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PRECAMBRIAN ROCKS OF THE NORTHERN PART OF THE NACIMIENTO UPLIFT, NEW MEXICO

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INTRODUCTION

The Nacimiento uplift bounds the central-eastern margin of the San Juan Basin and is the area of Precambrian exposure closest to the route covered by this field conference. Precambrian basement rocks have probably had a profound but subtle influence on the later geological development of the region; they are potential source rocks for mineral deposits (Woodward and others, 1974a; LaPoint, 1974) and have controlled some Cenozoic structures (Cordell, 1976).

REGIONAL SETTING

The principal areas having outcrops of Precambrian rocks around the San Juan Basin are the Needle Mountains to the north, the Tusas Mountains to the northeast, the Nacimiento Mountains to the east and the Zuni Mountains to the south (fig. 1). Small outcrops of Precambrian rocks in the Defiance uplift to the west are not discussed in this report.

Barker (1968) summarized the Precambrian geologic history of the Needle Mountains as follows: deposition of quartzose polymictic conglomerate; deposition of volcanic rocks of basaltic to intermediate compositions with minor graywacke, quartzite, siltstone, clay and iron-formation; emplacement of hypabyssal sills and dikes or ash-flows of silicic composition interlayered with basalt; intense folding and metamorphism; post-tectonic intrusion of granite about 1,720-1,780 m.y. (million years) ago; deep erosion; deposition of Uncompahgre Formation (quartz sand, aluminous shale and silt); low-grade metamorphism and isoclinal folding; intrusion of quartz monzonite and gabbro about 1,460 m.y. ago.

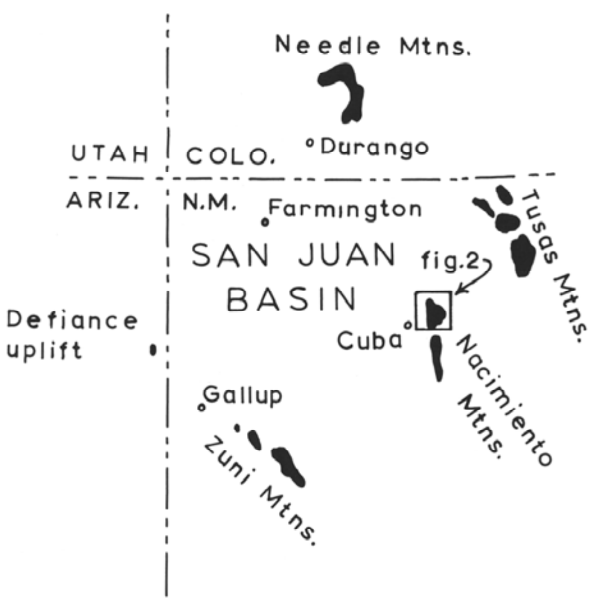

Figure 1. Index map showing outcrops of Precambrian rocks (in black) around the San Juan Basin. Scale approximately 1:4,760,000.

A summary of the Precambrian rocks of the Tusas Mountains was presented by Bingler (1974). He noted the occurrence of quartzite, quartz-muscovite-biotite schist, hornblende-chlorite schist, leptite, granitic gneiss, quartz diorite gneiss and granite porphyry. Bingler (1974, p. 111-112) reported three fold systems and described the facies developed during regional metamorphism. Schistosity generally trends northwest.

In the Nacimiento Mountains, there are two major areas of Precambrian exposures. The northern exposures are the main topic of this report and are discussed in detail below. Precambrian rocks of the southern part of the Nacimiento Mountains were described by Woodward and others (1974c); they described, from oldest to youngest, mafic xenoliths, muscovite-quartz schist, hornblendite, gneiss, quartz diorite, mafic dike rocks, granite, muscovite quartz monzonite and leucocratic dike rocks. At least two episodes of regional metamorphism occurred; the later metamorphism imparted a strong northeast-trending foliation across much of the area.

Fitzsimmons (1967) reported that the Precambrian rocks in the northwestern part of the Zuni Mountains were mostly red gneissic granite with minor metarhyolite and suggested that west-northwest-trending foliation is common. A map of the southeastern Zuni Mountains by Goddard (1966) shows that the most abundant rocks are gneissic granite, metarhyolite and porphyritic aplite; other lithologic types present include biotite schist, quartz biotite gneiss, hornblende gneiss, quartzite, quartz monzonite gneiss, aplitic granite, porphyritic granite, gneissic aplite, hornblendite, gabbro, intrusive basalt, diorite and monzonite dikes, syenite and biotite granite. In the southern part of the area, the foliation mostly trends northeast; in the northern and western part, the foliation is mostly east-west, although it is locally variable.

Northern Nacimiento Area

Only a generalized geologic map (fig. 2) is presented here, but the reader interested in the details of the geology can consult a series of 1:24,000-scale maps published by the New Mexico Bureau of Mines and Mineral Resources (Woodward and others, 1972, 1973, 1974b, 1974c, 1976; Woodward and Timmer, 1977). This area is about 6.4 km east of Cuba, New Mexico. The mapping of the Precambrian rocks was done by

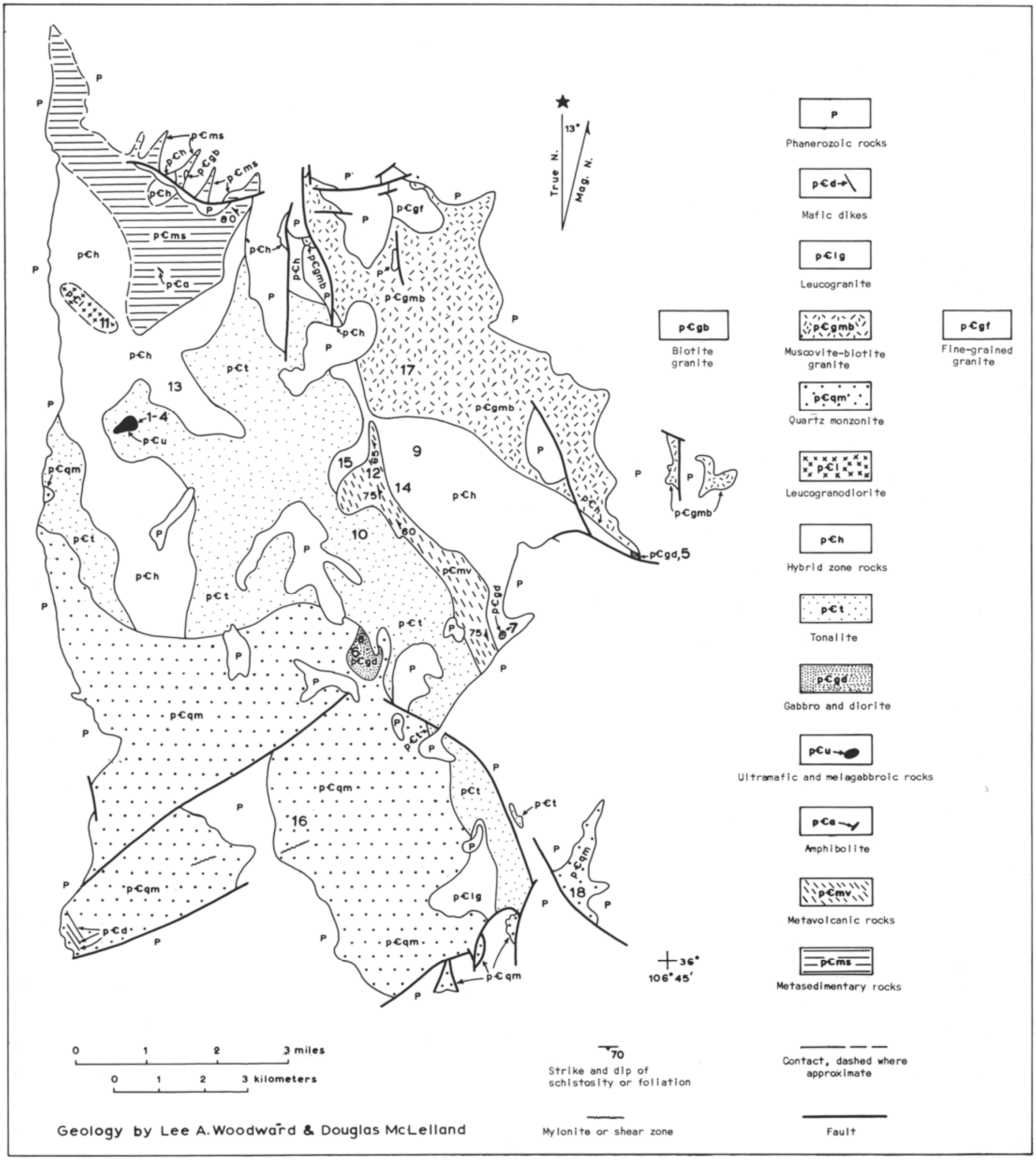

Figure 2. Generalized geologic map of Precambrian rocks of the northern part of the Nacimiento uplift, New Mexico. Numbers on map are keyed to chemical analyses shown on Table 1; there is no chemical analysis for locality 18. Western part of area is about 6.4 km east of Cuba, New Mexico.

Woodward and McLelland, and the chemical analyses were performed by Husler.

No previous detailed work has been done on the Precambrian rocks of this area. A reconnaissance map by Wood and Northrop (1946) shows the generalized outcrop pattern of Precambrian rocks undivided. A report by Santos and others (1975, p. C5-C7) noted that the Precambrian rocks of this area are granite, granite porphyry and diorite gneiss; however, the map in that report shows all the Precambrian as "granitic" rock.

Most of the area covered by this report is within the San Pedro Parks Wilderness, except for a strip about a kilometer wide along the western margin and small areas on the southern and eastern sides.

ROCK UNITS

Fourteen Precambrian rock units were mapped in the northern Nacimiento Mountains. Metasedimentary and metavolcanic rocks appear to be the oldest; they are followed by plutonic igneous rocks ranging in composition from ultramafic to leucogranite. The rocks are described in their probable chronologic order from oldest to youngest, and their generalized distribution is shown on Figure 2.

Metasedimentary Rocks

Very fine grained, light-tan to medium-gray metasedimentary rocks are exposed in the northwestern part of the area (fig. 2). These rocks are meta-quartz wacke, meta-arkose, metaquartzite, metagraywacke and silty argillite. They range from mineralogically and texturally mature rocks containing 98 percent quartz to rocks containing feldspar and quartz clasts in an extremely fine grained matrix of chlorite and sericite that makes up 60 percent of the rock. These latter immature and poorly sorted rocks are by far the most abundant. Textures range from granoblastic to moderately schistose, with minor amounts of porphyroblastic chlorite and biotite. Intercalated with the metasediments are minor amounts of metavolcanics and amphibolites that are described below.

The metasediments were sandstone, arkose, graywacke and silty shale prior to undergoing regional synkinematic metamorphism in the greenschist facies. Schistosity is not strong, but where present it trends northwest and dips steeply.

Metavolcanic Rocks

Metavolcanic rocks are exposed mainly in an elongate, northwest-trending roof pendant and as minor intercalations in the metasedimentary sequence. The metavolcanics are gray, pink and light greenish-gray, with a blastoporphyritic texture consisting of relict phenocrysts of quartz up to 3.0 mm in diameter in a very fine grained xenoblastic aggregate of quartz, albite and microcline with accessory biotite and white mica. Foliation, weak and defined by faint compositional banding and alignment of reddish-brown biotite, trends northwest and dips steeply.

The normative minerals calculated from a single chemical analysis (no. 12, table 1) indicate that this rock is best classified as a meta-quartz latite (=meta-dellenite). Chemically, the rock is intermediate between Nockolds' (1954) average dellenite and rhyolite.

The metavolcanic rocks were derived by regional metamorphism of silicic volcanics. The foliation probably is due mostly to penetrative deformation during regional metamorphism, although some may be attributed to relict primary flow. After regional metamorphism the metavolcanics were locally metasomatized near the contacts with a tonalite intrusion, resulting in growth of oligoclase poikiloblasts. Non-metasomatized metavolcanics analyzed by the Rb-Sr method give ages of 1,800 ± 50 m.y. (Brookins, 1974).

Amphibolite

A few small lenses of amphibolite up to 10 m long and 1 m wide are surrounded by metasedimentary rocks in the northwestern part of the area. The amphibolite is fine grained, dark greenish gray and slightly schistose. It is composed mostly of subhedral to euhedral hornblende and sodic plagioclase that is altered to epidote, sericite and chlorite. Trace amounts of opaque minerals and quartz are present.

These rocks appear to be derived from basic igneous dikes and sills injected into the sedimentary rocks prior to regional metamorphism.

Ultramafic and Melagabbroic Rocks

A body of ultramafic and melagabbroic rocks about 0.7 km across was marginally assimilated by tonalite. Near the core of the body the rock is dark gray to black; fine to medium grained; and composed of 45-50 percent hypersthene, 15-30 percent labradorite, 5-10 percent hornblende, 5-10 percent olivine and 5-10 percent biotite, with minor amounts of chlorite, opaque minerals and epidote. Modally these rocks are near the transition between melagabbro and pyroxenite. Four chemical analyses of rocks from this unit (table 1, nos. 1-4) more closely resemble Nockholds' (1954) average olivine-rich alkali basalt than average pyroxenites or other ultramafic rocks. Normative color indices range from 58.76 to 62.02.

Although the evidence is not conclusive, it appears that this unit was emplaced as a hypabyssal igneous body of mafic to ultramafic composition. Its original extent and configuration are unknown, as it is surrounded by younger tonalite that displaced and assimilated the margins of the body.

Gabbro and Diorite

Three small bodies ranging in composition from gabbro to diorite were marginally assimilated by younger tonalite and quartz monzonite. These mafic rocks are dark gray to black, fine to medium grained, and granular. The modal classification for many specimens could be either gabbro or diorite, depending on whether color index or plagioclase composition is chosen as the determining factor.

A specimen from location 6 (fig. 2) is composed of 25 percent pyroxene (augite and hypersthene), 15 percent hornblende, 45 percent plagioclase (mostly andesine), and minor amounts of biotite, chlorite, opaque minerals, epidote, sericite, and a trace of quartz. At locality 5 (fig. 2) the rock consists of about 25 percent hornblende, 5 percent biotite, 60 percent plagioclase (ranging from labradorite to andesine), 5 percent quartz, minor amounts of opaque minerals and epidote, and traces of pyroxene, apatite and chlorite. The rock at locality 7 (fig. 2) contains 30 percent hornblende, 10 percent biotite, 2 percent pyroxene, 50 percent plagioclase (mostly andesine), 5 percent quartz, and minor amounts of opaque minerals, apatite, epidote, sphene and myremekite.

Chemically these rocks (table 1, specimens 5, 6, 7 and 8) more closely resemble Nockolds' (1954) average pyroxene gabbro than diorite average compositions. Normative color indices range from 39.10 to 43.18, and normative anorthite content for plagioclase ranges from 60.62 to 63.64.

These mafic igneous rocks were probably emplaced as small hypabyssal bodies. Their original extent and configuration are not known, because they have been engulfed and partly assimilated by younger intrusive rocks.

Tonalite

Gray, medium-grained, equigranular tonalite is intrusive into the metasediments, metavolcanics, ultramafic-melagabbroic rocks and the gabbro-diorite bodies. The tonalite is composed of about 60 percent plagioclase (mostly oligoclase, but locally andesine), 25 percent quartz, up to 10 percent microcline, 5-10 percent biotite, and minor amounts of epidote, chlorite, sphene and opaque minerals. Locally the rock is granodiorite, containing abundant large pink megacrysts of microcline that appear to have formed metasomatically near contacts where the tonalite was intruded by younger quartz monzonite (PCqm).

Two chemical analyses of the tonalite (table 1, nos. 9, 10) are very similar to Nockolds' (1954) average biotite tonalite.

The mechanism of emplacement of this pluton is not known, although it clearly is of igneous origin. In the western part of the outcrop area, there is a northwest-trending foliation that may be either primary flow structure formed during emplacement or gneissic texture imparted by later synkinematic metamorphism.

Hybrid Zone Rocks

The hybrid zone consists of numerous irregularly shaped bodies of tonalite and pink porphyry that are too small to map individualy at 1:24,000 scale. The porphyry consists of quartz and milky-white oligoclase megacrysts up to 5.0 mm long in a very fine grained pink groundmass of microcline, quartz, sodic plagioclase and minor biotite. Contacts between the hybrid-zone rocks and the tonalite are broadly gradational.

The porphyry appears to have formed by recrystallization of the metavolcanics, with growth of oligoclase porphyroblasts near the contacts with the tonalite. Chemically the porphyry (table 1, nos. 13, 14 and 15) is very similar to the metavolcanics (table 1, no. 12).

Leucogranodiorite

A small body of leucogranodiorite (table 1, no. 11) appears to be intrusive into the tonalite in the northwestern part of the area. The leucogranodiorite is fine to medium grained and pink weathering; it has a weak foliation defined by narrow, gently undulating bands of quartz and feldspar surrounded by a xenomorphic granular mosaic of quartz, oligoclase and microcline. Biotite occurs in fine-grained, elongate lenses parallel to the foliation. The biotite is mostly replaced by chlorite and is accompanied by minor apatite and opaque minerals.

Brookins (1974) reported a radiometric age of 1,840 ± 170 m.y. for rocks from this unit.

Quartz Monzonite

Pinkish-gray quartz monzonite (table 1, no. 16) is composed of euhedral to anhedral pink microcline megacrysts up to 1.5 cm long in a medium-grained groundmass of blue-gray quartz, pink microcline, greenish-gray sodic plagioclase and minor biotite. Plagioclase is euhedral and sericitized, whereas the microcline is fresh and in the groundmass is anhedral. Locally the microcline megacrysts are mantled with sodic plagioclase, giving rapakivi texture. The exposures of quartz monzonite along the erosional inlier at American Creek (fig. 2, loc. 18) are equigranular, lacking megacrysts.

The quartz monzonite has partly assimilated and locally metasomatized the older host rocks, especially the tonalite. Shear zones trending east-northeast produced cataclastic rocks ranging from flaser gneiss to mylonite; the age of shearing is not known, but is presumed to be Precambrian.

Muscovite Biotite Granite

This rock is pink and weakly porphyritic, with elongate megacrysts of pink microcline widely scattered in a medium-grained groundmass of smoky quartz, pink microcline and pinkish-gray sodic plagioclase. There is accessory muscovite and biotite and a trace of garnet. Locally the granite contains irregularly shaped bodies of simple pegmatite. Only the southwestern margin of the pluton is exposed; it is marked by a fine-grained aplitic border facies. A single chemical analysis (no. 17) is shown on Table 1.

A small body of pink, fine-grained, muscovite-biotite granite occurs within the coarser granite (fig. 2) and may represent another facies of the larger pluton.

Biotite Granite

An erosional inlier of pink, medium-grained biotite granite is exposed in the northwestern part of the area. This rock is composed of microcline-microperthite, quartz, sodic plagioclase and accessory biotite. The relation of this rock to the muscovite-biotite granite is not known, but the biotite granite might be an extension of the larger granite pluton. The minor difference in composition could be caused by assimilation of the surrounding metasediments by the biotite granite.

Leucogranite

A body of leucogranite about 1.5 km long is intrusive into the quartz monzonite; a few other bodies of leucogranite are present but are too small to be shown on Figure 2. This rock is pink, fine grained and consists of microcline, quartz, sodic plagioclase and a trace of biotite. Numerous xenocrysts up to 1.0 cm long of blue-gray quartz and milky-white plagioclase appear to be derived from the quartz monzonite host.

Mafic Dikes

Several north-northwest-trending mafic dikes are intrusive into quartz monzonite in the southwestern part of the area. These dikes are up to 6 m wide and 1 km long and show well-developed primary flow structures. They are dark greenish gray, very fine grained and are composed of about 50 percent plagioclase (mostly albite), 20 percent greenish-brown biotite, 10 percent chlorite, 10 percent epidote and minor amounts of opaque minerals (mostly pyrite), calcite and hornblende.

Plagioclase is intensely altered to epidote, and the biotite is partly chloritized. This rock is mineralogically similar to kersantite, but lacks the characteristic lamprophyric texture (ferromagnesian phenocrysts in a groundmass in which the ferromagnesian minerals are notably idiomorphic).

One of the dikes contains abundant pyrite, and an analysis of this rock shows 2.2 ounces of gold per ton (table 2).

SUBSURFACE DATA

Very few wells have penetrated Precambrian rocks along

Table 1. Chemical analyses and molecular (modified CIPW) norms of Precambrian rocks of northern part of Nacimiento uplift. Numbers refer to localities shown on Figure 1.

	Ultramafic and Melagabbroic Rocks				Gabbro and Diorite				Tonalite		Leuco-granodiorite	Metavolcanic Rock	Hybrid Zone Rocks			Quartz Monzonite	Muscovite-Biotite Granite
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
SiO_2	45.55	46.09	46.66	46.94	49.25	50.00	51.56	52.31	66.91	68.26	75.71	74.92	71.43	77.06	77.21	71.06	77.51
Al_2O_3	10.30	10.70	10.75	9.89	15.15	15.78	11.99	14.80	14.67	14.65	13.15	11.40	13.55	12.20	11.80	14.80	13.00
Fe_2O_3	5.84	3.80	4.64	3.90	6.87	3.14	2.79	2.69	2.61	2.44	0.30	2.34	1.44	1.02	0.76	1.48	0.44
FeO	5.95	6.73	6.88	7.04	8.26	5.25	6.04	4.64	2.74	2.48	0.31	1.09	1.40	0.34	0.45	1.23	0.13
MgO	19.20	18.00	16.99	17.80	5.25	8.48	10.34	7.98	1.30	1.10	0.38	0.17	0.80	0.12	0.15	1.03	0.15
CaO	7.60	8.00	8.33	8.30	8.95	11.35	8.30	10.91	3.41	2.65	0.89	0.97	2.40	0.60	0.57	2.26	0.26
Na_2O	1.28	1.50	1.62	1.38	2.26	2.16	2.36	1.95	4.14	4.03	4.13	3.58	3.45	3.52	3.26	3.18	3.40
K_2O	0.57	0.71	0.80	0.64	0.60	0.53	1.61	0.94	1.87	1.79	3.70	3.80	3.80	4.25	4.60	3.48	4.82
$H_2O(+)$ $(+CO_2)$	3.77	2.93	2.06	2.66	1.50	2.27	2.45	2.22	1.47	0.96	0.87	0.62	0.84	0.54	0.33	0.80	0.40
$H_2O(-)$	0.14	0.14	0.10	0.24	0.07	0.12	0.11	0.08	0.02	0.15	0.07	0.16	0.06	0.10	0.02	0.04	0.00
TiO_2	0.53	0.56	0.60	0.51	1.30	0.62	1.22	0.49	0.64	0.79	0.05	0.34	0.50	0.16	0.15	0.42	0.10
P_2O_5	0.17	0.22	0.18	0.17	0.16	0.09	0.52	0.165	0.17	0.16	0.025	0.07	0.120	0.02	0.026	0.12	0.01
MnO	0.180	0.176	0.179	0.176	0.231	0.147	0.151	0.135	0.101	0.176	0.017	0.077	0.060	0.019	0.021	0.057	0.035
SrO	0.056	0.057	0.058	0.044	0.020	0.044	0.088	0.050	0.030	0.32	0.014	0.009	0.025	0.010	0.007	0.022	0.001
TOTAL	100.14	99.61	99.84	99.69	99.87	99.98	99.53	99.35	100.08	99.66	99.62	99.54	99.87	99.96	99.35	99.98	100.25
Total Fe (as Fe_2O_3)	12.45	11.28	12.28		16.05	8.97	9.50		5.66							2.85	0.59
L.O.I.	3.22	2.33	1.55		0.61	1.76	1.79		1.17							0.66	0.39
FeO after L.O.I.	1.03	1.31	2.26		0.21	0.66	0.14		0.00							0.00	0.00
SO_4 =	(-)	(-)	(-)		(-)	(-)			(-)								
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Q	0.0	0.0	0.0	0.0	6.52	0.92	1.04	4.91	24.68	28.56	33.01	35.91	29.08	36.79	37.31	31.20	36.13
Or	3.37	4.23	4.74	3.81	3.71	3.20	9.75	5.72	11.34	10.87	22.26	23.20	22.98	25.64	27.88	21.00	28.83
Ab	11.52	13.57	14.57	12.50	21.26	19.81	21.73	18.02	38.16	37.18	37.36	33.21	31.70	32.28	30.03	29.17	30.91
An	20.72	20.52	19.74	19.07	30.83	32.48	17.81	29.71	16.31	13.32	4.32	3.94	10.51	2.93	2.73	10.71	1.24
Di	12.89	14.54	16.52	17.17	11.73	19.64	16.92	20.01	0.0	0.0	0.0	0.47	0.77	0.0	0.0	0.0	0.0
Hy	23.05	17.26	16.60	22.60	16.18	19.52	26.90	17.76	5.42	4.48	1.31	0.25	2.45	0.34	0.42	3.30	0.42
Ol	21.24	24.64	21.76	19.66	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Mt	6.12	4.00	4.86	4.11	7.52	3.35	2.99	2.90	2.80	2.62	0.32	2.08	1.54	0.51	0.80	1.58	0.19
Il	0.74	0.79	0.84	0.72	1.90	0.88	1.74	0.70	0.92	1.13	0.07	0.49	0.71	0.23	0.21	0.60	0.14
He	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.30	0.0	0.38	0.01	0.0	0.18
Ap	0.36	0.46	0.38	0.36	0.35	0.19	1.11	0.37	0.36	0.34	0.06	0.15	0.26	0.04	0.06	0.26	0.02
Thornton-Tuttle normative differentiation index	14.60	17.49	18.87	15.97	29.90	22.94	31.52	28.02	73.07	75.56	93.04	91.40	83.18	94.44	94.98	81.15	95.92

Table 2. Atomic absorption spectrophotometric analyses of Precambrian rocks from northern Nacimiento uplift showing content of silver, gold, lead, bismuth, cobalt, cadmium, copper, zinc and manganese.

Sample	Ag oz/ton	Au oz/ton	Pb ppm	Bi ppm	Co ppm	Cd ppm	Cu ppm	Zn ppm	Mn ppm
Mafic dike	.006	2.2	70	480	600	<4	124	144	660
Tonalite	.040	.020	<20	80	150	<4	24	110	960
Quartz monzonite	.023	.008	<20	40	110	<4	14	84	420
Two-mica granite	.006	<.001	<20	110	15	<4	62	52	30

the east side of the San Juan Basin (table 3); the density of these deep tests is less than one per township.

The information in Table 3 was compiled mostly from completion cards and partly from Foster and Stipp (1961), who examined cores and cuttings from some of the wells. The lithologies noted on the completion cards should be used with caution, as Precambrian rocks are commonly called granite regardless of their actual lithologies. Also, arkosic rocks in the Paleozoic section have been mistaken for Precambrian basement upon occasion.

In view of the sparsity of subsurface information about the

Table 3. List of wells that have penetrated Precambrian rocks along the eastern side of the San Juan Basin (east of R. 6 W., New Mexico Principal Meridian). Depths and elevations in feet.

Operator and lease	Sec.-T.-R.	Depth to Precambrian	Elev. of Precambrian	Lithology of Precambrian
Texaco #1 Howard Major	10-13N-3W	6,275	-75*	?
Continental #1 L Bar	2-13N-4W	6,215	355	schist
Humble #1 Santa Fe	20-14N-1W	6,008	141	schist
Avila #1 Odlum	15-15N-1W	?	?	?
Tidewater #1 ESG	7-16N-1E	2,477	4,173	granite
Brinkerhoff #1 Cabezon	7-17N-3W	7,970	-1,721	granite
Shell #42-26 Wright	26-17N-3W	6,930	-591	granite
Abraham #1 Star Lake	5-18N-5W	9,241	-2,358	?
Magnolia #1 Hutchinson	14-19N-3W	9,625	-2,791	granite
Dunigan #1 Santa Fe	31-19N-5W	9,204	-2,339	?
Union #1 M-13 USA	13-21N-5W	11,970	-4,818	?
Magnolia #1 Jicarilla "A"	18-23N-2W	13,550	-6,235	?
Lowry #1 Morton	24-24N-5E	1,450	5,103	quartzite, schist
Watson #1 Pack	35-24N-4E	3,150	3,144	schist
Skelley #1 Crittenden	36-24N-1E	4,840	3,780	rhyolite porphyry
Hall #1 Silver	20-26N-2E	2,256	5,569	rhyolite porphyry
Helmerich and Payne #1 El Vado	3-27N-2E	1,815	5,806	quartzite
Southwest Explor. #1 Penn Bldg.	22-28N-2E	2,459	5,100	?
Derby #1 Jicarilla	33-28N-1E	5,852	1,483	schist
Continental #1 South Dulce	6-28N-2W	13,185	-5,889	quartzite
El Paso #50 San Juan 29-5	7-29N-5W	14,030	-7,538	?
California #1 Looney	31-30N-2E	1,785?	6,215?	?
Williams #1 Willow Creek	23-30N-2E	1,595?	6,605?	?
Dugan #35 La Corina	6-30N-1E	4,550	3,255	?
Pan American #1 Pagosa Jicarilla	23-32N-3W	11,270	?	?

at exposures in the Nacimiento uplift, it seems premature to make any sweeping conclusions about the distribution of Precambrian lithologies in the subsurface.

SUMMARY

Our interpretation of the principal events in the Precambrian geologic history in the northern Nacimiento Mountains, from oldest to youngest, is as follows:

1. Deposition of very fine grained graywacke and related immature sediments and accumulation of silicic volcanics occurred about 1,800 ± 50 m.y. ago.
2. Mafic dikes and sills were injected into the sedimentary rocks.
3. Regional metamorphism imparted a northwest-trending schistosity to the metasediments and metavolcanics.
4. Ultramafic to diorite hypabyssal plutons were emplaced.
5. Tonalite was intruded into the older rocks noted above and locally caused contact metamorphism of the metavolcanic rocks.
6. A small body of leucogranodiorite intruded the tonalite, perhaps during the waning stages of synkinematic metamorphism.
7. Quartz monzonite was emplaced and marginally metasomatized the tonalite, resulting in growth of microcline porphyroblasts.
8. Granite bodies were emplaced.
9. Mafic dikes were injected into the quartz monzonite.
10. East-northeast-trending shear zones locally produced mylonite and flaser gneiss zones into the quartz monzonite.

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