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William R. Muehlberger and R. E. Denison

1964, pp. 62-69. https://doi.org/10.56577/FFC-15.62

in:

Ruidoso Country (New Mexico), Ash, S. R.; Davis, L. R.; [eds.], New Mexico Geological Society 15 th Annual Fall Field Conference Guidebook, 195 p. https://doi.org/10.56577/FFC-15

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PRECAMBRIAN GEOLOGY OF SOUTH-CENTRAL NEW MEXICO

William R. Muehlberger and Rodger E. Denison

Department of Geology and Crustal Studies Laboratory
The University of Texas, Austin, Texas

INTRODUCTION

The Ruidoso country contains no Precambrian outcrops and no wells in the region to penetrate to it. To interpret the Precambrian geology of the actual field trip area we have therefore selected the larger area shown in figure 1, which gives sufficient regional control for interpolation into the Ruidoso country. The extensive outcrop belt of the San Andres Mountains, Sierra Oscura, Los Pinos and southern Manzano Mountains form the western flank; the exposures in southern Torrance County as well as the numerous wells in that area form the northern; a line of wells along the western margins of some of the Precambrian belts in eastern New Mexico forms the eastern flank; the southern line has been drawn in Otero County north of the Tertiary intrusive rocks that extend into Trans-Pecos Texas. This contribution furnishes petrographic descriptions of basement well and outcrop samples (Denison) and a synthesis of Precambrian history in the map area (both authors).

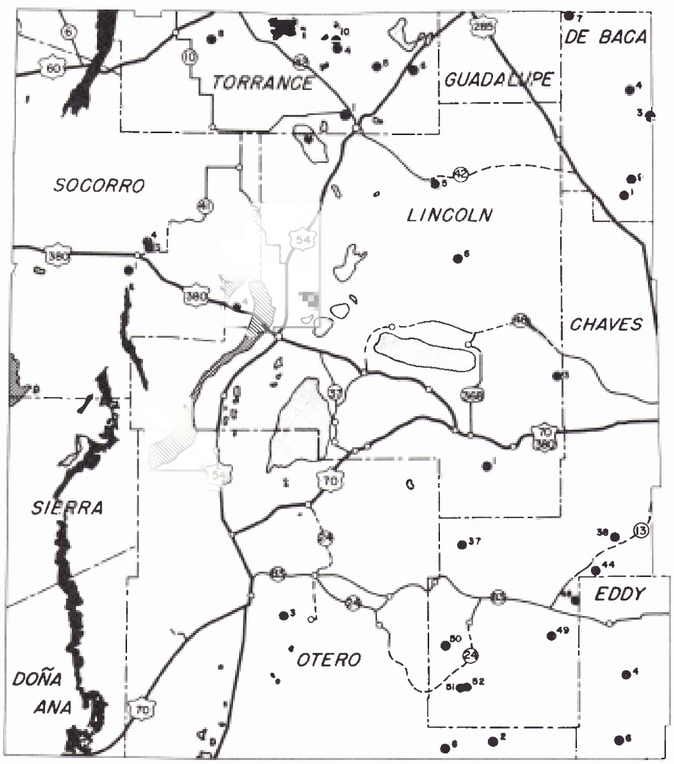
PREVIOUS WORK AND PRESENT PROJECT

Numerous studies have touched on various aspects of the map area. The most complete general references include individual studies on outcrop belts in the southern Manzano (Stark, 1956), Los Pinos (Stark and Dapples, 1946), San Andres (Kottlowski and others, 1956, Kottlowski, 1959), and Organ Mountains (Dunham, (1961), and Flawn (1956).

The basement rocks in this area can be placed into petrographically allied rock groups. Some of the state-1935); Bent dome (Bachman, 1960); and regional subsurface studies by Foster (1959), Foster and Stipp ments made concerning these groups are defensible only in light of our larger study to make a geologic map of the buried basement of North America. This project is an outgrowth of the AAPG Basement Rocks Committee project to prepare a map at a scale of 1:5,000,000 showing the wells that penetrate the basement, contours on the surface of the buried basement, and gross lithology of the exposed basement. We are making a petrographic study of sample materials from each basement well, and isotopic age determinations of selected samples in order to work out the geologic history of the Precambrian.

ACKNOWLEDGEMENTS

Our sincere thanks to Roy W. Foster, New Mexico



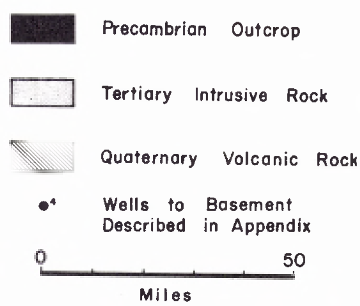


Figure 1. Map of south-central New Mexico showing locations of wells to basement, Precambrian outcrops, Tertiary intrusive rock and Quaternary volcanic rock.

Bureau of Mines and Mineral Resources, who picked the sample materials from the wells and collected samples from the Sierra Oscura and San Andres Mountains. In addition we have obtained samples from various company files and individuals which have made isotopic age determinations possible. In areas of such sparse control and complex geology, each basement well is valuable and needed. Isotopic age determinations for our program have been made by members of the Isotope Geology Branch, U.S. Geological Survey, S. S. Goldich, Chief. This work has been performed under Contract AF 49 (638)-1115 of the Air Force Office of Scientific Research as part of the Advanced Research Projects Agency Project VELA UNIFORM.

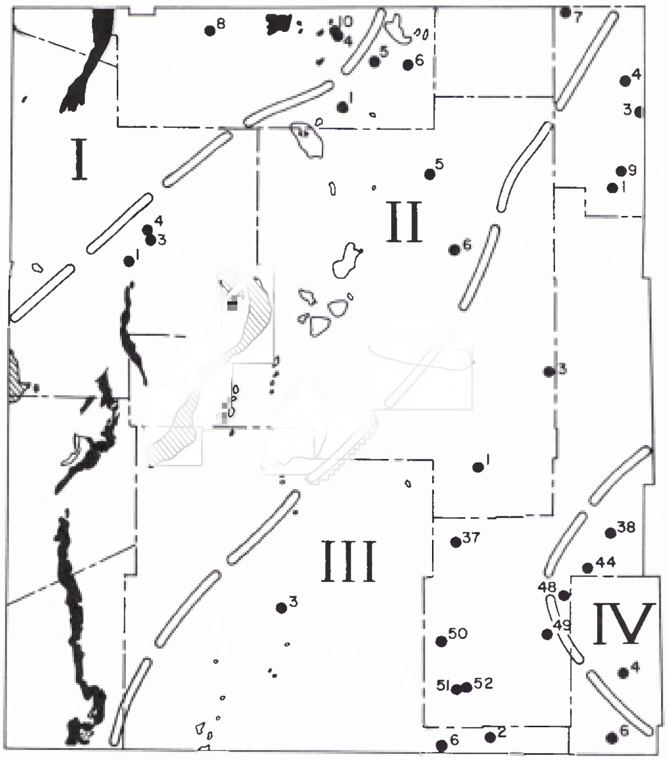


Figure 2. Map of south-central New Mexico showing Precambrian subdivisions described in text: 1, Northwest metamorphic area; II, Central granite belt; III, Sediment and diabase belt; IV, Southeast granite gneiss area.

REGIONAL STATEMENT

The Precambrian rocks of the map area are divisible into four geologic units.

1. *Northwest metamorphic area (I)*.— This includes the southern Manzano and Los Pinos Mountains (the band of black shown in fig. 1) in northeastern Socorro County, and most of southern Torrance County. The basement rocks are dominantly metasedimentary and metavolcanic with minor intrusive granitic masses.

2. *Central granite belt (II)*.—The area north of a line drawn from the southwest to the northeast corner of the map area and south of the Northwest metamorphic area includes practically all of the Precambrian outcrops in the San Andres Mountains and Sierra Oscura and the wells in Torrance and Lincoln Counties that penetrated either granite, granite gneiss, or granodiorite gneiss. This also includes metasedimentary rock exposed in the San Andres Mountains in a band straddling the Sierra-Dona Ana county lines.

3. *Sediment and diabase belt (III)*.—The belt south of the central diagonal and also possibly the area of the field conference are underlain by Precambrian sedimentary rocks that have been extensively intruded and contact metamorphosed by sills and dikes of diabase. The sequence consists largely of quartzite and siltstone, and in a small portion of the area impure limestone. Some of these rocks also crop out in the San Andres Mountains where they overlie the older metamorphic rocks and underlie the Bliss Sandstone (Kottlowski, 1959, p. 261). This Precambrian sedimentary sequence resembles those found in the Franklin Mountains near El Paso (Harbour, 1960) and in the Van Horn region of Trans-Pecos Texas (King and Flawn, 1953). The total thickness is unknown but is probably not great.

4. *Southeast granite gneiss area (IV)*.—A group of wells penetrate granite gneisses in southern Chaves and northwest Eddy Counties. This is the western edge of a complex igneous-metamorphic suite of basement rocks in southeast New Mexico.

DESCRIPTION OF INDIVIDUAL AREAS

Northwest metamorphic area (I).—The Los Pinos and southern Manzano Mountains have been mapped and described by Stark and Dapples (1946) and Stark (1956). The following summary is abstracted from their work. The trend of metamorphic rocks essentially parallels the length of the range. The Precambrian stratigraphic sequence consists of a lower metaclastic series unconformably overlain by about 7,000 feet of quartzite, muscovite schist, and quartzite in ascending stratigraphic order. These have been named Sais Quartzite, Blue Springs Muscovite Schist, and White Ridge Quartzite, respectively. This sequence is in turn overlain unconformably by the Sevilleta Rhyolite, which is at least 4,000 feet thick. All of these units have been tightly folded into an asymmetric syncline whose axis strikes northeast across the range. Regional cleavage was developed during this folding episode. Cross folding, faulting and small crenulations were later developed on earlier schistosity. Granitic rocks that intruded this metasedimentary sequence have been divided into a gray equigranular biotitic granite and a younger porphyritic pink granite that is gneissic in places. Granitic rocks of this character have an isotopic age of about 1.35 b.y. in the Sandia Mountains near Albuquerque (Tilton, Wetherill, and Davis, 1962).

Southern Torrance County includes the southernmost portion of the Estancia basin wherein most wells have penetrated metasedimentary rocks that are very similar to the Precambrian rocks in the Los Pinos and Manzano Mountains. The Pedernal uplift consists of granitic rocks flanked by these metasedimentary units. The trend of this belt appears to be south-southwestward under the Jornada del Muerto and may well connect with the metasedimentary rocks of the central San Andres Mountains. North of the map area this metasedimentary terrane extends under the Galisteo basin and is exposed in the high mountains of the upper Pecos River drainage.

Central granite belt (II).—The San Andres Mountains and Sierra Oscura are dominantly underlain by Precambrian rocks that are described by Kottlowski (1959, p. 261) as follows:

> "Red to gray granites, including roof-pendants of various schists and gneisses, and cut by pegmatite and diabase dikes, occur in the northern and southern parts of the mountains. From Sulphur Canyon to south of Hembrillo Canyon a thick series of metamorphic rocks is exposed including mica and quartz-feldspar schists, quartzites, amphibolites, phyllites, talc schist, talc, and dolomite, intruded by diabase and aplite dikes and by small masses of granite. Foliation of the metamorphic rocks along Hembrillo Canyon strikes N. 30-45°W. and dips steeply westward."

Samples furnished by Foster from this outcrop belt and from wells to the north of the Sierra Oscura demonstrate similar lithologies, the rocks being either granite, granite gneiss, or granodiorite gneiss. Some of these are porphyroblastic granite or porphyroblastic gneiss. Foster suggests (written communication, 1963) that the gray biotite granite has been intruded by pink two-mica granite. Similar appearing granite and granite gneiss are found in southeastern Torrance and northern Lincoln Counties. Isotopic age determinations in this belt of granitic rocks are somewhat variable and suggest two thermal events. Samples from the Sun #1 Bingham State (Socorro 1) give 1.57 b.y. by the rubidium-strontium method on feldspar and 1.35 b.y. by potassium-argon on biotite. This suggests that the rock had an original age near the feldspar age and was reheated at about the time of the biotite age. Determination by rubidium-strontium methods on samples from the southern Sierra Oscura in sec. 5, T. 9 S., R. 6 E., gave a total rock age of 1.30 b.y. and gave 1.43 b.y. on a sample of granodiorite gneiss from sec. 3, T. 13 S., R. 4 E., in east-central Sierra County. Isotopic determinations to the southwest in Dona Ana County suggest ages near 1.30 b.y. with no evidence of two thermal events. Farther south in west Texas ages near 1.00 b.y. have been reported (Wasserburg, and others, 1962).

The variations in isotopic ages in this belt suggest two successive thermal events for at least the northwestern portion of the area. Two ages of metamorphism, or at least two ages of shearing, can be demonstrated in much of the outcrop belt in the Manzano and Los Pinos Mountains. These events may well be those recorded by the isotopic ages determined on samples from the Sun #1 Bingham State well. The total rock age in central Sierra County is apparently an average of the two ages in the Sun well. The other isotopic dates suggest that no record of this early event remains in the minerals used in isotopic age determinations.

Sediment and diabase belt (III).—Most of the map area south of the central granite belt contains Precambrian quartzite and siltstone and in some cases impure limestone. These have been extensively intruded and contact metamorphosed by dikes and sills of diabasic rock. Similar sedimentary rocks are exposed in the Central San Andres Mountains where they are intruded by dikes of pale pink aplite (Kottlowski, 1959, p. 261). These aplite dikes are truncated by the basal beds of the Bliss Sandstone.

This nearly unmetamorphosed sedimentary section which underlies the Bliss Sandstone is very similar in general character to the Precambrian rocks exposed in the Franklin Mountains and may well be correlative with them. The presence of lithic fragments of what appears to be rhyolite indicates a rhyolite source in the near vicinity. There are two of these: the Panhandle volcanic terrane to the east, with isotopic age of about 1.2 b.y.; the Franklin Mountains rhyolite to the south which gave a total rock age of 0.99 b.y. by rubidium-strontium techniques on a sample from 4,850 feet south, 500 feet west of 31°52'30"N, 106°30'W. It is not known which of these was the source although the presence of diabase suggests that the sediments are younger than the Panhandle Rhyolite and older than the Franklin Mountains rhyolite.

The curious occurrence of albite in the basic rock in six of the wells, as well as its generally femic-poor character makes these rocks distinctive. Strongly amygdaloidal textures and devitrified volcanic glass in some of these basic rocks suggest that the diabases may be part of an extrusive-intrusive complex that was contemporaneous with deposition of the clastic sediments. No physical connection is known, nor have isotopic age determinations been made to corroborate this suggestion.

The exposure of these rocks nearest to the field trip area is at Bent Dome (Bachman, 1960) where Precambrian quartzite, granitic rock, and associated diorite underlie the Paleozoic rocks at the south end of the Pedernal uplift.

Tertiary igneous rocks occupy much of the Pedernal uplift today and obscure the Precambrian. In addition the Precambrian crystaline basement is downwarped out of sight in the broad Laramide basin extending from Sierra Blanca northward to the Jicarilla Mountains, but the late Precambrian sedimentary rocks are preserved along the southeast flank of this basin.

Southeast granite gneiss area (IV).— Four wells in the southeast corner of the map area penetrate banded granitic gneisses. Detailed petrographic study show these to be gneisses of metamorphic origin rather than primary flow-banded intrusive granitic rocks. They are of high rank metamorphic grade and are the extension of an area of similar rocks lying immediately to the east. The Eddy County well, however, penetrated two distinct rock types: a coarse biotite granite, and a rock similar to the granitic gneisses previously described. These rocks are similar in age to those of the central granite belt although those to the southeast toward the Central basin platform are somewhat younger.

SUMMARY

A thick Precambrian sedimentary and rhyolitic sequence was deposited, folded, and then intruded and metamorphosed by granitic rocks about 1.57 b.y. ago. Igneous activity again occurred about 1.35 b.y. ago followed by a long period of erosion. Limestone, sandstone, and siltstone were deposited across the deeply eroded surface of these older rocks and diabasic rocks were intruded and extruded. If these rocks are related to those in the Franklin Mountains their minimum age is 1.0 b.y. The Precambrian history of the area as presently interpretable ended with the basal Paleozoic deposition of the Bliss Sandstone. Hopefully a study of Laramide intrusions will furnish information on the general composition of the underlying crustal layers, and inclusions within the igneous rocks may preserve sufficient material to indicate the nature and composition of the Precambrian basement rocks that underlie the eruptive centers.

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APPENDIX

Petrographic descriptions of basement samples in the area of figure 1. For data concerning depth to basement, total penetration, etc. see Foster and Stipp (1961). County well numbers are those of Foster and Stipp. Mineral percentages are given only for rocks which were suitable for modal analysis.

CHAVES COUNTY

Chaves 37: Humble #1 State N; 35-14S-17E. Thin sections: 2610-2700'; 2700-2770'; 2770-2790'; 2790-2830'; 3880-4010'.

Flawn (1956, p. 210) described cores at 3476', 3500-3503', 3804-3809', 3835', 3936', 3939' as diabase, microgranodiorite, and metaquartzite and suggested the possibility of a Tertiary age for the igneous rocks. The later interpretation of Foster (1959) indicated a Precambrian age for the overlying sediment (thought to be Permian by Flawn) and appears to fit the general pattern to the west. The upper intervals are generally medium-grained quartzites and arkoses in part argillaceous and thin bedded. There are no identified crystalloblastic minerals, and micaceous minerals are interpreted as detrital. The diabases are unaltered with clear plagioclase laths and subophitic pyroxenes. Some olivine is present and olivine diabase is probably the best general name to apply to all of the intrusions. No microgranodiorite was identified in any of the above intervals.

Chaves 38: Magnolia #1 Turney; 23-14S-22E. Thin sections: 4920-5000'; 5150-5200'; 5245-5280'; 5290-5340'.

A difficult well to interpret—Flawn (1956) considered the rock at 5321-24' to be an albite granodiorite gneiss and epidote chlorite oligoclase gneiss. The rock from 4920' through 5200' is a rather coarse diabase with local granophyric patches in the upper interval. The diabase contains some fresh pyroxene, plagioclase, opaque minerals and various alterations. The lower intervals are characterized by exceptionally erratic texture and uneven quartz distribution. Some parts appear gneissic with preferentially oriented chlorite and a rude banding of quartz-poor and granophyric material. It is possible that the rock is banded by primary flowage but similarities to the rock in Chaves 44 support a metamorphic origin. In any case the grade of metamorphism is comparatively high grade. The feldspars appear to be perthitic and are uniformly clouded with alterations and hematite dust. The diabase intrudes the granitic rock; however, if the features of the granitic rock are metamorphic and not primary igneous then the diabase is also post metamorphic.

Chaves 44: Humble #1 Gorman; 30-15S-22E. Thin section: 5805-5825'.

This rock appears to be a banded granite gneiss. Some chips are composed of plagioclase, quartz and preferentially oriented chlorite; others are a mosaic of clear microcline, quartz and plagioclase in a typically metamorphic granoblastic texture. The plagioclase is sodic oligoclase and contains both sericite shreds and uniform clouding accompanied by hematite dust. One cutting chip contains biotite with minor chlorite alterations which suggests that the chlorite in other chips is retrograded from biotite. Epidote, a strongly colored variety, is associated with chlorite. The general character of the material in this well supports a metamorphic origin for the rock in Chaves 38.

Chaves 48: Black #1 Shildneck; 24-16S-20E. Thin sections: 6740-6780'; 6830-6850'; 6890-6910'; 6970-6990'.

The first interval is a well defined granite gneiss. Partly chloritized biotite appears to have a fair preferential orientation and is set in a granoblastic mosaic of clear microcline, quartz and plagioclase. Smaller amounts of opaque minerals, sphene, zircon and apatite are present. The lower three thin sections are of diabase which is fairly uniformly altered. The upper diabase is considerably finer grained and undoubtedly younger than the granite gneiss and is post metamorphic. Most of the plagioclase has numerous micaceous alterations uniformly distributed. Chlorite and epidote replace portions of the pyroxene. Cutting chips in the lower interval contain patches of finer material rich in apatite and stained a reddish color by hematite. This reddish material may be but a residual potash feldspar and is unusual.

Chaves 49: Magnolia #1 Black Hills Unit; 31-17S-20E. Thin sections: 5915-5940'; 6000-6045'; 6065-6085'.

Quartzitic and arkosic sandstones are associated with argillaceous intervals. The argillaceous material appears to have no preferred orientation and is somewhat silty and highly siliceous. The interval from 6000-6045' contains delicately bedded chloritic-carbonaceous shaly intervals and dirty sand. At least one chip in this interval contains abundant fine-grained carbonate. Sparse glauconite is found in the sandy beds. The quartzites have abundant feldspar or feldspar alterations and some lithic (rhyolitic?) detritus. This interval is very well cemented by secondary growth and is essentially nonporous.

Chaves 50: Gulf #1 Chaves "U"; 10-18S-16E. Thin section: 3100'±.

The thin section is in the Texas Bureau of Economic Geology collection and was described by Flawn (1956, p. 208) as a tuff or flow. This may be a correct interpretation but the evidence is not strong. Foster and Stipp (1961, p. 147) reports a section of dolomite and talc above this interval. Pray (1961, p. 26) believes the Precambrian interval in this well to be several hundred feet of relatively pure dolomite and some igneous intrusive rocks that have created contact metamorphic minerals. The rock is exceptionally fine grained, containing sparse sand-size grains of microsline, quartz and other feldspars set in a sub-microscopic matrix that in plane light has a tuffaceous appearance. However it is most unusual for a devitrified tuff material to have no crystalline structure in polarized light and the matrix may be clay-like material. Small porphyroblasts in the goundmass have anomalous interference colors near the cores, are slightly zoned, contain abundant inclusions, and are tentatively identified as scapolite. Abundant disseminated carbonate is present in some areas of the slide. The well is possibly related to the meta-carbonate sequence in Otero 6. We interpret the rock in this well as of clastic sedimentary origin rather than a tuff.

Chaves 51: Sun #1 Pinon Unit; 19-19S-17E. Thin sections: 1732-1761'; 1800-1823'; 1848-1883'; 1897-1911'.

The entire interval appears to be an altered albite andesite porphyry as reported by Flawn (1956, p. 213). The interval and chips within intervals vary slightly but the general character is comparatively uniform. The only primary minerals are albite occurring as both phenocrysts and groundmass material and opaque material. Epidote replaces them extensively throughout as aggregates of crystals, abundant discrete crystals in albite and in amygdules. Chlorite and vermicular biotite masses replace the former femic mineral. Chlorite, quartz and albite are amygdaloidal minerals. It is suggested that the rock has been metamorphosed rather than simply epidotized and hydrothermally altered. Biotite appears crystalloblastic and unlike simple secondary (alteration) biotite. Some phenocrysts are up to 4 mm in diameter.

Chaves 52: Sun #2 Pinon Unit; 20-19S-17E. Thin section: 1650-1659'.

This is a meta-albite andesite containing phenocrysts of albite (near An_9) set in a recrystallized groundmass of quartz, biotite-chlorite and micaceous alterations; some cutting chips contain hematite, which masks the character of the minerals. Epidote is common in some chips but is never as abundant as in Chaves 51 and is in fine granular aggregates — never well crystallized. Sparse zircons are striking and unusual in this type rock. The albite phenocrysts are partly altered with mottled micaceous material. The groundmass is finely granoblastic with olive-green biotite as the most crystalline mineral. Rounded quartz aggregates may be a reconstitution of amygdules. This porphyry is considered to be metamorphosed to middle greenschist facies in the groundmass while the phenocrysts remain as igneous relicts.

DE BACA COUNTY

DeBaca 1: Transcontinental #1 McWhorter; 6-3S-22E. Thin sections: 4360-4370'; 4636-4768'.

The upper interval is a diabase containing laths of slightly zoned calcic plagioclase, relict pyroxene mostly calcitized and chloritized, opaque minerals, and tremolitic amphibole, biotite and generally indeterminant feldspar alterations. The fabric is subophitic. Samples from the lower interval are exceptionally poor—the largest cutting chip is less than 1 mm. in length. On the basis of the partial textures seen in the larger chips the rock is interpreted as a slightly metamorphosed clastic sediment. Quartz appears to be the most abundant detritus and certain chips may be derived from quartzite beds within this interval. Argillaceous and silty argillaceous material is also present in abundance.

DeBaca 3: Katz #1 Marble Field; 13-1N-22E. Thin sections: 5390-5490'; 5490-5550'; 5550-5580'.

The nearly two hundred feet of penetration appears to be totally in altered albite basalt (spilite?). The rock is now composed chiefly of plagioclase and its alteration products, chlorite and opaque minerals. There are numerous amygdules filled with chlorite, hematite-stained plagioclase, and chalcedonic quartz. The general character of a devitrified semiopaque basaltic glass, partially well-defined pilotaxitic texture and development of amygdules strongly suggest an extrusive basalt flow. The rock has undergone no metamorphic events of any sort since extrusion as shown by the undisturbed devitrified glass. The alteration of the feldspars either to calcite or an indeterminate clay-mica-zeolite mixture is considered deuteric. The alteration may be associated with the albitization of a more calcic plagioclase.

DeBaca 4: Pair #1 Overton-Federal; 20-2N-22E. Thin section: 5410-5420'.

This is an amygdaloidal albite basalt containing chiefly plagioclase, chlorite, and opaques. The plagioclase appears to be intermediate albite but is extensively and uniformly clouded with alterations and disseminated hematite dust. All primary femic minerals have been converted to chlorite. Calcite is found as thin veinlets. Numerous tiny apatite needles are present. This rock is similar to that found in DeBaca 3 and the sodic character of the plagioclase in both wells is distinctive.

DeBaca 7: South Basin #1 Good; 5-4N-20E. Thin sections: 4670-4730'; 4730-4770'.

Both intervals appear to be essentially the same type of rock, a metamorphosed clastic sediment. The common crystalloblastic minerals are chlorite, sericite-muscovite and epidote, and all are preferentially oriented. In at least one chip the mineral assemblage includes a blue-green amphibole, biotite, epidote, quartz and feldspar, and suggests a metabasic rock. The crystalloblastic micas and epidote vary extensively in proportions in cutting chips and are set in a quartz or quartz-feldspar mosaic, again varying from cutting chip to cutting chip. This rock is interpreted to have been an argillaceous silty sediment in which a diabase was injected and then metamorphosed to a greenschist facies assemblage in the quartz-albite-muscovite-chlorite subfacies.

DeBaca 9: Talbert #1 Andree; 20-2S-22E. Thin section: 5110-5340'.

This well penetrated silty iron-rich argillites and fine arkosic sandstones. The argillaceous material is hematite-rich, and one chip contains abundant fine carbonate. The hematite-rich areas are local and at least one has a tuffaceous appearance. The fine arkosic sandstone chips average about 0.1 mm in grain size and contain abundant intergranular carbonate. The mineral detritus is largely quartz with feldspars of various types and some lithic debris possibly rhyolitic in origin. Opaque minerals are common in the sandstones, apparently as detrital grains. The well is interpreted to be in an essentially unmetamorphosed sequence of bedded sandstones and argillites and is not dissimilar to rocks penetrated in surrounding wells.

EDDY COUNTY

Eddy 4: Magnolia #1 Tres Ranchos Unit; 10-19S-23E. Thin section: 10,000-10,010'.

This rock is granitic but appears to be of two types. One is a coarse biotite granite containing plagioclase, microcline and strained quartz with a typical hypidiomorphic (igneous) texture. The grain size is generally greater than 3 mm. Minor amounts of hornblende, magnetite, sphene, apatite, zircon, sphene-leucoxene, epidote and chlorite-calcite replacing biotite are present. Alteration of feldspars is minor. The finer grained chips are equigranular about 1 mm. in size. In the other rock type the texture is not typical of igneous rock and is very similar to gneissic granites. In the finer cutting chips chlorite shows a very modest preferential orientation, some associated with muscovite. Microcline is generally fresh. Plagioclase, near An_{10}, is more altered and contains small sericite flakes. Quartz in both coarse and fine chips is generally strained. Tentatively the rock is interpreted as a banded granite gneiss possibly derived from the metamorphism of normal granite.

Eddy 6: Magnolia #1 State W; 16-21S-22E. Thin sections: 11,230-11,250'; 11,280-11,290'; 11,312' (core).

The first interval contains chips of relatively pure quartzite. The quartz contains secondary overgrowths and is associated with minor amounts of feldspar, opaque minerals, and lithic detritus that mostly appears to be rhyolitic. A material identified as collophane occurs as common, apparently detrital, grains. All other chips are of diabasic rock. The plagioclase is calcic albite and is in lath shapes associated with chlorite, well crystallized epidote, opaque minerals and calcite. The lowest interval is a quartz-epidote rock with smaller amounts of chlorite, opaque minerals and sphene. The alteration of the diabase and indeed the original rock are very similar to those in Chaves 51 and 52. The rock in this well is interpreted as an albite diabase intruding a quartzite and later metamorphosed or hydrothermally altered.

LINCOLN COUNTY

Lincoln 1: Stanolind #1 Picacho; 10-12S-18E. Thin sections: 2538-2603'; 2682-2759'.

This rock is a feldspathic quartzite containing coarse material about 1 mm. in size and fairly well sorted sand averaging 0.15-0.2 mm in diameter. No new metamorphic minerals are noted but calcite-siderite has replaced other minerals along grain boundaries in some cutting chips. Most of the detritus is quartz with considerable feldspar, microcline, plagioclase and perthite. Rock fragments appear to be metamorphic in origin and many of the large quartz grains are extensively strained. Minor sphene, zircon, chlorite, opaque minerals, and feldspar alterations are present. This rock is similar to many sediments in the basement of eastern New Mexico.

Lincoln 3: Texam #1 Boyle; 11-9S-20E. Thin sections: 3100-3160'; 3270-3300'; 3400-3440'; 3500-3520'.

About 470 feet of albite diabase were penetrated in this well. The alteration is erratic but in general the albite laths are uniformly clouded and locally replaced by fine alterations. Brownish pyroxene has been almost completely replaced by chlorite and opaque minerals or epidote. Hematite-magnetite is common. Chlorite is present as femic pseudomorphs and amygdule-like fillings. Masses of epidote together with minor chalcedony and quartz replace portions of the original rock completely. Some intervals are porphyritic and amygdaloidal with chlorite-calcite-epidote and one is filled with well-crystallized brilliant apple-green pumpellyite. The rock name suggests an intrusive rock although the porphyritic and amygdaloidal character indicates an extrusive albite basalt.

Lincoln 4: Standard of Texas #1 Heard; 33-6S-9E. Thin sections: 7790-7840'; 8010-8040'; 8040' (core).

The rock in this well is, strictly speaking, a troctolite (olivine plagioclase rock). Troctolites, however, connote a large differentiated mass of gabbroic rock and this may not be the origin of this rock. Pyroxene occurs as thin rims around olivine and minor crystals. Olivine contains cracks filled by opaque minerals along which variable alteration has taken place. Very bright reddish biotite is well crystallized but present only in small amounts. Plagioclase contains mottled alterations but is generally fresh and well twinned. The core is the most altered of the three samples, and contains a sheared zone with a very mildly pleochroic yellowish biotite, calcite and chlorite. Most olivine has been replaced by chlorite-iddingsite. Plagioclase contains masses of a colorless amphibole. An approximate mode of the freshest material in percent is: 58.2, plagioclase; 19.7, olivine; 8.0, plagioclase alterations; 7.2, opaque minerals; 4.1, olivine alterations; 2.2, pyroxene; 0.6, biotite.

Lincoln 5: Malcom and Morrow #1 Franks; 23-2S-15E. Thin section: 2040-2100'.

This is a granodiorite containing minerals in the following percentages: 40.9, plagioclase; 32.4, quartz; 14.3, microcline; 5.0, plagioclase alterations; 3.0, chlorite; 2.8, epidote; 1.6, calcite; and traces of opaque minerals, sphene-leucoxene. The rock has a generally altered appearance with calcite and hematite veinlets in some chips. Epidote is well crystallized and abundant. Microcline is clear and unaltered; plagioclase is turbid with alterations, hematite dust and abundant discrete sericite flakes. The plagioclase appears to be intermediate oligoclase. Quartz is mildly strained to unstrained. Chlorite replaces a former femic mineral, probably biotite, and is accompanied by sphene-leucoxene as an alteration byproduct.

Lincoln 6: Elliot Production #1 Federal; 10-5S-16E. Thin sections: 2590-2660'; 2710-2760'; 2760-2770'; 2910-2970'; 3190-3250'; 3380-3420'.

This well penetrated about 850 feet of granite gneiss cut by abundant diorite dikes. The granite gneiss has a sheared appearance with relict eyes of plagioclase and microcline set in a biotite-rich quartz-feldspar mosaic. Some chips have a typical hypidiomorphic texture but most are gneissic. Plagioclase is slightly zoned and all feldspars are fresh except in some lower intervals where there is relatively uniform alteration. The diorite contains minor late intergranular quartz. Plagioclase laths are calcic andesine, are generally fresh, and near cores contain dustlike particles that may be rutile. Pyroxene contains schiller opaque minerals. Large red-brown biotite crystals are common but not abundant. A pale green amphibole appears to replace large parts of the pyroxene. The well is interpreted as intergranular granite gneiss intruded by diorite of unknown age. The diorite does not have a definite metamorphic imprint and no similar rocks are found in basement rocks of this area.

Lincoln: outcrop sample, Sierra Oscura; SE 1/4, 5-9S-6E.

This is a coarse-grained red granite with the following mineral percentages: 34.0, microcline; 31.0, quartz; 28.9, plagioclase and plagioclase alterations; 2.6, muscovite; 1.6, chlorite; 1.0, biotite; 0.6, epidote; 0.2, opaque minerals; and traces of sphene-leucoxene and zircon. Large microcline crystals contain poikilitically enclosed plagioclase and quartz. Microcline is generally fresh. Plagioclase is sodic oligoclase in composition and is turbid with alterations. Large porphyroblasts of muscovite are found as intergranular crystals and as smaller crystals enclosed in plagioclase. Quartz is moderately strained but there are no mortar textures or shear lineations. Biotite is partly converted to chlorite with attendant sphene-leucoxene and epidote. A rubidium-strontium isotopic age on a whole rock sample gave 1.30 b.y.

OTERO COUNTY

Otero 2: Standard of Texas #1 Scarp; 18-21S-18E. Thin sections: 2630-2635'; 2655-2660'.

Flawn (1956, p. 228) interpreted the lower interval as an analcitic syenogabbro, and the other rocks as gabbro. The rock in our thin sections is gabbroic with no positively identified potash feldspar and we favor the rock name diabase for the entire drilled interval. The freshest rock has a subophitic texture with reddish-brown pigeonitic pyroxene, sericitized plagioclase, primary opaque minerals, femic alterations, reddish-brown biotite near the opaque minerals, and a blue-green amphibole as well as a pale tremolitic amphibole replacing primary femic minerals. Epidote is common as a replacement mineral. Some sheared chips are noted. Numerous cracks in plagioclase are filled with a white virtually non-birefringent mica. The rock is fairly coarse grained with relict crystals to about 4 mm. in diameter.

Otero 3: Southern Production #1 Cloudcroft; 5-17S-12E. Thin sections: 4520-4530'; 4530-4540'; 4558-4561'; 4582-4593'; 4593-4602'; 4602-4607'; 4607-4620'; 4620-4631'; 4631-4643'; 4665-4672'; 4684-4686'; 4686-4697'; 4697-4702'.

The fourteen thin sections from this well show a quartzite and argillaceous quartzite sequence cut by diabasic dikes at 4558-4561', 4607-4631', and 4686' to total depth. Most intervals contain moderately well sorted and rounded quartzites and have only small amounts of lithic and feldspathic detritus. Some intervals around 4665' have quartz-feldspar detritus in a sericite matrix that appears to have been reconstituted. The interval from 4675-4680' contains masses of what appears to be fine-grained biotite with small enclosed grains; these masses are of unknown origin but are possibly reconstituted glauconite. The diabases range from exceptionally fine-grained indeterminate semiopaque devitrified glass with sericitized plagioclase laths to medium crystalline rock (4607-4631') containing fresh calcic plagioclase and mostly altered pyroxene. Apatite needles are common.

Otero 6: LeFors #1 Federal; 22-21S-16E. Thin sections: 2230-2250'; 2240-2250(2)'; 2255'.

Diverse metamorphic rocks were penetrated in this comparatively short interval. The four thin sections are all slightly different; however, some generalizations can be made. Several chips are epidote-feldspar rock with slight banding. Epidote locally is virtually the sole mineral. Wollastonite in radiating fibrous mats, very mildly anisotropic garnets, calcite and tremolite are the main rock forming minerals. The rock is interpreted as a contact metamorphosed impure limestone. The impurities are probably clays and silica with some dolomite. Several other minerals may be present but the fine character of the rock does not lend itself to confident determinations. Diabasic intrusion or the syenites found to the south may be the metamorphic agent.

SIERRA COUNTY

Sierra: outcrop sample, north side of Rhodes canyon; SW 1/4, 3-12S-4E.

This is a granodiorite gneiss with the following mineral percentages: 32.2, plagioclase; 19.0, quartz; 17.9, biotite; 16.6, microcline; 10.3, feldspar alterations; 1.7, sphene; 1.2, opaque minerals; 0.3, apatite; 0.3, hornblende; and traces of zircon, epidote, and chlorite. The foliation is outlined by a rude but persistent preferred orientation of the biotite associated with minor amounts of blue-green hornblende. Abundant well-crystallized sphene is associated with biotite and opaque minerals. Microcline is generally fresh with very delicate twinning. Plagioclase is intermediate oligoclase and contains extensive mottled alterations. Small amounts of myrmekite are present. Apatite is in large well-formed crystals. Quartz is mildly strained. Microcline crystals exceed 5 mm. Isotopic age on whole rock by rubidium-strontium methods is 1.43 b.y.

SOCORRO COUNTY

Socorro 1: Sun #1 Bingham State; 23-5S-5E. Thin section: 3139-3140' (core).

This is a granite gneiss with the following mineral percentages: 35.3, microcline; 27.7, plagioclase; 26.9, quartz; 7.4, biotite; 1.0 opaque minerals; 0.9, muscovite; 0.5, chlorite; 0.3, epidote; traces of zircon and apatite. The plagioclase is near An_{10} incomposition, though faintly zoned and containing general disseminated alterations. The microcline is clear and in part well twinned. The quartz is generally strained. Olive-green biotite is strongly pleochroic and has good preferred orientation. Chlorite replaces small amounts of the biotite. Muscovite is generally associated with biotite. The composition of this rock is essentially a "perfect" igneous granite. The rock is therefore interpreted as metamorphosed rock of igenous granitic composition. The microcline was dated at 1.57 b.y. by the rubidium-strontium method and the biotite was dated at 1.36 b.y. by the potassium-argon method.

Socorro 3: Lockhart #2 Lockhart; 33-4S-6E. Thin section: 2700-2800'; 2800-2850'.

This is a granodiorite gneiss containing uniformly sericitized feldspar; the few fresh chips do contain microcline. Both hornblende and biotite are common and are preferentially oriented. Chlorite replaces some biotite, sphene is well crystallized, and large epidote masses replace some feldspar. One quartz crystal contains over twenty included or partly included zircons. The plagioclase also occurs in crystals larger than 4 mm., and is calcic albite in composition. Average grain size is slightly larger than 1 mm. The interpretation is an igneous granodiorite metamorphosed by a later event, possibly that reflected in the Sun #1 Bingham State.

Socorro 4: Lockhart #1 Lockhart Federal; 28-4S-6E. Thin section: 2975' (core).

This is a granite or granodiorite gneiss with the following mineral percentages: 40.2, plagioclase and alterations; 28.7, quartz; 27.2, microcline; 1.2, biotite; 1.1, chlorite; 0.6, opaque minerals; 0.6, epidote; 0.4, muscovite; traces of zircon, sphene, and apatite. It is a crudely banded rock containing concentrations of biotite-chlorite showing modest preferred orientation along planes. The concentration of biotite is accompanied by an impoverishment of microcline. This suggests metamorphic differentiation of a rock, possibly very similar to that found in Socorro 1. The plagioclase, near An_{20}, is turbid with alterations and intensely altered near biotite-rich bands. Microcline is clear, containing very minor alterations. Epidote and muscovite are concentrated in the biotite-poor areas. Sphene is concentrated near biotite-rich zones.

Socorro: outcrop sample; 23-2N-3E, in Sevilleta Grant.

This is a pink granite gneiss with the following mineral percentages: 46.6, microcline; 41.4, quartz; 8.5, plagioclase; 1.7, biotite; 1.3, muscovite; 0.2, fluorite; 0.2, opaque minerals; and traces of sphene, feldspar alterations, and epidote. The general character is a highly siliceous gneissic granite containing only modest amounts of accessory minerals. The gneissic characters are mortared boundaries, aggregate quartz and biotite-muscovite preferentially aligned along planes. The biotite has a very unusual bright apple-green color and is associated with sphene. Microcline is fresh and slightly perthitic. The plagioclase is calcic albite and contains abundant fine sericite flakes. The quartz also occurs as large extensively strained crystals. This is probably a phase of the Los Pinos Granite of Stark and Dapples (1946).

TORRANCE COUNTY

Torrance 1: Lubbock Machine #1 Colbaugh; 12-1N-12E. Thin sections: 981-1000'; 1055-1075'; 1102-1126'.

This is a granite gneiss and sheared granite gneiss(?) containing roughly equal microcline, plagioclase and quartz with small amounts of biotite. The upper interval contains about five percent biotite having a moderate preferred orientation. The general character is very similar to rocks from wells to the southwest in Socorro County. The intermediate interval appears to be in part slightly coarser but has been brecciated and sheared to obscure many original characteristics. The lowest interval is similar to the upper interval but contains virtually no biotite. The sequence is interpreted as a granite gneiss possibly crudely banded and containing local shear zones that are probably not associated with a Precambrian event but with Paleozoic or younger tectonism.

Torrance 4: Stewart #1 Lemmons; 3-3N-12E. Thin sections: 190-234'; 352-414'; 614-701'.

These three intervals appear to be in the same type of rock: a muscovite-quartz-feldspar schist. Relicts(?) of quartz, plagioclase and potash feldspar are set in a finely granoblastic quartzo-feldspathic groundmass containing lepidoblastic muscovite. Rare micrographic material was noted and interpreted as relict. Minor opaque minerals including zircon and sphene-leucoxene and feldspar alterations are present. Replacement calcite is significant in some chips. The rock is tentatively called a rhyolite porphyry. One chip is a quartz-muscovite schist which does not support a rhyolite origin, but this may be a local band or other inhomogeneity in the rock.

Torrance 5: Associated #1 Luna-Federal; 25-3N-13E. Thin section: 546-568'.

The cuttings are composed of single mineral fragments, all smaller than 0.7 mm in maximum dimension. The fragments are quartz, microcline, plagioclase, biotite, opaque minerals, feldspar alterations, chlorite and epidote. The general composition and relative abundances correspond to a granitic rock. The lack of finer grained fragments suggest it may be a granitic rock and not a mineralogic equivalent such as metarhyolite. No interpretation of rock type is justified on the basis of the fine cuttings.

Torrance 6: Duran Dome #1 State; 31-3N-15E. Thin sections: 1457'.

There are only three small cutting chips on this slide and all appear to be granite gneiss. Microcline, plagioclase and quartz are common, myrmekite is locally developed. The biotite is strongly pleochroic and preferentially oriented. Microcline is clear with only minor alterations while primary plagioclase is mottled with extensive alterations. Small amounts of epidote and opaque minerals are present. This rock is tentatively correlated with the gneisses in Socorro County.

Torrance 8: Eidal #1 Mitchell; 33-4N-8E. Thin sections: 3518-3542'; 3557-3580'.

The upper interval is a hematite-rich muscovitic phyllite.

Most of the rock is hematite in ragged anhedral grains with abundant fine muscovite and quartz. Small amounts of tourmaline in smoky blue-green crystals and sphene are present. Minor feldspar may be associated with the quartz but the fine-grained character (finer than 0.7 mm) does not permit resolution of most of the rock. The lower interval is an amphibolite containing a pale green, mildly pleochroic amphibole, chlorite, epidote, sphene, opaque minerals, quartz, sericite, apatite, and minor indeterminate feldspar. Calcite replaces portions of the rock. Biotite was not identified. The texture is granoblastic with no apparent preferred orientation. The rocks are interpreted to be a pelitic rock and basaltic rock later metamorphosed to greenschist facies.

Torrance 10: Rogers and Poynor #1 Federal; 34-4N-12E. Thin section: 250-265'.

This is a muscovite schist containing granoblastic quartz-feldspar with lepidoblastic muscovite. There is a former abundant mineral now replaced by calcite rimmed by what appears to be a yellowish-red hematite stain. This stain also is found in linear bands in certain cutting chips. Small amounts of smoky blue-green tourmaline are present in sun bursts. Opaque minerals in discrete crystals and ragged anhedra, zircon, and feldspar alterations make up the remainder of the rock. The rock is interpreted to be a metamorphosed argillaceous feldspathic sandstone or may possibly have been derived from a volcanic rock although all relict textures have been destroyed.