5-27-1960

Geology of the Area Between Virden and Red Rock, Hidalgo and Grant Counties, New Mexico

Biswa Pradhan

GEOLOGY
OF THE
AREA BETWEE
VIRDEN AND
RED ROCK

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Geology of the area between Virden and Red Rock, Hidalgo and Grant Counties, New Mexico

By

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A Joint Thesis

Submitted in Partial Fulfillment of the Requirements

for the Degree of Master of Science in Geology

University of New Mexico

May, 1960

This thesis, directed and approved by the candidate's committee, has been accepted by the Graduate Committee of the University of New Mexico in partial fulfillment of the requirements for the degree of

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GEOLOGY OF THE AREA BETWEEN VIRDEN AND RED ROCK, HIDALGO AND GRANT COUNTIES, NEW MEXICO

By
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ABSTRACT

The area between Virden and Red Rock is located in southwestern New Mexico, about 30 miles northwest of the town Lordsburg. Mapping covered an area of about 94 square miles.

This report deals with the stratigraphy of sedimentary and igneous rocks of the area, with particular attention to the faunal and floral assemblages of Cretaceous sediments and the consequent determination of age of interbedded volcanic rocks.

Upper Cretaceous sedimentary rocks, about 2,500 feet thick, overlie Precambrian granite porphyry. The Cretaceous rocks include: Beartooth sandstone, which is devoid of fossils; Colorado shale, with invertebrate remains; and the Virden formation, with plant fossils. The name Virden formation is new, first suggested in this report. Its flora includes *Araucarities longifolia*, *Canna? magnifolia*, *Ficus eucalyptifolia?*, *Zizyphus hendersoni*, *Viburnum sp.*, *Cinnamomum sp.*, *Juglans leconteana*, *Salix? sp.* and is probably of Lancean age.

Three groups of volcanic rock are recognized in the area. The oldest group is older than the Virden formation and younger than the Colorado shale.

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[illegible] New Mexico, about 70 miles [illegible]

covered an area of about 70 square miles.

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The rocks consist of dacite and rhyolite tuff, up to 5,000 feet thick. The two post-Virden volcanic groups consist of: (1) rhyolite tuff, ignimbrite and flow rock, about 1,500 feet thick, and (2) basaltic andesite and basalt flows, about 500 feet thick.

Gila conglomerate of late Tertiary(?) age is interbedded with the basaltic andesite and basalt, especially with basalt flows. Some basalt may be as young as Quaternary. These are overlain by terrace gravels, alluvium and bolson deposits, which were locally derived.

The pre-Gila beds dip about 8° - 20° NE. The Gila conglomerate and post-Gila rocks dip gently towards the Gila River. Faults of two different ages are recognized: In the northeast corner area the northwest-trending Steeple Rock fault is truncated by the northeast-trending Martin fault. The youngest rock cut by the Steeple Rock fault is Tertiary rhyolite; the youngest rock cut by the Martin fault is Gila conglomerate.

Several manganese mines and prospects are located in the southeastern part of the mapped area. Host rock is Gila conglomerate interbedded with basaltic andesite. Veins follow northwest-trending faults and are believed to be epithermal. The chief mineral is psilomelane, accompanied by some pyrolusite.

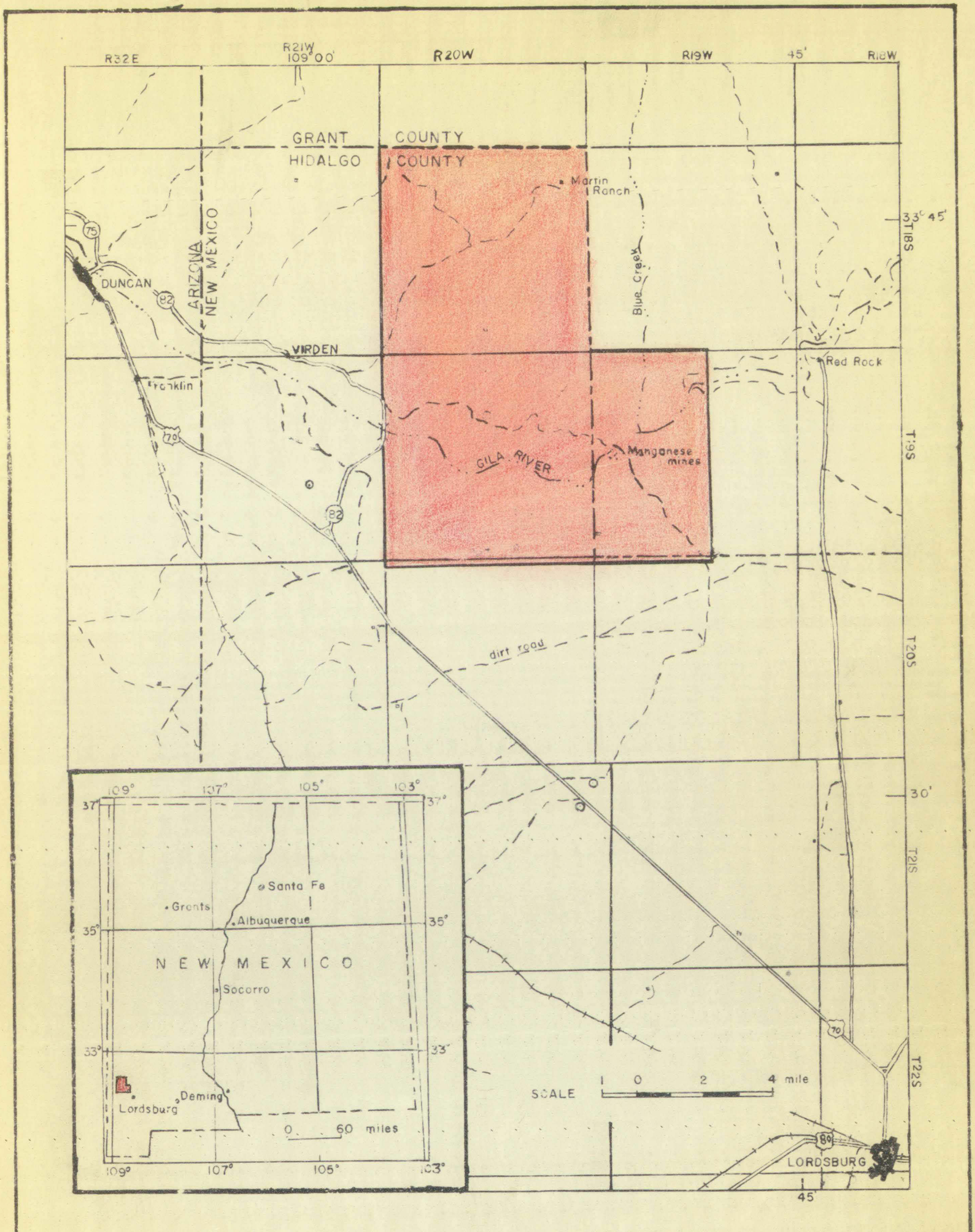

FIGURE 1. MAP SHOWING LOCATION OF VIRDEN-RED ROCK AREA

INTRODUCTION

Location and size of the area

The area between Virden and Red Rock is located in southwestern New Mexico, about 30 miles northwest of Lordsburg and 5 miles southeast of the Steeple Rock mining district. It covers an area of 94 square miles, largely in Hidalgo County and partly in Grant County (plate 1). It is a part of the Virden 30-minute quadrangle.

Purpose and scope of investigation

This report is written with two purposes in mind: First, to aid the understanding of the Cretaceous sedimentary sequence, with particular emphasis on its geologic setting and the age and taxonomy of its fossil assemblages. Secondly, we have tried to describe and date the three volcanic groups. Manganese deposits are briefly described.

Field investigation was started in the latter part of June, 1959, and was continued intermittently until the end of the year.

Method of investigation

Most of the geologic features were marked on 1:31,680 aerial photographs taken in 1942 by the U. S. Soil Conservation Service. The base map was prepared by combining several 7-1/2-minute topographic sheets of the Virden quadrangle published as advanced prints on a scale of 1:24,000 by the U. S. Geological Survey.

Previous Work

Previous geologic work of the area consisted of a reconnaissance geologic survey of the Virden 30-minute quadrangle (Elston, 1960) and of an attempted correlation of the volcanic rocks with those of adjacent areas (Wargo, 1959). Otherwise no specific data are available on the area. However, information can be obtained on nearby regions.

Gilbert (1875) described the desert ranges of western New Mexico and eastern Arizona as islands of deep-red Archean granite and Paleozoic rocks in basins of Gila conglomerate and other gravel deposits. Lindgren, Graton and Gordon (1910) noted a volcanic sequence of rhyolite-andesite-basalt over much of New Mexico and briefly described the Steeple Rock mining district. Callaghan (1951, 1953) outlined the succession of volcanism throughout the western United States, and pointed out the application of this knowledge as a tool for finding new ore deposits. Elston (1957) considered an andesite-rhyolite-basalt suite an important feature in many parts of southwestern New Mexico. Paleozoic and Mesozoic rocks near the Virden quadrangle have been described by Darton (1917), Flower (1953), and Paige (1916). Knechtel (1936) and Heindl (1952) described fanglomerates and conglomerates of Tertiary age.

GEOGRAPHY

Topography

The area north of the Gila River is hilly. Elevations generally rise from the river (about 4,000 feet above sea level) toward the north. The

highest hill is Black Mountain (elevation 5,587 feet). In the country south of the Gila River a few low hills rise above a bolson plain (average elevation about 4,200 feet). Drainage is by numerous arroyos, all emptying into the Gila River.

Physiography

The area lies on the faulted southern edge of the Datil plateau, an area of volcanic rocks that lies between the Mexican Highland section of the Basin and Range Province to the south and the Colorado Plateau to the north (Fenneman, 1931).

Climate and Vegetation

The Virden quadrangle is characterized by typical desert climate and vegetation. During the summer, the daytime temperature is commonly well over 100°F. Heat is bearable because of low humidity. Nights are usually comfortable. In the winter, snowfalls are infrequent and short-lived except in uplands. Annual precipitation is probably less than 12 inches.

The vegetation of the area is not diversified. Common plants are mesquite, greasewood, and many varieties of cacti. Grama grass of several species grows sparsely throughout the region and provides pasture for cattle. Poison ivy and poison oak are common at moist places.

Outside the Gila Valley plant cover is sparse and bed rock is usually well exposed.

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of the Gila [illegible]

tion about [illegible]

[illegible] Gila River.

[illegible]

The [illegible]

area of volcanic [illegible]

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[illegible]

The [illegible]

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well over 100°F. [illegible]

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except in [illegible]

The vegetation [illegible]

mesquite, greasewood, [illegible]

several species [illegible]

for cattle. [illegible]

Outside the Gila [illegible]

well exposed.

Accessibility

Most of the area is accessible by jeep or pick-up. Private roads can be used, although they were not always well maintained. Some roads are seldom used and a few are hardly passable. The private roads meet State Highway 82 west of the mapped area.

ACKNOWLEDGMENTS

The writers are highly indebted to Dr. Wolfgang E. Elston for his suggestion to study the area in which the project was undertaken and for his guidance of the entire work. Thanks are also due to Dr. Roger Y. Anderson for his help in the identification of fossils and for other valuable suggestions.

The authors are very grateful to the following individuals: Dr. Stuart A. Northrop, Chairman of the Geology Department, University of New Mexico, who supplied much valuable paleontological information and many suggestions for the preparation of this report; Dr. W. A. Cobban of the Paleontology and Stratigraphy Branch, U. S. Geological Survey, Denver, Colorado, who kindly identified invertebrate fossils found in the Colorado shale; and Dr. Erling Dorf of Princeton University who briefly examined some of the plant fossils from the Virden formation. Dr. J. P. Fitzsimmons criticized the manuscript.

STRATIGRAPHY

The rocks consist of Precambrian granite, about 2,500 feet of late Cretaceous sedimentary and volcanic rocks, and over 3,000 feet of Cenozoic continental sedimentary and volcanic rocks. Paleozoic and early Cretaceous sedimentary rocks, host to mineralization in surrounding areas, are missing. A generalized stratigraphic section of Virden and Red Rock area, New Mexico, is shown in Table 1.

Precambrian Rocks

Precambrian rocks crop out in sec. 20, T. 18 S., R. 20 W. They consist of pink microcline granite cut by aplite dikes. Coarsely crystalline granite crops out as rounded knobs, deeply weathered to a brick red color. Gentle slopes and canyon beds are usually veneered with partly decomposed fragments. Finer grained granite is more resistant to erosion.

Thin section analysis of the granite shows similar composition to that of the northern Big Burro Mountains (Hewitt, 1959) (Table 2).

The granite is almost certainly Precambrian, although in this area it can only be dated as pre-Upper Cretaceous. In the Silver City quadrangle to the east similar granite is overlain by the Cambrian Bliss sandstone and other Paleozoic rocks (Paige, 1916). In the entire Virden quadrangle the Paleozoic rocks were removed by erosion, probably in early Cretaceous time (Elston, 1958b).

The rocks [illegible] Late Cretaceous [illegible] Cenozoic [illegible] early Cenozoic [illegible] ing zones, are [illegible] and Red Rock area [illegible]

[illegible]

Precambrian rocks [illegible] consist of [illegible] granite crops out [illegible] Garnia slopes and [illegible] fragments. [illegible]

Thin section analysis [illegible] of the [illegible]

The granite is [illegible] can only be [illegible] to the most similar granite [illegible] other Paleozoic [illegible] Paleozoic [illegible] (Gibson, 1964[illegible]).

Table 1

Generalized stratigraphic section of Virden and Red Rock area, New Mexico

Age			Formation	Lithology	Thickness in feet
Quaternary		Recent	Alluvium and bolson	Bolson deposits, and stream gravels	20
			Terrace gravel and basalt (?)	Stream gravels on raised terraces	30
				Unconformity	
		Pleistocene	Gila conglomerate		
				Local unconformity	
Tertiary		Pliocene	Basalt and basaltic andesite	Purple red to black flows and breccias locally interbedded with Gila conglomerate	500
		Miocene	Datil formation	Massive mainly rhyolite, ignimbrite, flow rocks, tuff, dikes and sills	1300+
		Oligocene			
		Eocene			
		Paleocene			
				Unconformity	
Cretaceous	Upper Cretaceous	Lance			
		Montana	Virden formation	Sandstone, conglomerate gray to black shale containing plant fossils	1238+
				Unconformity	
			Andesite	Not represented in the mapped area	
			Rhyolite	Greenish and pinkish, porphyritic tuff	200
		Colorado	Dacite	Porphyritic, gray to purple flows and tuff	300+
			Colorado shale	Massive gray shale and sandstone containing molluscan fossils	570
		Dakota	Beartooth sandstone	Orthoquartzite, white or pink, with hematite stains, unfossiliferrous	0-50
				Unconformity	
Pre-cambrian		Granite porphyry		Coarse microcline granite with aplite dikes	?

Table 2

Modes of Precambrian granite from Big Burro Mountains compared with granite from Virden and Red Rock area (figures indicate percent by volume).

	(1)	(2)	(3)	(4)	(5)
Quartz	15	26	23	23	27
Microcline	42	35	57	42	46
oligoclase	29	22	12	28	20
hornblende	3	9	6	-	2
biotite	9	5	-	5	3
others	2	3	2	2	2

(1) Wild Horse Canyon, sec. 12, T. 18 S., R. 17 W.
(2) Northeast of Burro Springs Canyon, sec. 20, T. 19 S., R. 16 W.
(3) Ash Creek Canyon, sec. 16, T. 18 S., R. 18 W.
(4) Southeast of Eccles Canyon, sec. 19, T. 19 S., R. 16 W.
(5) Southwest of Martin's Ranch, sec. 20, T. 18 S., R. 20 W.

Modes 1 - 4 from Big Burro Mountains (Hewitt, 1959). Mode 5 from Virden - Red Rock area

Cretaceous Rocks

Beartooth sandstone

Paige (1916) gave the name Beartooth sandstone to a formation which he correlated with the Dakota sandstone. The name comes from Beartooth Creek near Fort Bayard, about 8 miles east of Silver City, New Mexico. In the Silver City quadrangle the Beartooth sandstone truncates rocks ranging from Permian red beds to Precambrian granite. From east to west, it lies in progressively older rocks (Paige, 1916).

Near Virden, New Mexico the Beartooth formation ranges from a few feet to a maximum of 50 feet. It lies directly on pink Precambrian granite and is overlain by grayish black Colorado shale. It is mainly composed of orthoquartzite, buff colored, and is characterized by hematite stains. The

grains are rounded to subrounded and cemented by quartz. The texture ranges from fine to coarse grained. In some places the sandstone contains a few pebble conglomerate stringers with chert pebbles. It is notably non-calcareous.

The basal few feet of this formation are comprised of coarse-grained loose granite-wash, and similar rock occurs at frequent intervals in the section. Cross-bedding is widespread. No fossils were found.

The Beartooth sandstone may have been deposited by a slowly transgressing sea in a low lying region. The rounded and sorted sand grains show that the area has been stable and deposition slow, so that winnowing action could take place. Water must have been shallow, with shifting currents, as evidenced by the wide distribution of cross beds and the frequent occurences of granite-wash sandstone in the section.

The age of the Beartooth sandstone has not been definitely established, because of the lack of fossils. The Dakota sandstone, with which it was correlated by Paige (1916), lies on the Lower Cretaceous - Upper Cretaceous boundary. In Luna County, Darton (1917) found Lower Cretaceous marine fossils in the Sarten sandstone, which lithologically resembles the Beartooth sandstone.

Colorado shale

The name Colorado shale was given by Paige (1916) to a formation in the Silver City area, which contained marine fossils of Coloradoan age. Near Virden, New Mexico the Colorado shale is represented by some 570 feet

[illegible]

[illegible] ... [illegible]

[illegible]

Colorado Plate[illegible]

[illegible]

of carbonaceous to siltstone and shale. It lies conformably over the Beartooth sandstone.

Colorado shale crops out in secs. 17 and 21, T. 18 S., R. 20 W. and spreads over an area of about one square mile. It is highly silty and sandy. Carbonaceous flakes are scattered through it. Under the binocular microscope the siltstone appears well sorted and made up of rounded to subrounded quartz grains.

Lithologically, the Colorado shale can be divided into three members. They are the lower silty member, the middle septarian shale member and the upper sandy member.

Lower silty member: - This is a transition zone between the Colorado shale and the Beartooth sandstone, only a few feet thick. It consists of dark gray noncalcareous and irregularly bedded siltstone and shale.

Middle septarian shale member: - The lower sandy member is succeeded by about 100 feet of calcareous gray to gray-black shale which carries many concretions. These concretions are septaria of varied forms - spherical, oval to turtle-like, measuring up to 12 inches. When broken they show clear calcite inside.

Upper sandy member: - This is the top member of Colorado shale. The sandstone grades from course to fine grained, and locally appears quartzitic. In its lower part fossil mollusks were found in NW 1/4 sec. 21, T. 18 S., R. 20 W. Although they were poorly preserved, W. A. Cobban of the Paleontology and Stratigraphy Branch, U. S. Geological Survey was able to make the following identifications:

Pelecypods:

Protarca? sp.
Inoceramus sp.
Phelopteria gastrodes (Meek)
Ostrea soleniscus Meek
Ostrea cf. O. coalvillensis Stanton
Ostrea sp.
Anomia subquadrata Stanton
Laternula lineata (Stanton)
Cyrene securis Meek?
Dosiniopsis? sp.
Mactra (Cymbophora) utahensis
Mactra (Cymbophora) emmonsi Meek

Gastropods:

Gyrodes conradi Meek
Lispodesthes nuptialis White
Craginia sp.

According to Cobban, Cyrena securis and Craginia are brackish water forms and all others are shallow water marine forms. He wrote "This is Colorado assemblage possibly of Carlile (Turonian) or earlier (Cenomanian) age" (personal communication, 1959).

Dacite

Dacite crops out in secs. 2, 3 and 4, T. 18 S., R. 20 W. northwest of Martin's Ranch. Thickness is over 300 feet but the base is not exposed because of faulting. It occurs as rounded hills. It is separated from Tertiary rhyolite tuffs and flows to the southwest by the Steeple Rock fault.

Paleotype(s) [illegible]

[illegible]

Gastropoda

[illegible]

According to [illegible]

water forms and is [illegible]

"This is [illegible]

(Cenomanian) age [illegible]

Genus

[illegible]

of Nanaimo [illegible]

[illegible]

[illegible]

In hand specimens, dacite can be identified by its porphyritic texture and its gray to light purple groundmass. Phenocrysts are abundant plagioclase and some hornblende and biotite. Plagioclase crystals are generally more than 2 mm long.

Table 3

Modal analysis of dacite in
per cent by volume

Groundmass	67	
Phenocrysts	andesine	17
	hornblende and biotite	6
	quartz	6
	opaque	3

Location: SW 1/4 sec. 5, T. 18 S., R. 20 W.
Hidalgo County, New Mexico

Most of the hornblende and biotite crystals have been replaced by magnetite, either partly or completely. Quartz is distributed throughout the groundmass in amounts which cannot be estimated.

In the Steeple Rock mining district, northwest of the mapped area, the dacite was interpreted as an intrusive diorite porphyry by Lindgren, Graton, and Gordon (1910). Elston (1956) interpreted the dacite as a volcanic rock, citing the following evidence: The absence of instrusive relationships, the interbedding of tuffs and flow rocks, and the resorption of hornblende to magnetite, which was considered by Larsen et al (1936, 1937, 1938) to be a post-eruptive process.

Rhyolite tuff

Rhyolite tuff crops out immediately above the dacite but the contact was not observed because of faulting. It is exposed in secs. 2 and 3, T. 18 S., R. 20 W., and covers an area of about one square mile. Thickness is over 200 feet.

The tuff is rhyolitic in composition. It tends to be massive and to form bold cliff which is prominent east-northeast of Martin's Ranch. Locally the rhyolite tuff is capped by a flow breccia with fragments of rhyolite and dacite.

The dominant colors are light green, gray or pink. Phenocrysts, up to 2 mm long, consist of abundant sanidine and some oligoclase; quartz is rare. Some biotite and hornblende also show up. Oligoclase is often altered to clay minerals and/or calcite, and hornblende and biotite to magnetite. Sanidine is sometimes corroded marginally. The matrix is largely made up of glass shards. The rock closely resembles Tertiary rhyolite.

Andesite

No Cretaceous volcanic rocks younger than the rhyolite tuff are exposed in the mapped area. To the north and west the rhyolite tuff is overlain by 3,000 feet of purple to chocolate brown, vesicular and amygdaloidal andesite flows and breccias. These rocks are probably present in the subsurface of the mapped area.

Rhyolite tuff

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was not observed [illegible]

T. 18 S., R. 26 [illegible]

Thickness is over 500 feet.

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to form [illegible]

Locally the rhyolite [illegible]

rhyolite of Zeegers [illegible]

The [illegible]

up to [illegible]

quartz [illegible]

is often altered to clay [illegible]

to magnetite. [illegible]

is largely made up of [illegible]

rhyolite.

Andesite

No [illegible]

exposed in the [illegible]

consists of [illegible]

[illegible]

present in the [illegible]

Age of volcanic rocks

The dacite-rhyolite-andesite sequence can be dated as Upper Cretaceous (probably Montanan) because of its stratigraphic position above the Colorado shale (Carlile) and below the Virden formation (Montana-Lance equivalent). Its lower contact has nowhere been found because of faulting, but its upper contact with the Virden formation can be seen, just northwest of the mapped area (Elston, 1960). Also, the Virden formation contains abundant boulders of Cretaceous dacite, rhyolite, andesite, while the Colorado shale contains none.

Virden formation

The term Virden formation is a new name, used by Elston (1960) and the authors of this paper for the nonmarine subgraywake, carbonaceous shale, conglomerate, and fanglomerate found near Virden, New Mexico. The type locality lies in sec. 16, T. 18 S., R. 20 W. and thickness is about 1,200 feet. The formation occupies a position in time that probably corresponds to late Montana or early Lance. In the type section it rests unconformably on Colorado shale, but 3 miles to the northwest a thick section of volcanic rocks wedges in between the Colorado shale and Virden formation. It crops out in secs. 8, 10, 15, 16 and 17, T. 18 S., R. 20 W. The formation is mainly composed of sandstone, conglomerate, fanglomerate, siltstone and shale. The overall hue is light-gray to gray-green. The sandstone massive, is fine to coarse grained, cross-bedded lenticular, silty

Age of volcanic rocks

The [illegible]

Cretaceous (?) [illegible]

the Colorado shale [illegible]

equivalent). [illegible]

but its upper [illegible]

of the mapped area [illegible]

abundant [illegible]

Colorado shale contains some.

Virden formation

The term Virden formation [illegible] used by Winchell (1910)

and the authors [illegible]

shale, conglomerate, [illegible]

The type locality [illegible]

about 1,200 feet. The formation [illegible]

correspond [illegible]

unconformably on [illegible]

of volcanic [illegible]

N ranges [illegible]

tion is mainly [illegible]

stone and shale. [illegible]

stone members, [illegible]

and poorly sorted. Laminated non-silty micaceous carbonaceous black shale and mudstone are found here and there.

The conglomerate is mainly composed of rounded to subrounded pebbles and boulders, up to two feet in diameter, of Cretaceous dacite (Figure 1). Granite boulders are abundant in a few beds. Rare nodular limestone fragments also occur. Toward the northwest, outside the mapped area, the entire Virden formation changes facies into a coarse fanglomerate composed mainly of Cretaceous andesite boulders.

The sediments of the Virden formation are nonmarine. The laminated black shale and mudstone may have been deposited in shallow lakes or ponds. The sandstone and conglomerate were probably deposited in streams and floodplains. The fanglomerates were formed in alluvial fans. The Virden formation in T. 18 S., R. 20 W. probably was formed on the floodplains of an aggrading river, bordered by alluvial fans.

Vertebrate and invertebrate fossils have not been found. Some fossil plants, however, are known, and are of late Upper Cretaceous age. The most significant index fossil is Araucarites. The location where fossils were found is in SE 1/4 sec. 8, T. 18 S., R. 20 W., and NE 1/4 sec. 17, T. 18 S., R. 20 W. The typical sandstone for hunting fossils is as shown in Figure 2.

Hypabyssal rocks

A number of dikes occur in the Cretaceous sedimentary rocks, as shown on the geologic map. One of them cuts the Virden formation in

and poorly sorted. [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] and [illegible] [illegible] [illegible]

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Vertebrate [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] fossil plants, [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] The most significant [illegible] [illegible] [illegible] [illegible] [illegible] fossils were found [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] as shown in Figure [illegible].

[illegible] [illegible]

A [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] shown on the geologic [illegible] [illegible] [illegible] [illegible] [illegible]

Plate 1

Figure 1. Virden formation in sec. 8, T. 18 S., R. 20 W., showing interbedded shale and sandstone beds. Plant fossils were found in the two ledge-forming sandstone beds.

Figure 2. Virden formation - typical conglomerate beds with dacite pebbles and boulders. The boulder is about 18 inches in diameter.

secs. 16 and 17, T. 18 S., R. 20 W., and turns into sill in the Beartooth sandstone in sec. 20, T. 18 S., R. 20 W. It is yellowish green in color and has some vesicles. Most of the feldspar crystals are elongated. Magnetite is common and pyrrhotite rare. Hornblende is rare. Some magmatic quartz is present. Due to extensive alteration, the optical properties of feldspars cannot be determined. Secondary calcite is abundant. The above minerals are small phenocrysts in a fine grained matrix. The alteration is similar to that of the Cretaceous volcanic rocks and these dikes and sills are probably late Cretaceous or early Tertiary. They do not cut Tertiary volcanic rocks.

Table 4

A section of Upper Cretaceous rocks measured in secs. 16 and 20, T. 18 S., R. 20 W., Hidalgo County, New Mexico

Descriptions	Thickness ft.	in.
Tertiary volcanic rocks		
Major unconformity		
Upper Cretaceous rocks		
Virden formation		
53. Conglomerate and fanglomerate, boulders of granite, rhyolite and andesite	70	0
52. Sandstone, tuffaceous, color changes from light to dark green, cross-bedded, interbedded with scattered conglomerate lenses containing boulders of dacite and granite	515	0
51. Sandstone, tuffaceous, interbedded with conglomerate containing dacite and granite pebbles and boulders, some boulders two feet in diameter, boulders mostly rounded and subrounded; angular pebbles are also common	136	0
50. Sandstone, tuffaceous, contains plant fossils (<u>Araucarites</u>, <u>Ficus</u>, <u>Salix</u>, and palms), also spherulitic limonite concretions	224	0
49. Shale, black, fissile, fractured, slightly silty	8	0
48. Sandstone, tuffaceous, dirty yellow	285	0
Total, Virden formation	1,238	0

Table 4 (Cont'd)

A section of Upper Cretaceous rocks measured in secs. 16 and 20, T. 18 S., R. 20 W., Hidalgo County, New Mexico

Descriptions	Thickness ft.	Thickness in.
Unconformity		
Colorado shale		
Upper sandy member		
47. Sandstone, quartzose, fractured cemented	6	0
46. Sandstone, fine to coarse grained, rounded to subrounded, quartzose, grayish white	58	0
45. Mudstone, densely cherty, beds regular, each about 6 inches thick, nodular	10	0
Total, Upper sandy member	74	0
Middle septarian member		
44. Sandstone, fine to coarse grained rounded to subrounded, calcareous, argillaceous	25	0
43. Sandstone, fine to coarse grained, grains rounded to subrounded, calcareous, yellowish gray	75	0
42. Sandstone, silty, quartzose, poorly sorted	41	0
41. Shale, silty, massive, cross-bedded	65	0
40. Shale, fissile, yellow, slightly silty, calcareous	7	0
39. Shale, silty, massive	25	0

Table 4 (Cont'd)

A section of Upper Cretaceous rocks measured in secs. 16 and 20, T. 18 S., R. 20 W., Hidalgo County, New Mexico

Descriptions	Thickness ft.	in.
38. Shale, dark gray, slightly silty, fractured	8	0
37. Shale, silty, massive	17	0
36. Sandstone, yellow gray, calcareous contains fragments of poorly preserved mollusks	3	0
35. Shale, silty, fractured, interbedded with siltstone	15	0
34. Limestone, black to gray, shaly, concretional and fractured	3	0
33. Shale, silty and sandy, fractured calcareous	0	9
32. Shale, gray black, limy and silty, lamellar, thin clayey siltstone interbedded every 2 to 6 inches, abundant ovoid, turtlelike septaria	78	6
31. Siltstone, gray black, limy, small mud concretions	44	0
30. Shale, black to gray black, limy and silty, thin regular beds, lenses of silty black limestone, concretion up to 14 inches in diameter	60	0
Total, Middle septarian shale member	467	3
Lower sandy member		
29. Mudstone, dense, broken into rectangular fragments	1	0

Table 4 (Cont'd)

A section of Upper Cretaceous rocks measured in secs. 16 and 20, T. 18 S., R. 20 W., Hidalgo County, New Mexico

Descriptions	Thickness ft.	Thickness in.
28. Shale, silty, dense, gray, fissile, with small broken fragments	5	2
27. Siltstone, light pink, surgary texture, few impurities	2	4
26. Siltstone, black to gray, clayey, friable to consolidated, fractured	2	0
25. Siltstone, bluish black to light gray, consolidated, sugary texture, rusty stain predominant, shaly	1	0
24. Siltstone, bluish black to grayish black, carbonaceous, fragile, pieces of mudstone embedded	1	0
23. Sandstone, ash gray, shaly and silty, fine grained, friable, rusty	1	4
22. Shale, black, silty, with carbonaceous materials in thin lamellae, breaks into small angular fragments	2	0
21. Sandstone, shaly and silty, in thin irregular layers, irregular fractures, rusty stains, highly shaly pockets are occasionally present	3	0
20. Mudstone, bluish black to black, fractured	6	4
19. Sandstone, quartzose, coarse grained, argillaceous	1	6
18. Mudstone, yellowish gray, dense	1	8
Total, Lower sandy member	28	4
Total, Colorado shale	569	7

Table 4 (Cont'd)

A section of Upper Cretaceous rocks measured in secs. 16 and 20, T. 18 S., R. 20 W., Hidalgo County, New Mexico

Descriptions	Thickness ft.	Thickness in.
Beartooth sandstone		
17. Shale, gray to grayish black, silty	0	8
16. Sandstone, dark blue, fine-grained shaly, hematite stained. Contains scattered grains of rounded quartz	1	6
15. Sandstone, fine-grained, limonite concretions and stains	0	8
14. Sandstone, quartzose, coarse-grained, silica cement, hematite stains	1	0
13. Sandstone, arkosic, coarse-grained, unconsolidated, limonite stained	0	7
12. Sandstone, silty, pure quartz, sugary texture	0	6
11. Sandstone, quartzose, coarse-grained, consolidated	0	6
10. Sandstone, granite wash	0	3
9. Sandstone, quartzose, sugary texture, almost pure quartz, well-consolidated	2	9
8. Sandstone, granite wash	0	7
7. Sandstone, quartzose, coarse, rounded to subrounded, friable, clayey, and carbonaceous	0	8
6. Sandstone, quartzose, coarse, grains rounded to subrounded, cementing material is clay	0	6

Table 4 (Cont'd)

A section of Upper Cretaceous rocks measured in secs. 16 and 20, T. 18 S., R. 20 W., Hidalgo County, New Mexico

Descriptions		Thickness ft.	in.
5.	Sandstone, granite wash	0	3
4.	Sandstone, black gray, coarse-grained, grains rounded to subrounded, well-consolidated. Matrix consists of carbonaceous clay, bedding irregular	0	3
3.	Sandstone, ash gray, fine to coarse, rounded to subrounded, hematite stained, friable, clay matrix, slightly carbonaceous	1	6
2.	Quartzite, pink-white grains, fine to coarse, rounded to subrounded or angular quartz	2	0
1.	Sandstone, arkosic (granite wash) coarse-grained, rounded to subrounded, poorly cemented	2	0
	Total, Beartooth sandstone	16	2
	Total, Cretaceous sedimentary rocks	1,823	9
	Major unconformity		
Precambrian granite		?	

Tertiary Rocks

Rhyolite tuff

Rhyolite tuff covers an area of about 23 square miles. The largest outcrop area is a northwest trending belt in secs. 2, 3, 8, 9, 10, 11, 15, 20, 21, 27, 28, 29, 33 and 34, T. 18 S., R. 20 W., secs. 2, 3, 4, 10, 11, 12, 13, 14, 15, 16, 17, 20, 21, 22, 23, 24, 25, 27 and 28, T. 19 S., R. 20 W., and secs. 30, 31, 32, T. 19 S., R. 19 W. Rhyolite tuff tends to form bold cliffs with edges rounded by exfoliation. The beds consistently strike N 60° W, and dip about 20° NE. No complete section can be measured because either the base of the rhyolite is not exposed or its top is faulted out. The minimum thickness in secs. 4 and 9, T. 18 S., R. 20 W., can be estimated as over 1,300 feet.

In hand specimen, the rocks are pink in color and porphyritic in texture, with phenocrysts of glassy sanidine and minor oligoclase and magnetite. Some rocks are cream, light chocolate and gray and in these the phenocrysts are generally milky white.

Microscopic examination indicates that alteration of biotite and hornblende to magnetite is common. Magnetite also occurs as isolated grains unrelated to biotite or hornblende. The grains of sanidine are up to 3 mm long. Sometimes their crystal faces are corroded and this is even more common in oligoclase. Quarts grains are generally angular fragments. Modal analyses of rhyolite from two localities are given on page 28.

Rhyolite dikes

Rhyolite dikes [illegible] cutting [illegible] 22, 21, 22, 23, 25, 34 [illegible] 12, 13, 14, 23, 24 [illegible] N. 25 W., and [illegible] to form [illegible] strike N. [illegible] because [illegible] out. The [illegible] be [illegible].

In hand specimen [illegible] texture, with [illegible] magnetite. [illegible] the plagioclase [illegible].

[illegible] Inclusions of magnetite [illegible] grains [illegible] to 3 mm long. [illegible] [illegible] magnetite. [illegible] page 28.

Plate 2

Figure 1. Rhyolite tuff, showing corroded sanidine (S), alterated oligoclase (O) and secondary calcite (C). See table 5, no. 1 for modal analysis.

Figure 2. Looking south, in sec. 9, T. 18 S., R. 20 W., rhyolite tuff (Tdru), ignimbrite (Ign), and Virden formation (Kv).

Massive light green colored rocks were noticed at several places, generally near the top of rhyolite tuff. Microsscopic observations indicate that they consist of glass shards, which are elongated and welded together, and clay minerals, which may have been derived by the decomposition of glass or feldspars. These rocks appear to be of rhyolitic composition and are considered to be welded tuffs.

Table 5

Modal analysis of Tertiary rhyolite
(Percent by volume)

		1	2
Groundmass		42	45
Phenocrysts	sanidine	43	38
	oligoclase	9	10
	quartz	3	2
	biotite	1	1
	hornblende	-	1
	magnetite	2	3

(1) NW 1/4 sec. 10, T. 18 S., R. 20 W., Hidalgo County, New Mexico
(2) NE 1/4 sec. 22, T. 19 S., R. 20 W., Hidalgo County, New Mexico

Another massive rhyolite welded tuff or ignimbrite occurs in secs. 9 and 10, T. 18 S., R. 20 W., and secs. 23 and 24, T. 19 S., R. 20 W., and covers an area of about 1-1/2 square miles. It forms bold cliffs on northeast-dipping hogbacks (figure 4) and much of the rugged topography of the area is due to it. Crude columnar joints are characteristic. Thickness varies but may be estimated at 200-300 feet. Generally this ignimbrite is light gray to grayish green. Sanidine phenocrysts are

distinctly visible megascopically although grains are about 1 mm. Other minerals include plagioclase, quartz and minor biotite. The groundmass is made up of glass and its alteration products such as clay minerals and calcite. Because of small grains, modes could not be estimated by grain counting. However, groundmass predominates.

Intrusive rhyolite

Massive rhyolite, believed to be intrusive, occurs in secs. 20 and 21, T. 18 S., R. 20 W., and in secs. 15, 16, 21, T. 19 S., R. 20 W., covering an area of about 1-1/2 square miles. In all places, it caps the underlying Tertiary rhyolite tuff but never seems to associate with ignimbrite. The southeastern rim of Canador Peak displays the above feature very well. The strike of the flow banding is about N 50° W and the dip is about 50° NE, much steeper than in other volcanic rocks. It tends to be resistant to erosion and to form steep hills with cliffs near the tops. Thickness is about 500 feet in Canador Peak and about 150 feet in T. 18 S., R. 20 W.

In hand specimens, the intrusive rhyolite is grayish green in color. Sanidine phenocrysts are sometimes visible megascopically but no other minerals can be recognized. Because of its crytocrystalline texture, microscopic study did not reveal the minerals present in the rock.

distinctly visible megascopically [illegible]

Other minerals include [illegible]

groundmass is made up of [illegible]

clay minerals and calcite. [illegible]

be estimated by [illegible]

Intrusive rhyolite

Massive rhyolite, [illegible]

and 21, T. 18 [illegible]

R. 20 W., covering an area of [illegible]

it caps the underlying [illegible]

with lyddite. The [illegible]

above feature [illegible]

N 50° W and the [illegible]

rocks. It [illegible]

cliffs near the [illegible]

about 150 feet in T. 19 [illegible]

In hand specimens, the [illegible]

Besides phenocrysts [illegible]

minerals [illegible]

microscopic study [illegible]

Gila formation

The extensive deposits of detrital sediments underlying intermontane valleys in southwestern New Mexico and southeastern Arizona are known by various names such as Mimbres, Santa Fe, and Gila conglomerate. In the Gila Valley, Gila conglomerate is the generally accepted term.

Gila conglomerate is best displayed on both sides of the Gila River in T. 19 S., R. 19 W. and on the sides of arroyos in secs. 30, 31, T. 18 S., R. 20 W. The outcrops constitute an area of about 9-10 square miles. Gila conglomerate includes consolidated, semiconsolidated and unconsolidated sandstone, fanglomerate, and conglomerate. The sediments are all clastic and form broad fans dipping towards Gila River with gentle slopes. Color ranges from shades of red and brown to white.

Two members can be recognized in the field, but were mapped as a single unit. The rocks of the older member are coarse and consolidated conglomerate. They crop out in SE 1/4 sec. 29, T. 19 S., R. 19 W. and NE 1/4 sec. 32, T. 19 S., R. 19 W. The younger member is mainly semiconsolidated sandstone, minor conglomerate, some bentonitic(?) clay, and interbedded basalt. Along an arroyo in sec. 30, T. 18 S., R. 20 W. a profound unconformity was noticed between the two members. Thickness of Gila conglomerate is unknown, but is probably greater than 800 feet in the mapped area.

Gila formation.

The [illegible] suggest [illegible]

moraine [illegible]

are bounded by [illegible]

conglomerate [illegible]

are exposed [illegible]

[illegible]

in T. 19 S., R. [illegible] W. [illegible]

T. 18 S., R. 20 W. The [illegible]

ation. [illegible]

unconsolidated [illegible]

ments are all [illegible]

with gently dipping. [illegible]

The [illegible]

single unit. [illegible]

conglomerate, [illegible]

SE 1/4 Sec. 35, T. 18 S., R. [illegible] W. [illegible]

semiconsolidated, [illegible]

clay, and interbedded [illegible]

20 W., a [illegible]

Thickness of [illegible]

feet in the mapped area.

Plate 3

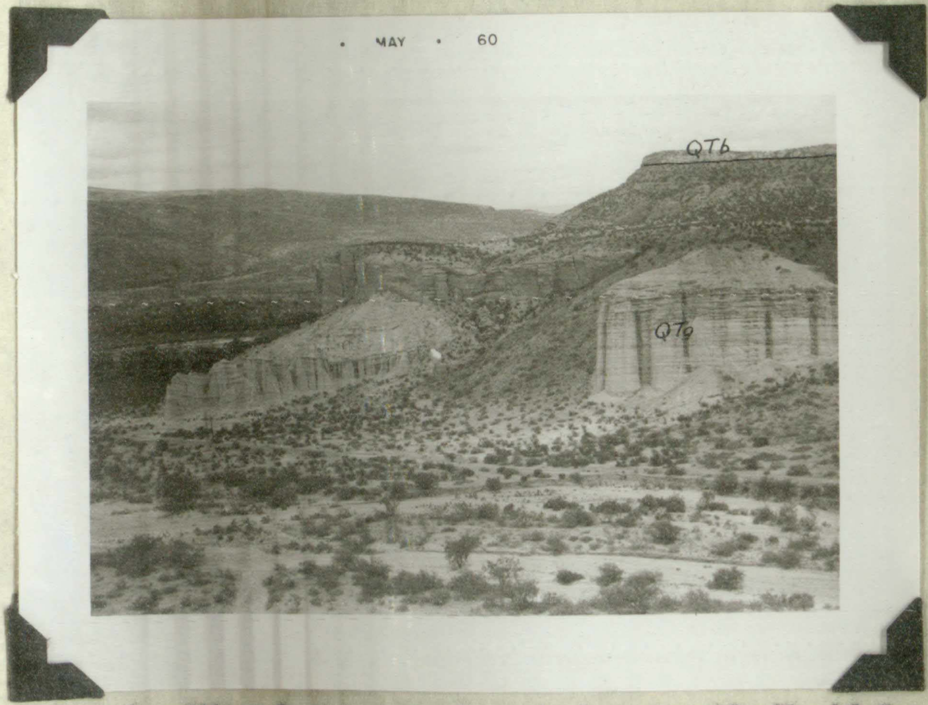


Figure 1. View looking southwest, in sec. 30, T. 19 S., R. 19 W. showing Gila conglomerate (QTg) and basalt and basaltic andesite (QTb).

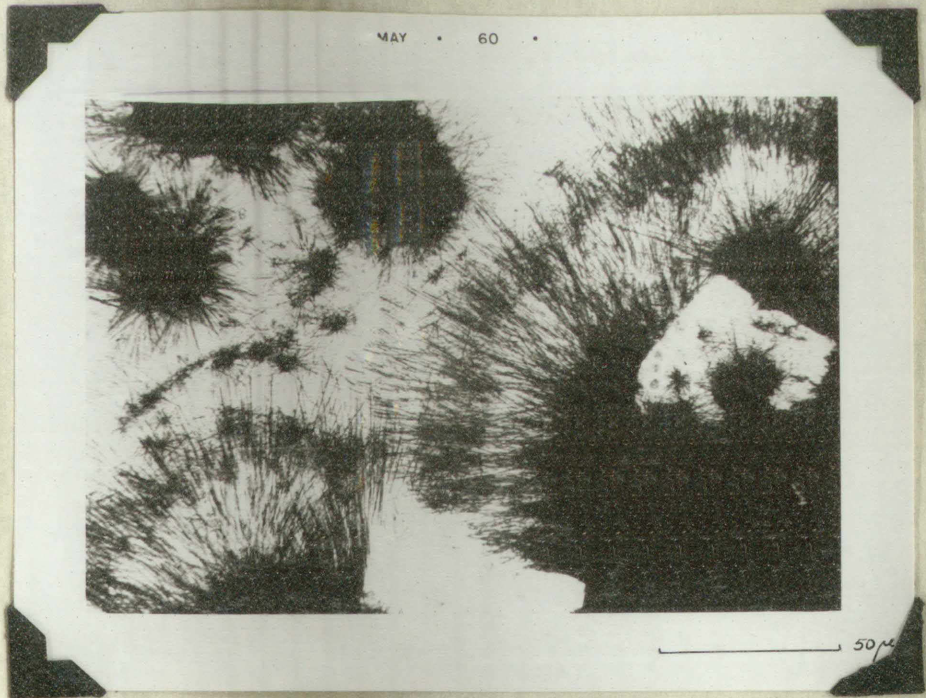


Figure 2. Characteristic fibrous nature of psilomelane replacing opaline silica in Cliffroy mine.

The following features of the Gila conglomerate show conditions of rapid continental deposition:

The boulders (mainly rhyolite tuff and other volcanic rocks) are of local derivation. The bedding is poorly developed. Sometimes irregular lenses of sand and tuff are interbedded gradationally with conglomerate. Conglomerate is poorly sorted. It is probable that the Gila conglomerate was deposited by the merging of alluvial fans formed around nearby volcanic mountains. Rare boulders of Precambrian granite may have come from the Big Burro Mountains to the east.

As early as 1875, Gilbert considered the Gila conglomerate to be early Quaternary. Ransome (1919) proposed the same age in the Ray and Miami districts of Arizona and Paige (1916) did the same in the Silver City quadrangle. On the basis of vertebrate fossils found in the southern Arizona, Knechtel (1936) inferred that the many of the thick valley deposits that have been described as Gila conglomerate belong to a common period of deposition, which he assigned, in part, to the Upper Pliocene. Other authors placed the age from Upper Miocene to Pleistocene(?) (Needham, 1936; Heindl, 1952).

Basalt and basaltic andesite

Basalt and basaltic andesite flows or breccias form a northwest-trending belt southeast of the Martin fault. Other outcrops are scattered in the southern part of the mapped area. They are the youngest volcanic unit present. In all, 12-13 square miles of these rocks are exposed. Generally, they overlie rhyolite tuff, as in the Black Mountain area, but in places, they seem to interfinger with Gila conglomerate, as was seen in SW 1/4 sec. 17, T. 18 S., R. 19 W. In such places, the area has been mapped arbitrarily as basalt and basaltic andesite where these rocks predominate, and Gila conglomerate where clastic sediments predominate.

Like other rocks, basalt and basaltic andesite strike N 60° W, dip 12°-15° NE, and forms southwest facing hogbacks. In the southern part of the area the rocks are nearly horizontal. Thickness varies from 100 to 700 feet.

Basalt and basaltic andesite are reddish brown to black, vesicular and sometimes amygdaloidal. Phenocrysts of plagioclase and magnetite are common, but are not present in all rocks. Some representative samples were examined microscopically and they are shown in table 6. Phenocrysts are generally 2 mm to 4 mm long and lath-shaped. Olivine grains are altered to iddingsite, either marginally (figure 7), or throughout. They are generally rimmed by magnetite. Calcite rhombs are often observed (figure 8), probably formed by alteration of

Plate 4

Figure 1. Basalt showing a grain of olivine replaced by iddingside marginally; lath-shaped crystals are labradorite. See table 6, no. 2 for modal analysis.

Figure 2. Basaltic andesite showing calcite rhombs probably formed by alteration of a ferromagnesian mineral, as indicated by rims of magnetite. See table 6, no. 4 for modal analysis.

ferromagnesian minerals as indicated by rims of magnetite. In all samples the groundmass is almost opaque.

Table 6

Modal analysis of basalt and basaltic andesite
(Percent by volume)

		1	2	3	4
Groundmass		29	21	18	41
Phenocrysts	olivine	-	6	3	-
	iddingsite	-	10	16	-
	andesine	58	-	-	40
	labradorite	-	55	49	-
	pigeonite	6	-	-	3
	augite	-	1	2	-
	magnetite	7	5	2	7
	calcite	tr.	2	10	7
	diopside	-	?	?	2

(1) Basaltic andesite NW 1/4 sec. 14, T. 18 S., R. 20 W., Hidalgo County, New Mexico
(2) Basalt, NE 1/4 sec. 17, T. 19 S., R. 19 W., Grant County, New Mexico
(3) Basalt, SE 1/4 sec. 8, T. 19 S., R. 20 W., Hidalgo County, New Mexico
(4) Basaltic andesite, SE 1/4 sec. 1, T. 19 S., R. 20 W., Hidalgo County, New Mexico

Age and correlation of Tertiary volcanic rocks

The discovery of a floral assemblage in the Virden formation is the basis for dating Tertiary rhyolites as later than early Lance and probably pre-Pliocene. The Tertiary rhyolites are probably continuous with those in the Black Range, near Kingston, Sierra County, which are older than lake beds tentatively dated by plant fossils as early Miocene to early Pliocene (Kuellmer, 1954).

Tertiary rhyolites can be recognized over most of southwestern New Mexico and the name, Datil formation has been applied to them farther north. Basalt and basaltic andesite are interbedded with consolidated Miocene-Pleistocene(?) Gila conglomerate. Some of the basalt in the southern portion of the map crop out as isolated hills surrounded by Quaternary gravels. The basalt-gravel contact was not seen, but it is possible that the basalt is Quaternary. Quaternary basalts are known to occur in adjacent areas - in the Animas and Hachita Valleys and near Silver City. Since there seem to be no obvious lithologic criteria for distinguishing Tertiary and Quaternary basalts, and because field relations are uncertain, all basalts were mapped as Tertiary.

Quaternary Rocks

Terrace and pediment gravels

The valleys of the meandering Gila River and its major and minor tributaries are flanked by one or two matched terraces of coarse unconsolidated fluvial conglomerate. They are widespread in the western part of the mapped area, especially south of the Gila River. They are well sorted, graded, well bedded, unconsolidated and contain rounded and sorted boulders up to 18 inches in diameter.

The terrace levels are successive erosion surfaces that represent pauses in downcutting by the Gila River. Rejuvenation and renewed downcutting could have resulted from either tectonic or climatic changes.

The erosion surfaces and terrace gravels dip gently toward the Gila River from both sides. The highest gravels lie 100 to 200 feet above the present river. The thickness of these unconsolidated gravels never exceeds 40 feet and rarely 50 feet.

The terrace gravels are younger than the consolidated Gila conglomerate and older than the Recent alluvium and bolson deposits. Similar gravels are reported to be common in the southwestern United States and are believed to be late Pleistocene or post-Pleistocene.

Alluvium and bolson deposits

These deposits were mapped as one unit. The southwest corner of the mapped area is covered by the unconsolidated and undissected bolson deposits made up of locally derived gravel sand, silt and mud which probably do not exceed 20 feet in thickness. The bolson plain continues south for many miles. It may be recognized by relatively smooth surfaces with no extensively developed drainage system. Recent stream alluvium occurs on the floors of the many washes and on the flood plain of the Gila River.

Fine alluvium and coarse gravels are at present being deposited in aggrading parts of streams, and on the bolson flats. The alluvium supplies most of the underground water of the region.

The erosion surfaces [illegible] the

Gila River [illegible]. The [illegible] in the [illegible]

above the present [illegible]. The [illegible]

[illegible] of [illegible].

The surface gravels [illegible] in [illegible]

[illegible] and also from the [illegible]

Similar gravels are [illegible]

[illegible] and are [illegible]

Alluvium and talus deposits

These deposits [illegible]. The [illegible]

of the [illegible] area [illegible]

[illegible]

which probably do not exceed [illegible]. The [illegible]

contains [illegible]. It may [illegible]

[illegible] surfaces with [illegible] system.

Recent stream alluvium [illegible]

on the flood plain of the [illegible].

The alluvium and [illegible]

in [illegible]

[illegible] of the [illegible] region.

GEOLOGIC STRUCTURE

The pre-Gila rocks of the mapped area consistently dip about 20° NE. Gila and the younger deposits dip not more than 7° towards the Gila River. Basalt and basaltic andesite interbedded with Gila conglomerate in the northeastern region gently dip to the northeast and Quaternary(?) basalt of the southern region seems to be horizontal.

A regional profile through the area shows fault blocks of the Basin and Range type with northwest-trending faults. The largest is the Steeple Rock fault, which bring Cretaceous dacite up against Tertiary rhyolite. This fault shows up in secs. 3, 4, 11, T. 18 S., R. 20 W., and extends far to the northwest of the area. It passes northeast of Steeple Rock, for which it was named by Elston (1960). The strike of the fault is about N 70° W in secs. 3 and 11, T. 18 S., R. 20 W., and nearly north in sec. 4, T. 18 S., R. 20 W. The dip of the fault plane could not be determined. Vertical movement was estimated to be over 4,000 feet; the minimum thickness of a faulted-out section of Cretaceous rhyolite, Cretaceous andesite, Virden formation and Tertiary rhyolite.

Northwest of Martin's Ranch, two faults form a small graben and eventually join the end of Steeple Rock fault towards the southeast. The rocks there are so disturbed that no amount of movement could be estimated.

A series of normal, northwest-trending faults are recognized in the southeastern part of the mapped area. This fault zone controls

STRUCTURE [illegible]

The pre-Gila rocks [illegible] in the [illegible]

NW. Gila and the younger [illegible]

the Gila River. [illegible]

conglomerate [illegible]

and (sedimentary?) [illegible]

A [illegible] through the [illegible]

Basin and Range [illegible]

the [illegible] fault, which [illegible]

rhyolite. This fault [illegible]

and [illegible]

Range [illegible], for which it was [illegible]

the fault is about [illegible]

nearly north in [illegible]

could not be determined. [illegible]

4,000 feet; the minimum [illegible]

rhyolite, [illegible]

[illegible] fault, [illegible]

eventually [illegible]

rocks that are so disturbed that no [illegible]

estimated.

A series of [illegible]

the southwestern part of the [illegible]

important manganese mineralization. All faults in the region are high angle to vertical.

Several northeast-trending faults were recognized in the mapped area, the major one of which is the Martin fault that passes northwest of Martin's Ranch. Its trend is roughly to the north in sec. 1, T. 18 S., R. 20 W., but nearly northeast from Martin's Ranch to the Precambrian granite outcrop area. This fault made possible the exposure of Precambrian granite and Cretaceous rocks in the area. Both ends of this fault are concealed under Gila conglomerate. Although the fault plane cannot be recognized, a zone oxidation and brecciation in sec. 20, T. 18 S., R. 20 W., appears to be nearly vertical. The top of the Tertiary rhyolite section has been brought next to the bottom of the Tertiary rhyolite section by the Martin fault. The minimum apparent vertical displacement is at least 2,000 feet, or the minimum thickness of the Tertiary rhyolite.

Two small faults, one of which strikes N 45° W and the other N 65° E, intersect near the northeast corner of secs. 21, 22, 27 and 28, T. 18 S., R. 20 W. A small local normal fault was noticed in sec. 22, T. 19 S., R. 20 W., which strikes N 80° E and dips vertical and the displacement is about 60 feet. Lastly, there is another normal fault that occurs in secs. 4 and 8, T. 18 S., R. 20 W., which roughly strikes northeast, dips nearly vertically and has a displacement of a few tens of feet.

important manganese mineralization [illegible] and high angle to vertical.

Several northwest-trending faults [illegible] mapped area. The major one [illegible] of McIntire's Ranch. Its [illegible] E. 20 W., [illegible] northwest [illegible] granite outcrop area. [illegible] brian granite and [illegible] are [illegible] the fault plane can only be recognized, a zone of [illegible] E. 20 W., appears to be [illegible] motion has been brought [illegible] by the Alamo fault. The [illegible] least 2,000 feet, as the [illegible]

Two small faults, one of which [illegible] T. [illegible] near the northeast [illegible] T. 18 S., R. 20 W. A small [illegible] T. 19 S., R. 20 W., which [illegible] displacement is about [illegible] feet. [illegible] that occurs in secs. 4 and 5, T. 19 S., R. 20 W. [illegible] northeast, dips nearly vertically and [illegible] of feet.

There are at least two periods of faulting:

(1) Faults that are younger than the Tertiary rhyolite and ignimbrite and older than the Martin fault. The Steeple Rock fault and associated northwest-trending faults probably belong to this period of faulting. As far as could be seen, these faults are truncated by the Martin fault.

(2) Faults younger than the Steeple Rock fault, younger than Gila conglomerate but older than Terrace gravels. They include the Martin and associated northeast-trending faults. The Martin fault truncates the Steeple Rock fault. They also include the northwest-trending faults which cut Gila conglomerate in the southeast corner of the area, and which control manganese mineralization.

ECONOMIC GEOLOGY

Precious metals (gold and silver) and base non-ferrous metals (copper, lead and zinc) are known to occur northwest of the mapped area, in the Steeple Rock mining district and to the east in the Silver City area but they are entirely lacking here. Manganese is the only metal produced and virtually all production has come from the southeastern corner of the area. Some additional traces of manganese mineralization show up in a fault in Precambrian granite porphyry in sec. 20, T. 18 S., R. 20 W.

[illegible]

(1) [illegible]

[illegible] and [illegible] the [illegible]

[illegible] and [illegible]

[illegible]. As far as [illegible]

[illegible] in fault.

(2) [illegible]

[illegible] conglomerate [illegible]

the [illegible] and associated [illegible] fault. [illegible]

[illegible] the [illegible]

[illegible] in the [illegible]

which [illegible]

[illegible]

Precious metals (gold [illegible]

(copper, lead and [illegible] are known [illegible]

in the [illegible]

but they are [illegible]

and virtually all [illegible]

area. Some [illegible]

[illegible]

History and Ownership

The mines are located in secs. 32 and 33, T. 19 S., R. 20 W., as shown in plate 2. There were two mines in operation prior to August, 1959. The mines are:

(1) Cliffroy mine in sec. 33, T. 19 S., R. 19 W.

(2) Consolation mine in sec. 20, T. 19 S., R. 19 W.

In addition there were several prospects. Two of them had been developed to a point where small shipments had been made. They were:

(1) The Ward mine in secs. 32 and 33, T. 19 S., R. 19 W.

(2) The Black Bob prospect in sec. 13, T. 19 S., R. 20 W.

All mines are located on psilomelane veins that follow small fault fissures. The Red Rock mining district was probably discovered during or since World War II. Wells (1918) mentioned some of the mines in the adjacent areas but not in this mining district.

Both the Consolation and Cliffroy mines were worked by R. W. Mathis of Silver City, New Mexico. He had leased the Cliffroy mine from Douglas Henry of Truth or Consequences, New Mexico and the Consolation mine from Duncan Mining Company, Duncan, Arizona. The Black Bob prospect was owned by Marshall Kuykendall of Lordsburg. The Ward mine was inactive in 1959.

[illegible]

The mines are located [illegible]

as shown by plate [illegible]

August, 1959. The mines are:

(1) [illegible]

(2) [illegible]

In addition there are [illegible] prospects. [illegible]

developed to a point [illegible]

(3) The [illegible]

(4) The [illegible]

All [illegible]

[illegible]. The [illegible]

in [illegible] World War II [illegible]

adjacent areas but not in [illegible]

Both the Constitution [illegible]

[illegible] Silver City, New Mexico. [illegible]

[illegible] Douglas [illegible]

Constitution mine from [illegible]

Black Hawk prospect [illegible]

The [illegible] mine [illegible]

Development and Production

Development of these mines was essentially due to governmental subsidy. In August, 1959, the government ceased to buy manganese ore because the allotment from the district had been filled under the General Services Administration Carlot Manganese Purchase Program. The manganese ore had been mined partly by open pit methods as in the Ward and Consolation mines and partly by sinking shafts, either vertical as in the Black Bob prospect and the Consolation mine, or inclined shaft, as in the Cliffroy mines.

The Cliffroy and Consolation mines accounted for the most of the ore production. The other two mines, namely Ward and Black Bob prospects, have been developed to some extent for shipment. About 15,000 tons of ore have been produced, valued at several hundred thousand dollars.

General Geology

Prior to 1940, it was believed that manganese oxide veins were formed by the superficial weathering and enrichment of "black calcite". Since then it has been established that the veins are hypogene epithermal deposits associated with travertine of Tertiary or Quaternary age in or near hot springs (Hewett and Fleischer, 1960). In the Cliffroy mine the ore grades upward into banded travertine within a few feet from the surface. The age of the mineralization is post-Gila (late Tertiary to Pleistocene).

Development [illegible]

Development of [illegible]

activity. In August, 1957, the government [illegible]

between the [illegible]

Services Administration [illegible]

manganese ore had been [illegible]

and Consolidation [illegible]

the Black Rock prospect and the [illegible]

the Cutter [illegible]

The Cutter and [illegible]

ore production. The [illegible]

prospects, have [illegible]

12,000 tons of ore have [illegible]

dollars.

[illegible] Geology

Prior to 1940, it was [illegible]

formed by the supergene [illegible]

Since then it has been [illegible]

deposits [illegible]

near the [illegible]

are graded [illegible]

surface. The age of the [illegible]

Pleistocene).

Host Rocks

The manganese veins did not show any particular preference for a particular type of host rock. In the Table Top Mountain district of Grant County, a few miles east from the mapped area, mineralization occurs in Precambrian granite and Tertiary rhyolite as well as in Gila conglomerate. In the Cliffroy mine, the manganese veins are entirely in coarse, consolidated conglomerate, the older member of the Gila conglomerate. At the Consolation mine, basalt and andesite flow rock lie on the foot wall and the fine grained, younger member of the Gila conglomerate in the hanging wall. Basalt is the host rock in the Black Bob prospect.

Geologic Structure

The manganese veins are all controlled by fault fissures. The mines are aligned along a general N 45° W trend, and this essentially parallels one of the major regional fault directions. The fault that controls the vein at the Consolation mine follows this trend. Here, slickenslides with vertical plunge on the foot wall indicate that the fault was of the dip-slip type. In other mines no evidence was noted for the direction of fault movement. Considering individual veins of all the mines, strikes vary considerably. In Cliffroy mine, the general trend is N 10° W. In the Ward mine, the veins strike about N 37° W. Many of the small prospects had a wide range of difference in strikes, but the

most common strike is about N 64° W. Dips are vertical or nearly vertical, and displacement is unknown.

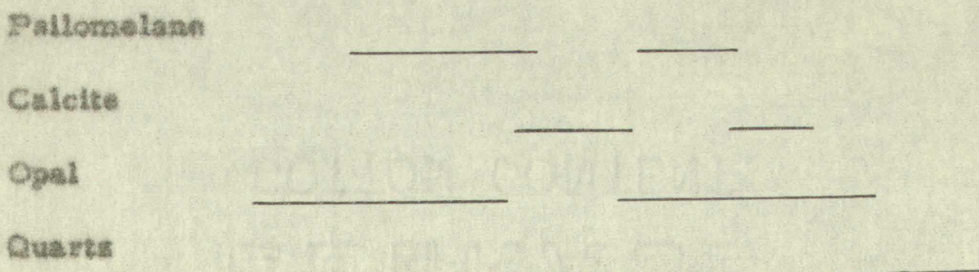
Mineralogy, Paragenesis, Alteration

The most important ore mineral is psilomelane, although some pyrolusite also may be present. Manganiferous calcite is known to occur and is black in color. The contact between banded travertine and psilomelane in the Cliffroy mine follows the present topography and probably it marks the site of former hot spring activity. Cross-cutting veinlets of psilomelane commonly replace the opaline silica cement of the Gila conglomerate at the Cliffroy and Ward mines, but sometimes opal veinlets and impregnations cut across psilomelane. Drusy quartz is youngest.

A paragenetic diagram is shown in table 7.

Table 7

Paragenetic diagram for Red Rock Manganese District



Psilomelane is the only commercial ore mineral, although a little pyrolusite may be present also. Calcite, on the whole, is scarce. Some of it is manganiferous and black in color. At the Cliffroy mine, the vein

grades upward into banded travertine. The psilomelane-travertine contact lies just a few feet below the surface and closely follows the topography of the area.

The entire district gives an impression of having been soaked by near-surface hot-springs water that precipitated calcite, opal and psilomelane. Some psilomelane, at least, is definitely younger than opal. Microscopic fibres of psilomelane are intergrown with opal, and seem to replace it (figure 6, p. 30).

Argillic alteration of basaltic andesite and iron staining are known near the Consolation mine, and in the Black Bob prospect the basalt host rock is also argillized. The paragenesis of the Black Bob prospect is somewhat different than that of the other mines. It is as follows: 1. Argillic alteration, 2. Precipitation of fibrous, drusy psilomelane and pyrolusite in fractures, 3. Precipitation of drusy, crystalline quartz that lines cavities in pyrolusite veins.

Description of Individual Mines

Cliffroy mine

The Cliffroy mine, located in sec. 33, T. 19 S., R. 19 W., is on a well-defined psilomelane vein in coarse, well-consolidated Gila conglomerate. The vein strikes about N 10° W and dips 75° NE to vertical. The vein is up to 5 feet thick but locally it goes up to 8 feet. It is controlled by a brecciated zone 5-9 feet wide. On the foot wall side small stringers of psilomelane branch off of the vein running off into the wall-rock in a SSE direction.

gneiss upward in a general [illegible]

contact lies just a few feet [illegible]

topography of the area.

The entire [illegible]

surface [illegible]

[illegible]

[illegible]

(figure 5, p. 30).

[illegible]

[illegible]

[illegible]

[illegible]

1. [illegible] 2. [illegible]

and [illegible]

quartz [illegible]

Description of mineralization

Gilfroy mine

The Gilfroy mine [illegible]

well-defined [illegible]

manner. The vein [illegible]

vein [illegible]

by a [illegible]

of [illegible]

[illegible] alteration.

The ore consists of psilomelane intergrown with opal so as to give a silicified impression. Manganese content averages about 25-35 per cent. It is much richer than the other mines. Due to the intergrowth of psilomelane and opal with silica milling could raise the grade to only about 36 per cent manganese. Lack of high degree of concentration was the main reason the mine failed to make a good profit.

About 5,000 tons of ore were shipped from the mine. Prior to the closing of the mine, five men were working there. Since the mine was located near the top of a hill water was not encountered. The mine consists of a single stope 300 feet long, 70 feet deep, and 5-9 feet wide. Access to the mine is through a 35° incline at the south end. The stope followed a single lens or ore pocket which was already mined out when the mine was closed in August, 1959. The vein dies off at the bottom of the stope but some ore can be seen on the northern end of the stope.

Ward mine

The Ward mine has been worked as an open pit during 1955 and 1956. The mine was abandoned after a short time because of the poor grade of ore. The pit is about 500 feet long, 25 feet wide. Its depth varies but is shallow for most of its length. The deepest part lies at the intersection of two fissure veins.

Two lean veins are controlled by two intersecting faults. One strikes N 28° W and the other strikes N 36° W. Both are nearly vertical. They intersect near the northwestern end of the open pit. Here, again, the host

The ore consists of pyrrhotite [illegible] with [illegible] a silicified fragmental [illegible] copper content averages about [illegible] per cent. It is much richer than the other veins. [illegible] mineralized and cut with silica stringers [illegible] per cent manganese. [illegible] reason the mine failed to become a good producer.

About 2,000 tons of ore were shipped from the mine. [illegible] closing of the mine, [illegible] working [illegible] located near the top of a hill [illegible]. The mine consists of a single stope 300 feet long, 75 feet deep, and [illegible] wide. Access to the mine is through a [illegible] at the [illegible] a single [illegible] which was [illegible] when the mine was closed in August, 1959. The [illegible] but some ore can be seen on the [illegible] of the stope.

Ward mine

The Ward mine has been worked [illegible] during 1951 and [illegible]. The mine was abandoned after a short time because of the poor grade of ore. The pit is about 150 feet long, 25 feet wide. The depth [illegible] shallow for most of its length. [illegible] two distinct veins.

The two veins are controlled by two intersecting faults. One strikes N 55° W and the other strikes N [illegible]. Both are nearly vertical. They intersect near the [illegible] of the open pit. [illegible]

rock is Gila conglomerate, coarse, and well-consolidated. The veins are poorly defined and occur as numerous branching stringers. The ore was too highly mixed with waste rock for profitable mining.

The ore mineral is psilomelane. The wall-rock is highly opalized.

Consolation mine

The Consolation mine was first located in 1951, in sec. 20, T. 18 S., R. 19 W. Here, also, a fault controls mineralization. It strikes N. 45° W. and dips steeply to the northeast. The hanging wall side of the fault is coarse, poorly consolidated sandstone of the upper member of the Gila conglomerate. The rock on the foot wall is andesite.

The ore shoot lies on a breccia zone up to 8-9 feet wide. The ore is richer on the foot wall side than on the hanging wall side. Mining was carried out to a length of 120 feet along the strike and to a depth of about 100 feet.

The ore is mainly psilomelane and brecciated wall-rock. The average grade is about 8-10 per cent manganese. It was concentrated to 43 per cent by jigging at Kirk's mill in the valley of the Gila River.

Originally, mining was carried out as an open pit. A vertical shaft was sunk later at the southeast end of the pit. The shaft was about 100 feet deep before the mine was closed during August, 1959. The ore was mined by overhand stoping. At the northwest end of the workings, the ore continues but is of poor grade. There is no ore southeast of the shaft. At the

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

The ore [illegible] [illegible] [illegible] [illegible] [illegible]

Connemara zone

The Connemara lode was [illegible] [illegible] [illegible] [illegible] [illegible]

E. 15 W. Here, [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

and dips steeply to the [illegible]. The [illegible] [illegible] [illegible] [illegible]

quartz, poorly [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible]. The [illegible] [illegible] [illegible] [illegible]

The ore [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] on the [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] a length of [illegible] [illegible] [illegible] [illegible] [illegible]

100 feet.

The ore is [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

grade is about [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

by [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

Originally, [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

by [illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible] [illegible] [illegible] [illegible] [illegible]

bottom of the shaft the ore is said to be still good grade, but heavy flow of water prevented development of the mine.

Output from the Consolation mine was about 10,000 tons before mining ended. The value was about $190,000. The concentrate obtained after jigging was sold for about $85 per ton. Three men were working in the mine before it was closed.

Black Bob prospect

The Black Bob prospect lies in sec. 13, T. 19 S., R. 20 W. The host rock, unlike that of the other mines, is Tertiary (pre-Gila?) basalt. The ore is essentially psilomelane. It is disseminated through a zone of soft argillized brecciated basalt and gouge of about 12 feet wide. Manganese mineralization seems to be very poor. Only a trace can be seen at the surface. The breccia strikes roughly east-west. A shaft was sunk to a depth of about 75 feet, inclined 78° W. in the prospect.

FLORA OF THE VIRDEN FORMATION

Introduction

The Virden flora is of particular significance to the latest Cretaceous geology of southwestern New Mexico. It is significant not only because it represents the first plant fossils ever to be found in that region, but also because they constitute a key by which hitherto unsolved problems of the age relations of the volcanic rocks can be solved.

Geologic Occurrence

The fossil leaves occur in sandstones intermingled with tuffs and clayey silts. They have been collected from two places at the locality in SE 1/4, sec. 8, T. 18 S., R. 20 W., and NE 1/4, sec. 17, T. 18 S., R. 20 W. Most of the larger pieces of Araucarites and almost all the leaves are found at one outcrop. In the other outcrops the sandstone is remarkably tuffaceous and unconsolidated and leaves are rare. Numerous palm fragments which could not be identified have been found. Fragments of wood which are still in the process of fossilization are commonly associated with them.

Composition

In spite of the authors' careful search only two fossil bearing places could be located although fragments of twigs and wood can be observed in many places. The majority of the specimens are conifers, probably all belonging to Araucarites. Quite a few dicotyledons and few monocotyledons were also found. Palms are numerous but not preserved in sufficient detail to allow a study of their species. The flora is largely represented by leaf impressions. Seeds, pollens, and spores were not found.

Identification

The leaves have been identified by comparison with illustration and

Geology & Occurrence

The fossil leaves occur in [illegible] at [illegible] clayey silts. They have been [illegible] in SE 1/4, sec. 2, T. 16 S., R. 27 E. [illegible] N. 23 W. Most of the larger [illegible] leaves was found at this outcrop. [illegible] is remarkably [illegible] and [illegible]. Numerous palm fragments [illegible]. Fragments of wood which are [illegible] commonly associated with them.

Composition

In spite of the authors' careful search [illegible] plants could be located although fragments of twigs [illegible] observed in many places. The [illegible] probably all belonging to Sabalites. [illegible] monocotyledons were also found. [illegible] be [illegible] detail to allow a study of their [illegible] represented by leaf impressions. [illegible] found.

Identification

The leaves have been identified [illegible]

description in the literature. Araucarites, however, was identified by Erling Dorf when he was in New Mexico as a visiting lecturer for the American Association of Petroleum Geologists.

Climatic Conditions

There are two methods by which fossil plants can be used as the indicators of climatic conditions of the past. They are:

1). By comparing the morphology of dicotyledon leaves with the modern leaves of known climatic requirements.

2). By the generic and species comparison of the fossil leaves with the modern ones whose climatic controls are known.

The present collection of dicotyledon leaves from the Virden formation is relatively small and too poorly preserved to make a thorough study of their size, veination, texture and marginal characters. Therefore, the first method cannot apply here. To consider the second method, a comparison of fossil leaves with their living equivalents is given below.

description in the literature. [illegible] (1957) [illegible] presented [illegible]
Erling Dorf when he was in [illegible]
American Association of Petroleum [illegible]

Climatic Conditions

There are two methods by which fossil plants [illegible] indicators of climatic conditions. (Dorf, [illegible])

1). By comparing the morphology [illegible] that produce leaves of known climatic requirements.

2). By the generic and specific [illegible] the modern ones whose climatic [illegible]

The present collection of fossil [illegible] is relatively small and too poorly [illegible] their size, venation, texture and margins [illegible] first method cannot apply here. [illegible] portion of fossil leaves with [illegible]

Table 8

Comparison of the fossil flora with living correlatives:

Fossil flora	Living correlatives	Recent distribution			
		Cool temperate	Warm temperate	Sub-tropical	Tropical
Araucarites longifolia	Araucaria	X	X		
Canna(?) magnifolia	Canna		X	X	X
Juglans leconteana	Maclura	X	X		
	Apocynum	X	X	X	
Cinnamomum sp.	Cinnamomum		X	X	X
Viburnum sp.	Viburnum	X	X	X	

The above table shows that the floral assemblage is neither cool temperature nor tropical. The other fossil leaves that are not compared above are Salix and Ficus. Ficus is seldom mentioned from the temperate latitudes. Salix is generally absent from deposits formed under tropical conditions (Arnold, 1947). These observations suggest that the Virden flora is warm temperate to sub-tropical with Auraucarites suggesting a temperate aspect.

Correlation

It is now established that the sequence of formations of upper Cretaceous age in the Western Interior occur in the following order:

1. Lance formation (Laramie group)
2. Montana group
3. Colorado group
4. Dakota sandstone

The Dakota sandstone and the Colorado group can be eliminated from correlation with the Virden formation because the Virden formation lies conformably on the Colorado shale.

From the stratigraphic position this formation occupies a position correlative with the Montana group in other places. But correlation by stratigraphic position alone is highly uncertain and misleading where the sequence of formations is not complete. Therefore the only reliable means of correlating the Virden formation is its fossil assemblage - the flora.

Table 9 summarizes the distribution of Virden species in other floras. This analysis indicates that the Virden fossil assemblage has its greatest similarity with the Lance flora. This is further strengthened by the dominant occurrence of Araucarites in both formations. Therefore, the Virden formation can be correlated with the Lance formation and is most likely to be Lancian in age.

[illegible]

It is now established that the sequence of [illegible] of Cretaceous age in the Western Interior [illegible] in descending order:

1. Lance formation [illegible] group

2. Montana group

3. Colorado group

4. Dakota sandstone

The Dakota sandstone and the Colorado group can be eliminated from correlation with the Vinton formation because the Vinton formation lies unconformably on the Colorado shale.

From the stratigraphic position [illegible] [illegible] a possible correlation with the Montana group is [illegible]. But the relation by stratigraphic position alone is highly uncertain and misleading since the sequence of formations is not complete. Therefore the main method of correlating the Vinton formation is the fossil [illegible] [illegible] the flora.

Table V summarizes the distribution of Vinton species in other floras. This analysis indicates that the Vinton fossil assemblage has its greatest similarity with the Lance flora. This is further strengthened by the abundant occurrence of [illegible] in both formations. Therefore the Vinton formation can be correlated with the Lance formation and is most likely to be Lancian in age.

Table 9

Distribution of Virden species in other floras

Age		Formations	Virden flora							
			Araucarites longifolia	*Canna ? magnofolia*	*Ficus eucalyptifolia ?*	*Zizyphus hendersoni*	*Viburnum sp.*	*Cinnamomum sp.*	*Juglans leconteana*	*Salix ? sp.*
Tertiary	Paleocene	Fort Union								
		Tullock-Ludlow	?							
		Raton					X	X		X
Upper Cretaceous	Lancean	Lance	X	X	X	X	X	X	X	X
		Hell Creek	X	X						X
		Medicine Bow	X	X			X	X	X	X
		Laramie	X			X	X	X	X	X
		Vermejo	X	X	X		X			X
		Colgate	X					X		X
	Montanan	Fox Hills							X	X
		Trinidad	X	X						X
		Fruitland-Kirtland			X					X

Dorf (1942) considered the Laramie and the Medicine Bow formation to be of Lancian age. The Vermejo formation is kept in a transition zone between Montana (lower Vermejo) and Lance (upper Vermejo).

Correlation with Tertiary formations can be discarded as Araucarites, so common in the Virden formation, is apparently confined to the Cretaceous.

Systematic Descriptions

Family ARAUCARIACEAE

Genus ARAUCARITES Presl.

Araucarites longifolia (Lesquereux) Dorf, 1942.

(Plate 5, Figs. 1-6)

Description

Stems stout with radial phyllotaxy; branches thick, leaves obtusely pointed, sessile ligulate, persistent; angle of divergence intermediate, marked by a groove in the middle, slightly narrowed to decurring base and marked by a medial fold.

Discussion

This is the dominant species in Virden flora. They occur mostly as twigs or fragments of branches. Unfortunately not a single cone-

bearing specimen was found. These fossils were identified by Erling Dorf when he was on a lecture to New Mexico (1959) and are the most important fossil for dating the Virden formation.

Due to lack of cones, seeds and detailed preservation, some specimens cannot be definitely identified. The authors think it is quite justifiable to include them in the same population for the present.

Occurrence

Trinidad, Vermejo, Colgate, Laramie, Medicine Bow, Lance, Hell Creek, and Virden formations (Upper Cretaceous).

Family CANNACEAE

Genus CANNA Linné

Canna? magnifolia Knowlton, 1917.

(Plate 6, Fig. 1)

Description

Only broken pieces were found. Midrib very strong, up to one centimeter in thickness, numerous parallel close straight veins arise from the midrib; veins not forked and diverging approximately 70°.

Discussion

It is unlike Canna? sp., which according to Knowlton (1917) differs from Canna? magnifolia in having veins arise at a slightly lower angle and is without cross veins.

bearing specimens were lumped. [illegible] were identified by [illegible] [illegible] which he [illegible] and [illegible] important [illegible] Prague formation.

Due to lack of [illegible] some specimens cannot be definitely identified. [illegible] justifiable to include them [illegible].

Occurrence

Trinidad, Venezuela, Colombia, [illegible] Gulf Coast, [illegible]

Family [illegible]

[illegible]

Genus? [illegible], 1949

(Plate [illegible])

Description

Only [illegible] specimens [illegible] from the [illegible]

Remarks

It is [illegible] from [illegible] and [illegible].

It differs from Musophyllum complicatum which is distinguished from Canna? magnifolia by its veins which are at right angles to midrib, are thinner at least where they reach the margin and do not have cross veins.

Occurrence

Trinidad, Vermejo, Medicine Bow, Lance, Hell Creek and Virden formations (Upper Cretaceous).

Family RHAMNACEAE

Genus ZIZYPHUS Adanson

Zizyphus hendersoni Knowlton, 1922

(Plate 6, Fig. 2)

Description

Leaf firm in texture, ovate or ovate-elliptical, abruptly rounded to the slightly wedge-shaped base; apex obtuse; margin perfectly entire; petiole stout; five ribbed, three of them prominent.

Discussion

Only one specimen was collected from the Virden formation of which the upper half is not preserved. The lower half is preserved in sufficient detail so that it can be identified and agrees with Knowlton's description very closely.

This specimen might be confused with Zizyphus fibrillosus Lesquereux, a species well known in the Denver and Raton formations, but it can be differentiated in having a distinctly wedge-shaped instead of truncate or heart-shaped base.

Occurrence

Laramie, Lance and Virden formations (Upper Cretaceous).

Family LAURACEAE

Genus CINNAMOMUM (Tournefort) Linné

Cinnamomum sp.

(Plate 6, Fig. 3)

Description

Leaf firm in texture, subcoriaceous, ovate lanceolate, nervation triple ribbed, midrib strong; Additional nervation not observable; Apex short, base broad.

Discussion

Only one specimen was collected of which the outer margin was not preserved.

This leaf compares in detail with Cinnamomum newberryi Berry (1914) which Berry describes as follows: "Leaves subcoriaceous,

This specimen [illegible]

Lamprocarpus, a [illegible]

but it can be [illegible]

of [illegible]

[illegible]

Locality. [illegible] Creek [illegible]

Family [illegible]

Genus [illegible]

[illegible]

[illegible]

Description

Leaf [illegible] in [illegible]

[illegible]

apex. [illegible]

Discussion

Only one specimen was [illegible]

not preserved.

This leaf [illegible]

(1914) which [illegible]

lanceolate to ovate lanceolate in outline, varying greatly in size and consequently in appearance. Apex short pointed or narrowly extended. Base broad, narrowed to the petiole. Primaries three, usually suprabasiculor." Because of poor preservation, the authors hesitate placing this specimen in this species.

The only other specimen which resembles our specimen is Cinnamomum heerii Lesquereux which can be distinguished by its relatively narrower form and acute basé.

Occurrence

Virden formation (Upper Cretaceous).

Family CAPRIFOLIACEAE

Genus VIBURNUM (Tournefort) Linné

Viburnum? sp.

(Plate 6, Figs. 4 and 5)

Description

Ovate in outline, coriaceous in texture, with an obtusely pointed apex and slightly decurrent base; midrib prominent and more or less straight; secondaries more or less straight and parallel, arising at an acute angle; the tertiaries well impressed and forming reticulate veination; margin seems very slightly serrated, but serration not distinct due to bad preservation; petiole not preserved.

Discussion

Five specimen of Viburnum? sp. were collected from the Virden formation. These specimen can be compared with Viburnum marginatum Lesquereux and Viburnum montanum Knowlton of the Vermejo formation, but due to lack of good preservation and enough specimens the species were not determined.

Occurrence

Virden formation (Upper Cretaceous).

Family SALICACEAE

Genus SALIX Linne

Salix? sp.

(Plate 7, Figs. 1 and 2)

Description

Generally long and narrow leaves with strong midribs; linear and linear-lanceolate to ovate lanceolate, tapering at both ends or narrowly wedge-shaped at the base; veination obscure.

Discussion

About five specimens of Salix? sp. were collected from the Virden formation. They are all poorly preserved.

Occurrence

Virden formation (Upper Cretaceous)

Family MORACEAE

Genus FICUS

Ficus eucalyptifolia? Knowlton, 1917.

(Plate 7, Figs. 3, 4 and 5)

Description

Leaves of variable size, poorly preserved, lanceolate in shape gradually tapering to both ends; petiole wanting; apex acuminate, in some not present; margin entire; midrib straight and prominent, other nervation effaced.

Discussion

Their shape and size may be compared to Ficus? starkvillensis Knowlton of the Vermejo formation or Ficus lanceolata Heer of the Laramie formation, but the lack of adequate numbers of specimens and poor preservation make closer identification impossible.

Occurrence

Fruitland-Kirtland, Vermejo, Lance and Virden formations (Upper Cretaceous).

Family JUGLANDACEAE

Genus JUGLANS Linné

Juglans leconteana Lesquereux, 1872

(Plate 7, Fig. 6)

Description

Leaf coriaceous, with entire margins; gradually narrowed from the widest point, to the base and upward to the long, narrow acuminate apex; midrib thick and straight; secondaries alternate; nervilles numerous; finer nervation not retained.

Discussion

This is exactly the same as Dorf's (1942) specimen in Fox Hills and Lower Medicine Bow. It also matches well with the specimens figured by Lesquereux (1872) and Knowlton (1922) from the Laramie and Black Buttes floras.

Occurrence

Fox Hills, Laramie, Medicine Bow, Lance and Virden formations (Upper Cretaceous).

SUMMARY AND CONCLUSION

1) The whole Paleozoic sedimentary section is missing in the mapped area.

2) Upper(?) Cretaceous Beartooth sandstone directly overlies Precambrian granite.

3) The Upper Cretaceous section is represented by Beartooth sandstone, Colorado shale, pre-Virden volcanic rocks and Virden formation, a new name proposed in this report. On the basis of marine fossils the Colorado shale is dated as Carlile or older. On the basis of plant fossils the Virden formation is dated as Lancean or slightly older.

4) There are three groups of volcanic rocks:

   (a) A post-Colorado pre-Virden group consisting of dacite, rhyolite and andesite.

   (b) A post-Virden and pre-Gila group consisting mainly of rhyolite and subordinate latite and andesite. It correlates with the Datil formation in Catron and northern Grant Counties.

   (c) A group of basalt and basaltic andesite, partly older than Gila conglomerate (Pliocene?), and partly interbedded with Gila conglomerate. Some flows may be post-Gila (Quaternary), but this has not been demonstrated in the mapped area.

5) Hot-spring type epithermal manganese mineralization occurs in the southeastern part of the mapped area. The ore can be concentrated by jigging, but profitable mining is impossible without a government subsidy.

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Prof. Paper [illegible]

Brown, [illegible] 19[illegible] [illegible]

[illegible] University [illegible]

Gallagher, [illegible] 19[illegible] [illegible]

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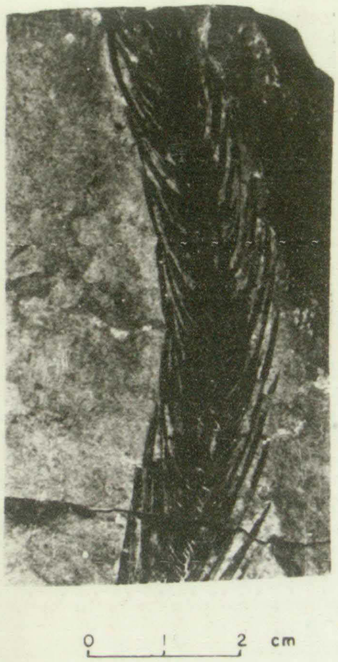
UPPER CRETACEOUS PLANTS FROM

THE VIRDEN FORMATION

PLATES 5-7

PLATE 5.



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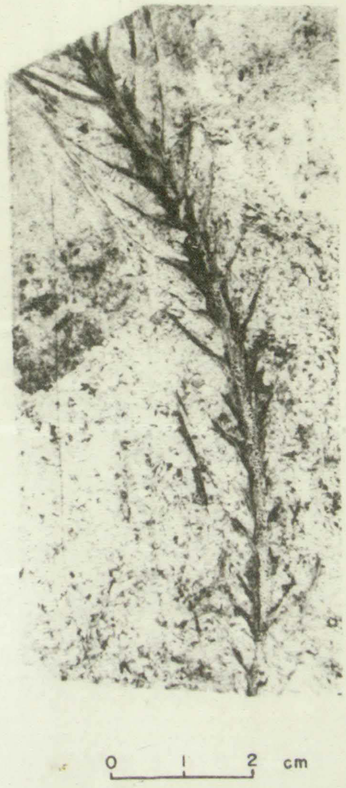

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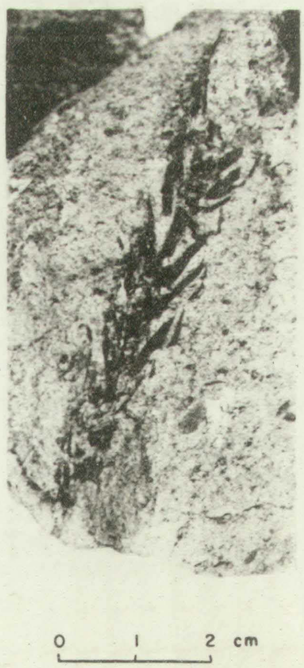

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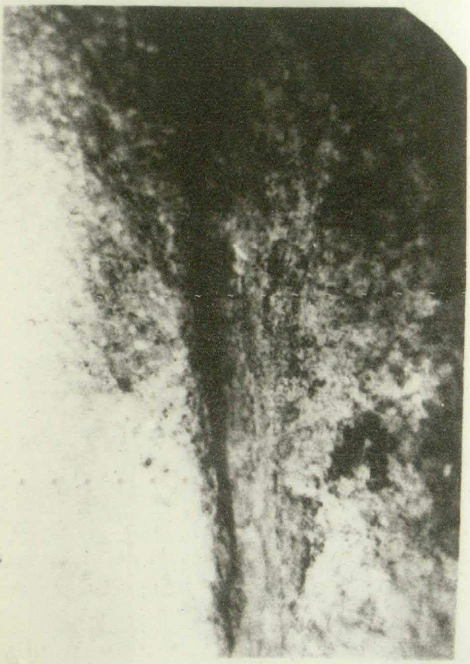

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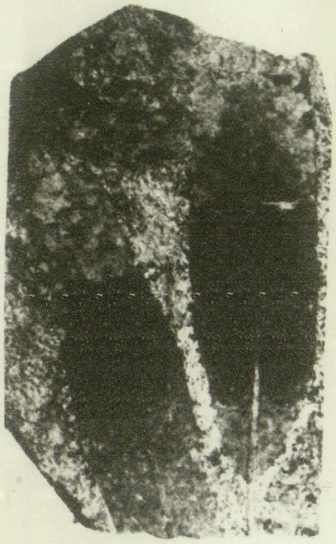
PLATE 7.



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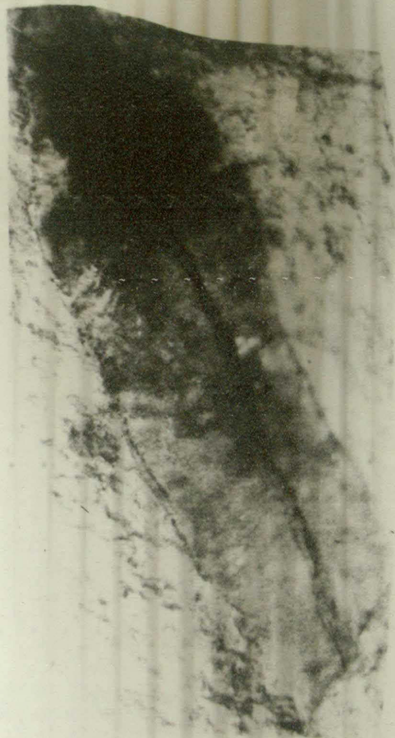

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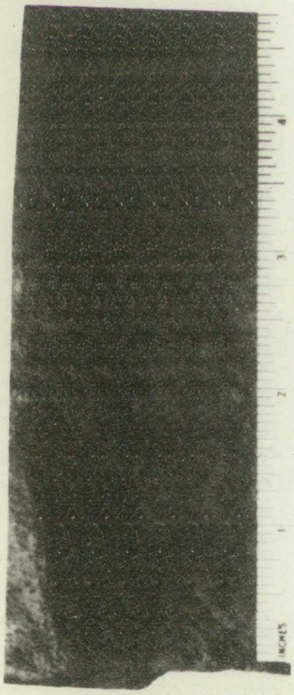

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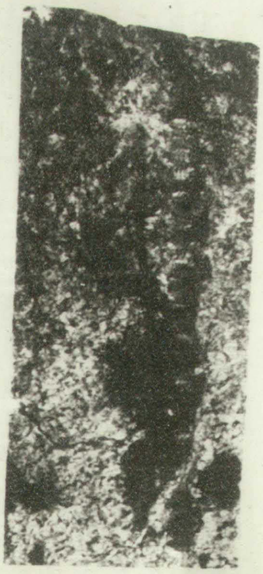

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One map in pocket