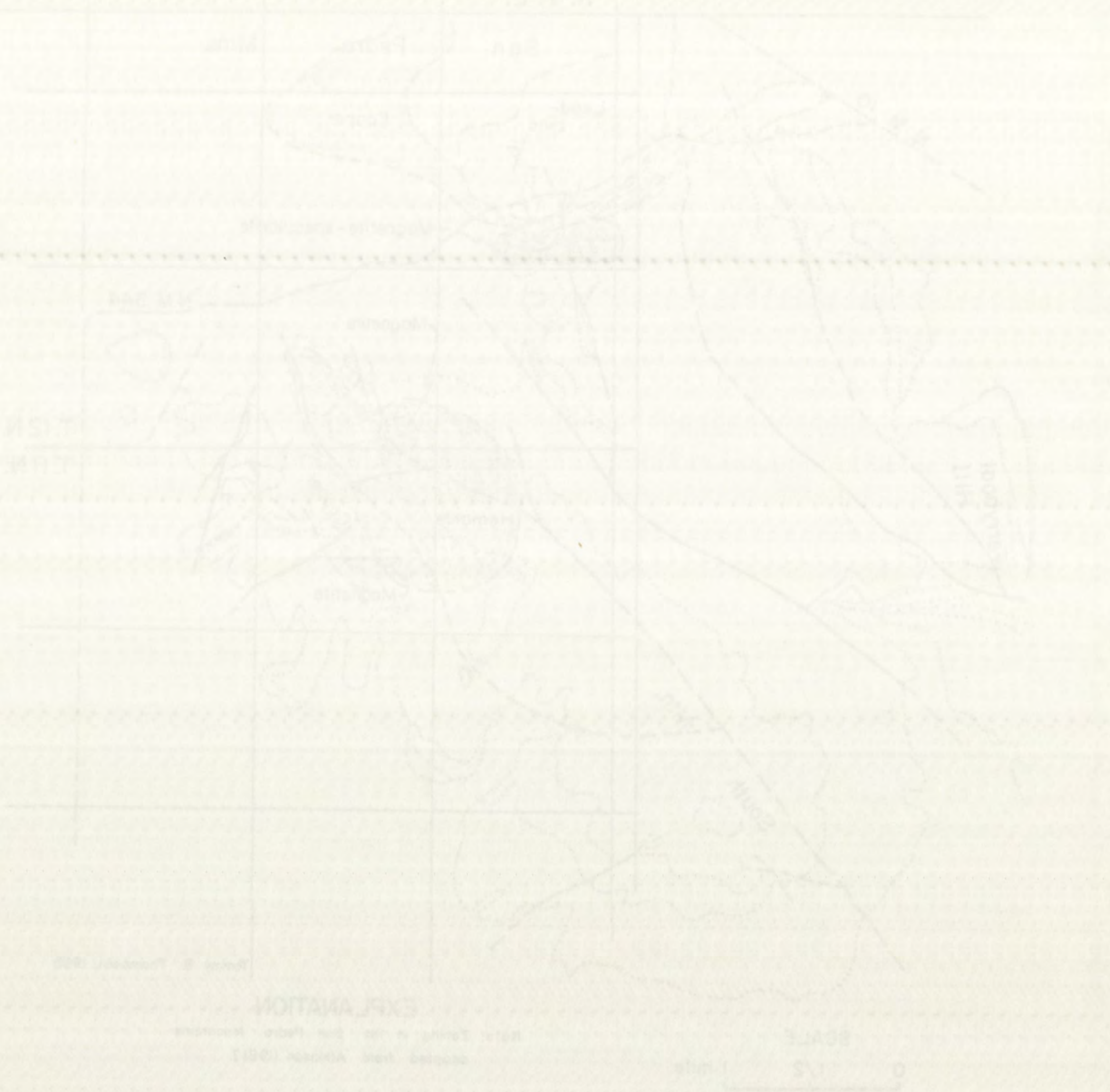


Figure 10. Hydrothermal zoning in the South Mountain area and parts of the San Pedro Mountains, Santa Fe County, New Mexico.



EXPLANATION

Note: Zoning in the San Pedro Mountains adapted from Atkinson (1961)

Magnetite or magnetite-specularite zone

Hematite zone

Copper zone

Lead-zinc zone

Figure 10. Hydrothermal zoning in the South Mountain area and parts of the San Pedro Mountains, Santa Fe County, New Mexico

is around the San Pedro Mountains. However, locally there is a minor modification of the concentric zones, possibly due to a feeder pipe in the SW1/4 sec. 28, T. 12 N., R. 7 E. Around this feeder there are magnetite-specularite deposits, such as occur around stocks in the San Pedro Mountains.

Iron Deposits.

Contact Metasomatic

The only contact-metasomatic magnetite deposit in the South Mountain area is on the Fuzzy Jim mining claim (Fig. 4). The ore is a lens about 300 feet long which replaces the Glorieta quartz sandstone (Psg_2). The replacements are irregular as shown on the cross section (Fig. 4, B-B') and vary in width from 0 to 10 feet. An X-ray powder pattern of the magnetite indicates there are no other ore minerals. In polished section (Appendix, SM-36, and Pl. 1-C) the ore is granular and associated with abundant asbestiform tremolite (Appendix, SM-24). In places the tremolite is similar to mountain leather. Thin-section studies of the tremolite indicate that it formed prior to magnetite which is similar to the iron ore deposits at Cornwall, Pennsylvania (Hickok, 1933, p. 226).

It is quite unlikely that the magnetite deposit on the Fuzzy Jim mining claim is large enough ever to be economic. Prospecting indicates at least two periods of development with very little accomplished in either one.

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Iron Deposits.

Contact Metasomatic

The only contact-metasomatic magnetite deposit in the South Mountain area is on the Fuzzy Jim mining claim (Fig. 4). The ore is a lens about 200 feet long which replaces the Glorieta quartz sandstone (Pg). The replacements are irregular as shown on the cross section (Fig. 4, B-B') and vary in width from 0 to 10 feet. An X-ray powder pattern of the magnetite indicates there are no other ore minerals. In polished section (Appendix, SM-26, and Pl. 1-C) the ore is granular and associated with abundant asbestiform tremolite (Appendix, SM-24). In places the tremolite is similar to mountain leather. Thin-section studies of the tremolite indicate that it formed prior to magnetite which is similar to the iron ore deposits at Cornwall, Pennsylvania (Hickok, 1933, p. 226).

It is quite unlikely that the magnetite deposit on the Fuzzy Jim mining claim is large enough ever to be economic. Prospecting indicates at least two periods of development with very little accomplished in either one.

Hydrothermal

There are several hydrothermal iron deposits in the South Mountain area, but they are very small. One of them occurs in the south-central part of sec. 28, T. 12 N., R. 7 E., about three-quarters of a mile south of State Road 344. The ore occurs in an easterly-trending fissure cutting rhyolite sills. There is some replacement of the sill and underlying Madera Limestone by primary magnetite and specularite (Appendix, SM-34). Supergene enrichment caused replacement of much of the magnetite and specularite by goethite, limonite, and hematite (Pl. 1-A).

Another hydrothermal deposit occurs in the SE1/4 sec. 3, T. 11 N., R. 7 E. (Fig. 3). The ore is in a southeasterly-trending fault which brings the Abo Formation in juxtaposition with monzonite. The mineralization consists of slaggy-appearing hematite, goethite, and limonite. A small vein of octahedral limonite pseudomorphous after pyrite and minor quartz crystals occurs along the eastern limit of the area shown in Figure 3. Pyrite remains in some of the pseudomorph cores.

Elsewhere, there are small accumulations of hematite, goethite, and limonite in the beds above the monzonite laccolith. Supergene enrichment of the mineralization is controlled by bedding planes, dip, jointing, fractures, and proximity to the monzonite. Limonite pseudomorphs after pyrite are rather common and may be up to 3/8 of an inch in length.

Supergene

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Another hydrothermal deposit occurs in the SE1/4 sec. 5, T. 11 N., R. 7 E. (Fig. 7). The ore is in a southeasterly-trending fault which brings the Abo Formation in juxtaposition with monzonite. The mineralization consists of slaggy-appearing hematite, goethite, and limonite. A small vein of octahedral limonite pseudomorphous after pyrite and minor quartz crystals occurs along the eastern limit of the area shown in Figure 5. Pyrite remains in some of the pseudomorph cores.

Elsewhere, there are small accumulations of hematite, goethite, and limonite in the beds above the monzonite laccolith. Supergene enrichment of the mineralization is controlled by bedding planes, dip, jointing, fractures, and proximity to the monzonite. Limonite pseudomorphs after pyrite are rather common and may be up to 3/8 of an inch in length.

Supergene

The South Mountain area contains an abundance of small supergene iron prospects. Only one has been mapped (Fig. 11). The

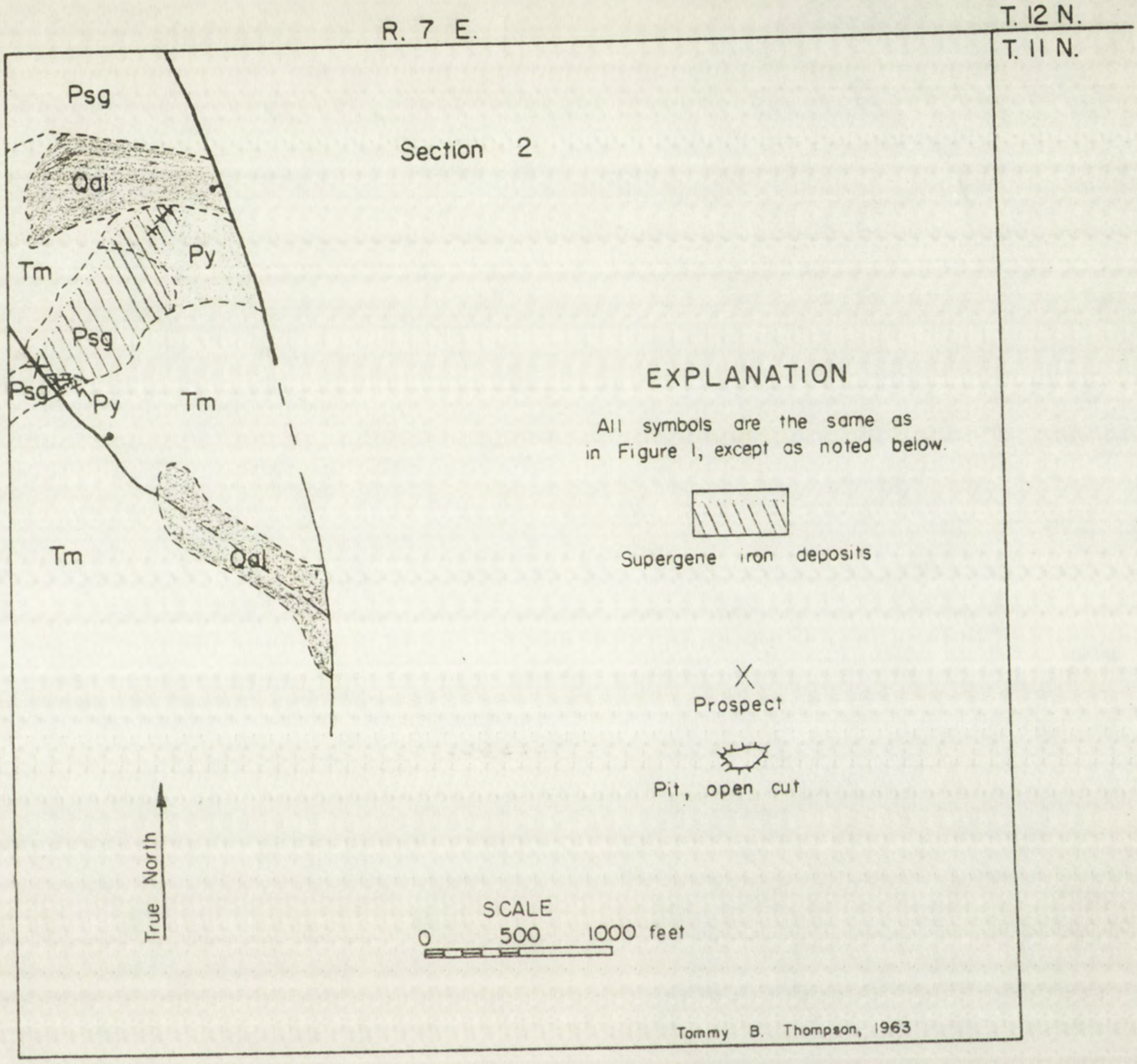


Figure 11. Geologic map of the supergene iron deposits in Sec. 2, T. 11 N., R. 7 E.

iron mineralization is in the Yeso Formation immediately beneath the Glorieta Sandstone and appears to be a replacement of shale or siltstone along bedding planes. Because of the impermeability of the overlying Glorieta Sandstone it appears that the iron was taken into solution up dip by ground water and deposited near the discharge area at the foot of the hill, although some may have percolated down through the Glorieta Sandstone along joints and fractures. The ore is goethite, hematite, and limonite (Appendix, SM-37, and Pl. 1-D). The limonite varies from soft ocherous masses to shiny dark-brown plates. The thickness of the ore varies from 0 to 2.5 feet over approximately 8 acres. There are five prospect pits and there may have been some production. The dumps are small compared to the size of the major prospect pit, and there is a loading stand full of ore beside a road leading out to State Road 344. There are no records, however, and it is unlikely that the venture was economic. This deposit is very similar to the Kennedy deposit at Glorieta Mesa, Santa Fe County (V. C. Kelley, oral communication).

Other Mineral Deposits.

There are two other mineral deposits in the South Mountain area. One is in the south-central part of sec. 28, T. 12 N., R. 7 E., approximately three-eighths of a mile south of State Road 344. There lead-zinc ore occurs along a southeasterly trending fault where the Madera Limestone is along a rhyolite sill. Galena and sphalerite replace the limestone without regard for bedding. Other minerals

numerous fragments containing magnetite and gibbsite in a quartz gangue. No outcrop or source of these fragments could be found. The gibbsite probably formed by hydrothermal alteration or weathering of hornblende and plagioclase while the magnetite is a contact-metasomatic mineral. The meager evidence has indicated for the mineral deposits in the South Mountain area a relatively low temperature of formation. This has been based on the texture and replacement characteristics of the deposits as well as on similar deposits in New Mexico (Kelley, 1949, p. 34-35). A low temperature is supported by the temperature of formation of tremolite (Bowen, 1940, p. 225-274) which is found in the Fuzzy Jim deposit. A high temperature mineral deposit would not fit into the conditions that are thought to have existed for the mineral deposits in the South Mountain area.

Water Supply

Two springs were found in the South Mountain area, both at what is termed Canyon del Agua Springs (Fig. 1). One is in the San Pedro Grant just west of sec. 32, T. 12 N., R. 7 E., and flows through a pipe into a concrete tank. The other occurs only 100 yards to the south of it but flows in the creek bed. In sec. 5, T. 11 N., R. 7 E., another concrete tank and pipe were found, but the pipe was silted up and the tank dry. The ground water of these springs flows from permeable units in the Madera Limestone. Other water sources in the South Mountain area come from wells which tap the Madera

Limestone or alluvium. The water is adequate for household use as well as for cattle. It is likely that the wells are no deeper than 200 feet.

APPENDIX

Petrographic Analyses

Petrographic analyses consisted of a study of 32 thin-sections and 8 polished sections. The sample locations are shown on Figures 2 and 4. The rock classification was adapted from Williams, Turner, and Gilbert (1955, p. 111-112). Mineral percentages were determined by visual estimation and comparing with percentage determination charts. The type of plagioclase was determined by measuring extinction angles on Carlsbad-albite twins. The angles obtained were plotted on a graph which had curves showing the limits of extinction angles corresponding to the plagioclase composition (Moorhouse, 1959, p. 59).

Table of Abbreviations used in
Figure 13, p. 50

Qtz – quartz
Cyte – microcline
Plag – plagioclase
Hbl – hornblende
Mag – magnetite
Ilmen – ilmenite
Ap – apatite
Sph – sphene
Chl – chlorite
Epi – epidote
Kaol – kaolinite

Sample No.	Vert. distance above floor of laccolith (feet)	Modal Analyses (%) by visual estimation										Remarks
		Qtz	Orth-Plag ratio	-total	Hbl	Mag-Ilmen	Ap	Sph	Chl	Epi	Kaol	
SM-28	2,000*	5	1:2	80	15	7-8	tr	tr		X		Ave. Plag: An_{37}
-26	1,900	5	1:1	80	15	4	tr					Plag: An_{36}-An_{57}
-43A	1,500		1:3	80-85	15	tr	tr	tr	X			Plag: An_{37} - An_{43}; Hbl replcd. by Chl.
-27	1,500		1:2	90-95	5	tr	tr		X	X	X	Felds. kaolinized; leucocratic
-12	500*	5	1:2	80-85	8	7			X	X	X	Kaolinized and epidotized felds; Hbl replcd by Chl
-17	500?*		1:2	85-90	10	tr	tr	tr	X		X	Felds. show Xlographic control on replcmnt.
-25	300		1:2	80-85	15	3	tr	tr				Plag:An_{25}-An_{37}; phenos (5%), 3mm; Mag repl. Hbl
-21	130		1:3	90	10	tr	tr	tr	X	X	X	Hbl replcd. by Mag, Chl; Mag altered to hem; leucocratic
-22	130		1:3	85-90	10	2	tr					Plag:An_{30}-An_{41}; Hbl lineated; fine-grained matrix w/ Plag & Hbl phenos.
-2	120?		-	85-90		7	tr	tr	X	X		Plag:An_{14}, albitized; Chl alteration of Hble; Epi conc. arnd hem; hydrothermal vein
-5	120	tr	1:1	85-90	10	2	tr	tr				Plag:An_{29}-An_{45};Mag replc. Hbl; Hbl xenolith
-14	80		1:3	80-85	10-15	2	tr	tr	X	X		Ap includ. in Sph
-30	20		1:1	80-85	-	3	tr		X	X	X	Plag:An_{33}; felds. kaolinized; fine-grained matrix; limonite stain
-20	10	tr	-	80-85	15	tr	tr	tr	X		X	Exten. saussuritized
-10	0-5		1:3	80-85	15	3						Ap incl. in Mag; contains aplitic sill-like features rich in Qtz that show sharp contact w/ monz & alters it.
-6		95					tr	tr				
-8			1:1	80-85	10	3						

*Denotes sample location near upper igneous-sediment contact.

Note: Table of abbreviations is given on previous page.

Figure 13. Comparison of the monzonite samples of South Mountain laccolith.

Sample No.: SM-24

Mineral Name: tremolite

Mode of occurrence: replacement mineral in contact-metasomatic magnetite deposit.

Microscopic description:

1) Elongate, acicular habit (length-slow), colorless.

2) Biaxial negative.

3) Low relief in thin section:

   a) Indices: $n_x = 1.600$; $n_y = 1.624$; $n_z = 1.613$

   b) 2V approaches 90°.

4) Extinction angle: 14 to 17° (it is monoclinic)

5) Not pleochroic.

6) X-ray powder pattern indicates that only an amphibole is present.

Remarks:

From the indices of refraction and lack of pleochroism, it can be said that the tremolite is low in iron content and near the $Ca_2Mg_5Si_8O_{22}(OH)_2$ composition (Larsen and Berman, 1934, p. 222-223).

The textural relationships show that the tremolite replaces quartz sandstone and in turn is replaced by magnetite with some overlapping in the tremolite-magnetite mineralization stages.

Sample No.: SM-32

Rock name: rhyolite

Mode of occurrence: sills and dikes

Microscopic description:

1) Quartz phenocrysts, rounded, corroded; quartz constitutes 15-20% of the rock.

2) Groundmass, very fine grained, crystalline; consists of orthoclase, quartz, plagioclase, magnetite, and trace of hornblende.

3) Orthoclase phenocrysts are common; orthoclase constitutes the greater part of the groundmass; some kaolinization is evident.

4) Hematite is present along fractures.

5) There is some epidote alteration of feldspars.

6) Pl. 2-B.

Remarks:

The rock is relatively fresh and unaltered.

Sample No.: SM-34 (Polished section)

Minerals: magnetite, specularite, hematite, and limonite

Mode of occurrence: fissure vein

Microscopic description:

1) Magnetite: disseminated, altered to hematite and limonite; occurs with specularite.

2) Specularite: spherical masses surrounded by bands of hematite and limonite; crosscutting the supergene bands are veinlets of specularite.

3) Hematite and limonite form concentric bands around cores of specularite-magnetite, often giving a nodular appearance on the weathered surface. The limonite is ocherous while the hematite is gray (yields a red powder).

4) Pl. 1-A.

Remarks:

Hypogene minerals appear to have been magnetite and specularite. Supergene processes caused the deterioration of these minerals in forming hematite and limonite. Replacement of the bands of hematite and limonite by specularite veinlets indicates either recurring hypogene mineralization or supergene mineralization. It is probably due to supergene processes.

Sample No.: SM-35 (Polished section)

Minerals: Galena, chalcopyrite, sphalerite, pyrite, covellite, anglesite, quartz, and calcite.

Mode of occurrence: fissure vein

Microscopic description:

1) Galena: major mineral constituent, but it is disseminated; contains chalcopyrite blebs with no particular orientation and showing mutual boundaries.

2) Sphalerite: occurs as a replacement mineral in galena; replacement controlled by cubic cleavage of galena (Pl. 1-B).

3) Pyrite, quartz and calcite: occur as veinlets through galena rimmed with sphalerite.

4) Covellite, anglesite, and malachite (tr.): show rim texture with galena.

5) Pl. 1-B.

Remarks:

A paragenetic diagram based on textural relationships is shown on page 44 (Fig. 12).

Sample No.: SM-36 (Polished section)

Minerals: magnetite and tremolite

Mode of occurrence: contact-metasomatic deposit

Microscopic description:

1) Magnetite: granular, occasionally euhedral in tremolite, but usually anhedral; isotropic; strongly magnetic; etch tests were all negative (HNO_3, HCl, KCN, $FeCl_3$, KOH, $HgCl_2$); color is bluish-gray.

2) Tremolite: see SM-24 for description.

3) Pl. 1-C.

Remarks:

The textural relationships indicate that the magnetite formed after the tremolite. This is indicated by euhedral magnetite in the tremolite and granular magnetite in the replacement of sandstone. The growth was not restricted in the tremolite as it was in the replacement of the sandstone. Also, thin section studies (SM-24) show euhedral magnetite veinlets that crosscut the fibers of the tremolite.

Sample No.: SM-37 (Polished section)

Minerals: goethite, hematite, specularite, and limonite

Mode of occurrence: supergene iron deposit

Microscopic description:

1) Goethite: gray to very light gray; negative to all reagents which rules out the possibility of psilomelane; yellow to orange powder; will not scratch; massive bands.

2) Specularite: occurs as disseminated blebs throughout the goethite and alters to hematite.

3) Limonite: brownish, hard conchoidal plates to ocherous soft masses.

4) Pl. 1-D.

Remarks:

This deposit appears to have been deposited by ground water with replacements occurring along bedding planes. Also, the bands indicate cyclic deposition. Late-stage weathering of the minerals has produced the ocherous limonite masses.

Sample No.: SM-38

Rock name: Latite-andesite porphyry

Mode of occurrence; laccolith

Microscopic description:

1) Feldspar phenocrysts: lath-shaped, epidotized cores with kaolin rims, constitute 10-15% of the rock; composition is indeterminant because of alteration.

2) Matrix: salt-and-pepper texture; fine-grained, consisting of plagioclase, hornblende, and accessory minerals; chlorite is a common secondary matrix mineral; matrix constitutes the remaining 85-90% of the rock.

3) Accessory minerals:

   a) apatite; anhedral, up to 2% content.

   b) Magnetite: euhedral, commonly contains apatite inclusions.

   c) sphene: anhedral.

4) Hornblende: dark-green; equigranular with some elongate crystals up to 3 mm in length.

5) There is no quartz.

6) Pl. 2-C.

Remarks:

1) The most distinctive feature is the complete saussuritization of this rock type.

2) In hand specimen the phenocrysts are white to greenish-gray with kaolin rims.

3) The matrix is green in the hand specimen with chlorite evident.

Sample Nos.: SM-41-A, B, C, D

Rock name: gneiss

Mode of occurrence: dikelike xenoliths in monzonite

Microscopic description:

1) Minerals present: hornblende (5%); microcline and quartz (85%); sphene (7-8%); magnetite (1%); and apatite (1%).

2) Microcline and quartz are the dominant minerals, and the quartz blebs are elongate showing banding.

3) Textures: banding of quartz and microcline; some microperthite.

4) Pl. 3-B.

Remarks:

This Precambrian gneiss is obviously not in place but occurs in a rather large group of xenoliths. The gneissic bands are nearly parallel to the foliation and banding of the Precambrian rocks in place in the southwestern part of the area.

Sample Nos.: SM-42-A, B, C (Polished section)

Minerals: magnetite and chlorite

Mode of occurrence: veinlets in gneiss and monzonite contact zone

Microscopic description:

1) Magnetite: thin veinlets that are altering to hematite and chlorite.
2) Wall rock shows intergrowth of magnetite-ilmenite as accessory minerals.

Sample Nos.: SM-48-A, B, C, D

Rock name: Quartz monzonite

Mode of occurrence: stock

Microscopic description:

1) Quartz phenocrysts constitute up to 17% of the rock constituents; anhedral, rounded, and corroded.

2) Plagioclase: lath-shaped; zoned (normal); twinned; range from An_{24} to An_{37} with average of An_{32} (andesine); constitutes 70 to 75% of rock;

3) Hornblende: pale-green to brownish-green; up to 15% maximum content.

4) Accessory minerals: magnetite, apatite, and sphene.

5) Texture: euhedral to subhedral plagioclase with interstitial hornblende and orthoclase; porphyritic.

6) Pl. 2-D.

Remarks:

There is little saussuritization evident in thin section and the rock is very similar to the monzonite except for the quartz phenocrysts and the differently colored hornblende.

Sample Nos.: SM-68-A,B,C,D)

Rock name: Quartz monzonite

Mode of occurrence: stock

Microscopic description:

1) Quartz phenocrysts constitute up to 12% of the rock constituents;

euhedral, rounded, and corroded.

2) Plagioclase: lath-shaped; zoned (normal); twinned; range from

An_{24} to An_{37}, with average of An_{32} (andesine); constitutes 70 to

75% of rock.

3) Hornblende: pale-green to brownish-green; up to 15% maximum

content.

4) Accessory minerals: magnetite, apatite, and sphene.

5) Texture: euhedral to subhedral plagioclase with interstitial

hornblende and orthoclase; porphyritic.

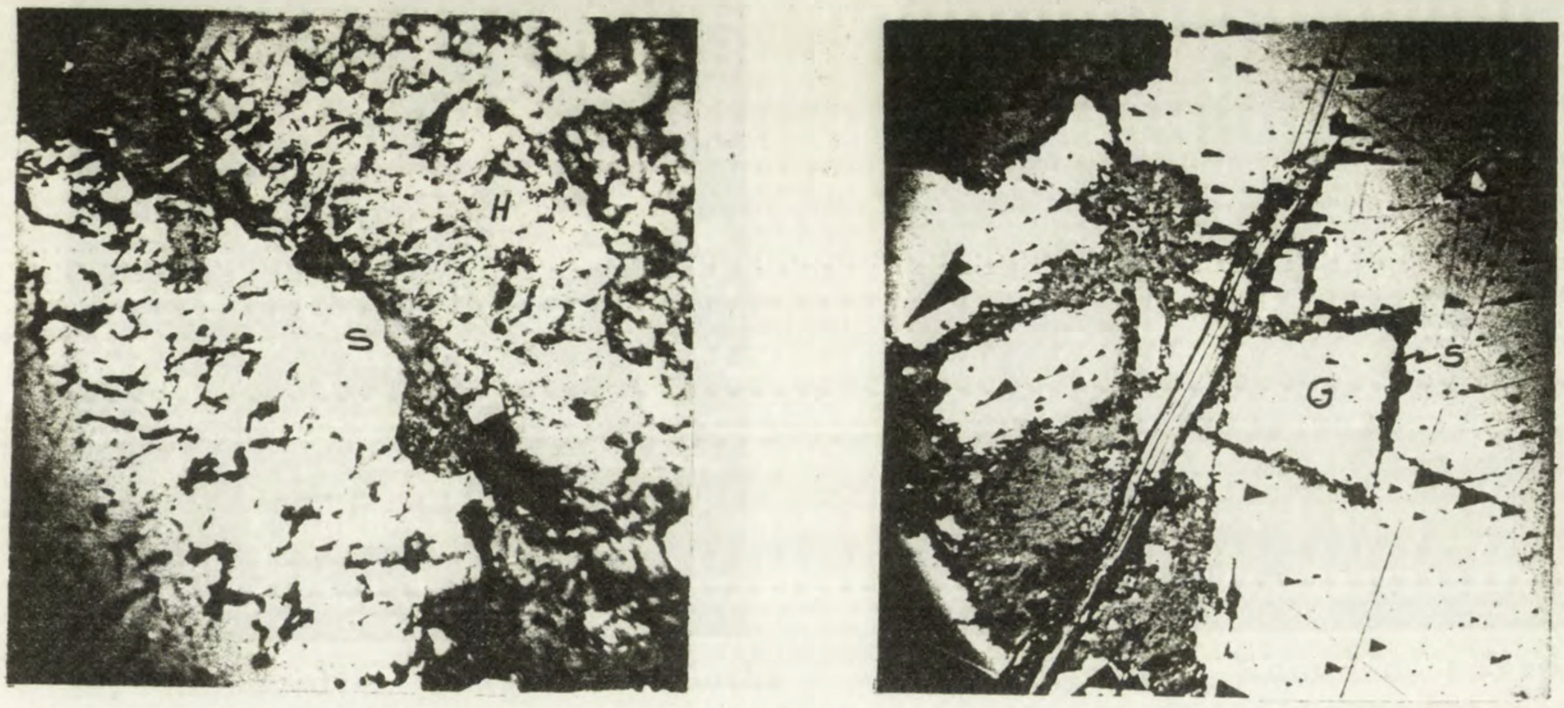
6) Pl. 2-D.

Remarks:

There is little sausuritization evident in this section and the

rock is very similar to the monzonite except for the quartz pheno-

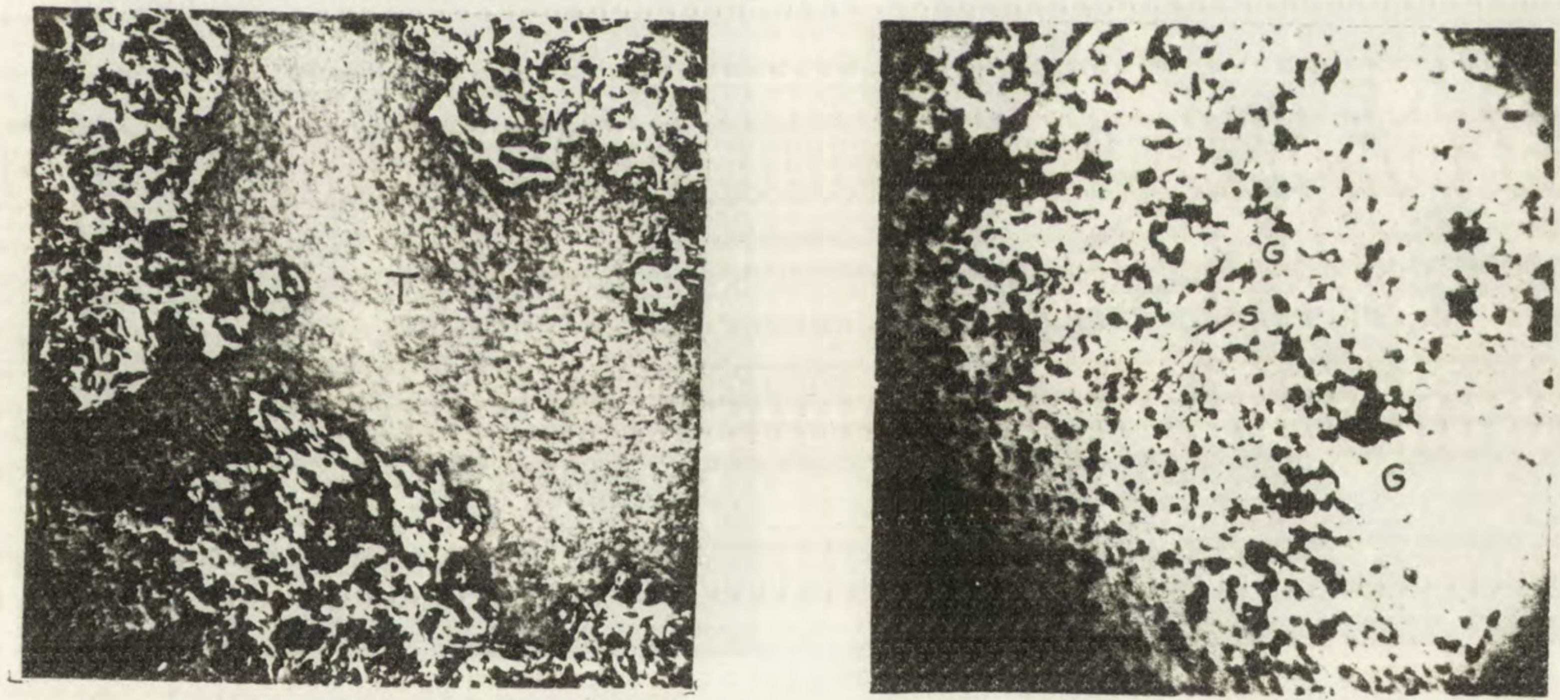
crysts and the differently colored hornblende.



A. Specularite (S) being replaced by hematite (H). Note secondary specularite veinlets (SV) that crosscut the hematite. Plain light. (SM-34)

B. Galena (G) replaced by sphalerite (S) along cleavage planes. Plain light. (SM-35)

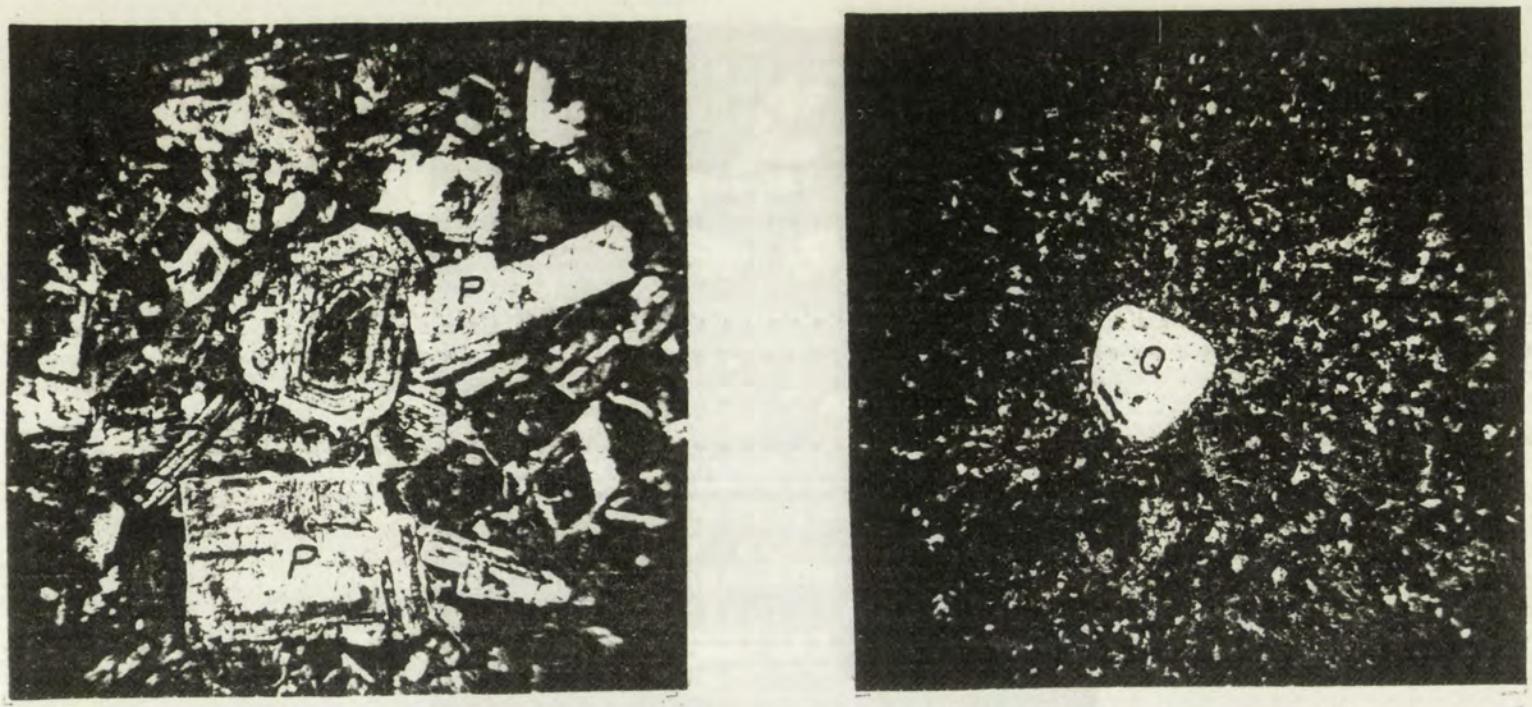
0 1/2 mm.



C. Magnetite (M) replacing tremolite (T). Magnetite is granular and contains much disseminated tremolite. Plain light. (SM-36)

D. Specularite (S) disseminated in goethite (G). (SM-37)

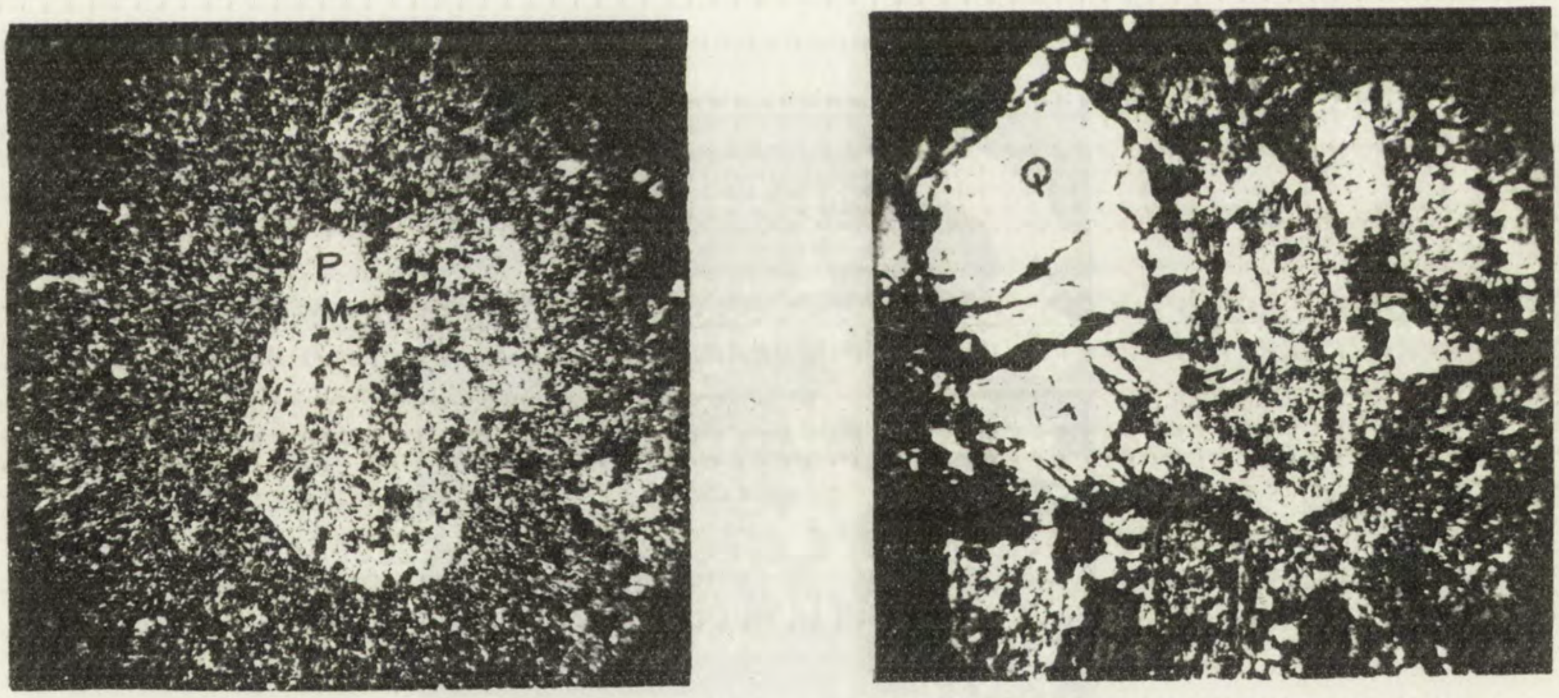
PLATE 1



A. Monzonite. Plagioclase laths (P) with interstitial hornblende (H) and magnetite (M). Zoning is common in the plagioclases. Crossed nicols. (SM-10)

B. Rhyolite. Rounded, corroded quartz phenocrysts (Q) in crystalline matrix of quartz and orthoclase. Crossed nicols. (SM-32)

0 1/2 mm.



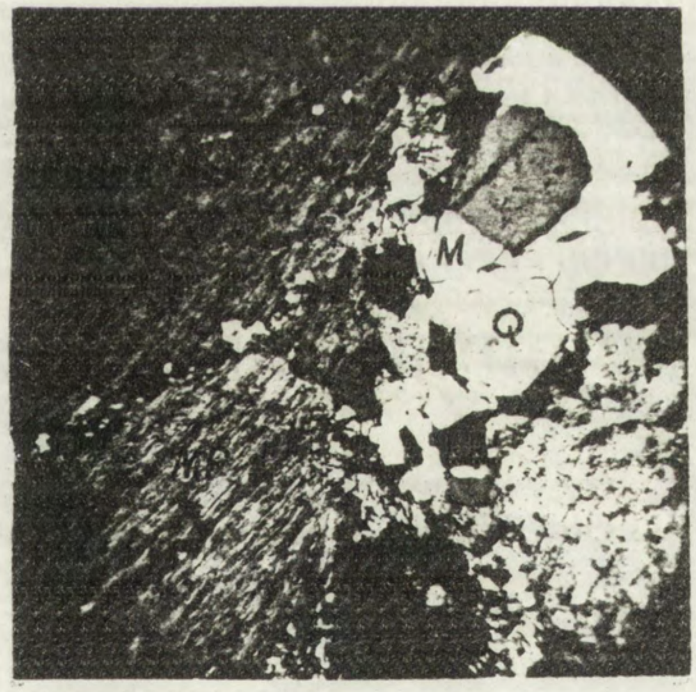
C. Latite-andesite porphyry. Epidotized plagioclase phenocrysts (P) in a matrix of plagioclase, hornblende, and magnetite (M). The magnetite forms inclusions in the phenocrysts. Shows typical salt-and-pepper texture. Crossed nicols. (SM-38)

D. Quartz monzonite. Quartz phenocrysts (Q) along with zoned plagioclase phenocr (P). Some magnetite (M) included in the plagioclas Crossed nicols. (SM-48)

PLATE 2

A. Biotite schist. Biotite and muscovite (BM) with bands of quartz (Q) and orthoclase (O). Crossed nicols. (SM-29)

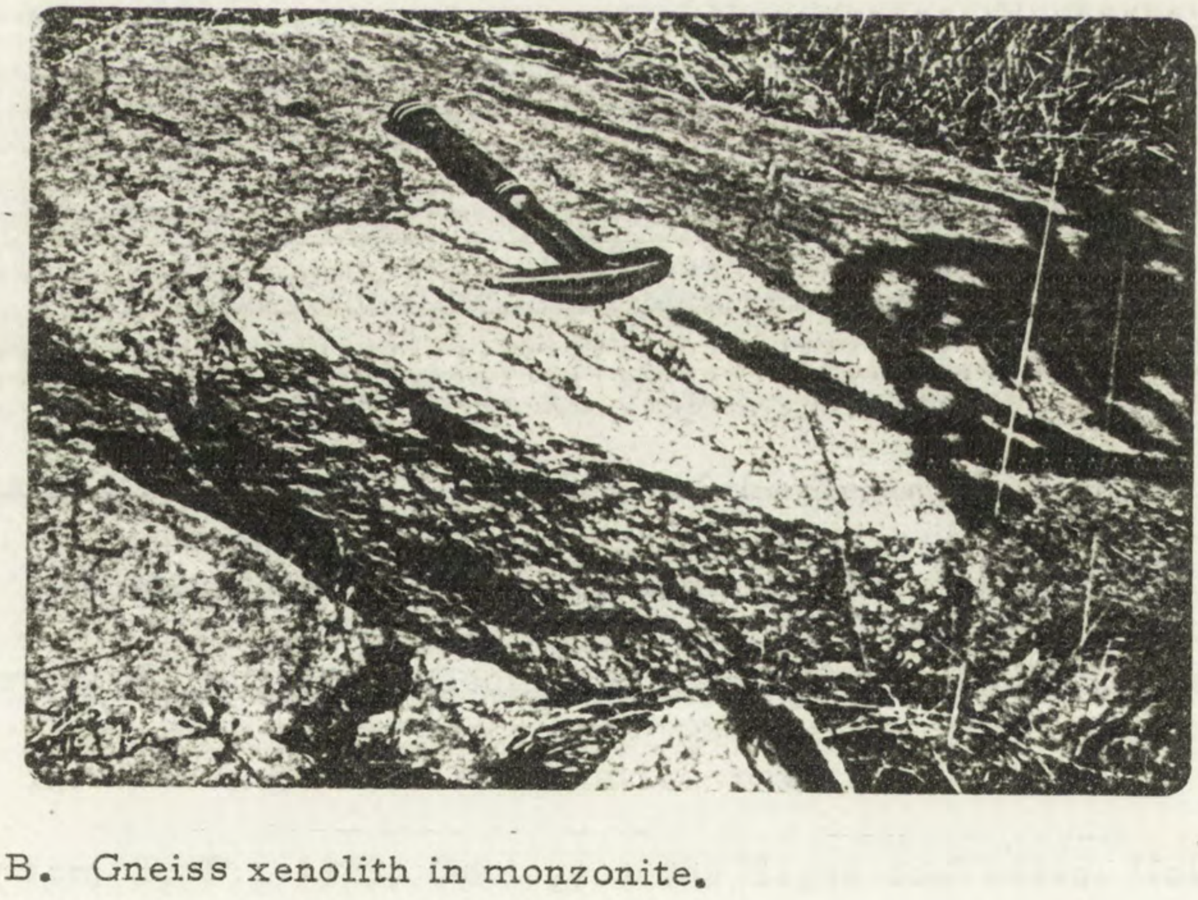
0 1/2 mm.



B. Gneiss. Quartz (Q) and microcline (M) band adjacent to microperthite (MP). Crossed nicols. (SM-41-A)

PLATE 3

A. View north of the San Pedro-Ortiz porphyry belt. South Mountain in the foreground, San Pedro Mtns., Ortiz Mtns., and Los Cerrillos (only faintly) extending northward.



B. Gneiss xenolith in monzonite.

PLATE 4

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