THE GEOLOGY OF A WESTERN PORTION
OF THE SANTA RITA QUADRANGLE, GRANT COUNTY
NEW MEXICO

by

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Director of Thesis Date

This report is preliminary and has not been edited or reviewed for conformity with U. S. Geological Survey standards and nomenclature.
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ABSTRACT

The area discussed in this paper lies along the western boundary of the Santa Rita quadrangle, Grant County, New Mexico.

The sedimentary rocks include the Osvaldo and Syrena formations of the Magdalena group (Pennsylvanian), the Abo red beds (Permian), the Beartooth quartzite (Cretaceous), and the Colorado formation (Cretaceous). The total thickness of the Paleozoic rocks exposed is approximately 350 feet, and that of the Beartooth quartzite about 60 feet. The rocks of the Colorado formation have a thickness in excess of 800 feet. They grade from marine shales at the base to continental sandstones and conglomerates at the top.

Igneous activity began during late Cretaceous time and continued intermittently through the Tertiary period. Two orogenic provinces separated by the Barringer fault developed during this time. South of this fault extensive sills were emplaced early, followed by two small stocks at Copper Flats and still later by a few small dikes. North of the Barringer fault, igneous activity began with a large intrusion, followed by the emplacement of many dikes. After an erosion interval igneous activity was renewed. It began with the extrusion of flows and continued through a long period of dike intrusion and the emplacement of two small stocks. After erosion had again intervened, the extrusion of a thick series of flows from the north in middle or late Tertiary time closed the igneous cycle.

The salient structural features are a broad northeasterly-trending anticline, an easterly to northeasterly-trending belt of faults including
the major Barringer fault which lies on the northern edge of the belt; and a network of fissures, filled by dikes, radiating from an intrusive center located about a mile north of the Barringer fault and near the western boundary of the quadrangle.
INTRODUCTION

Previous Work

The area covered by this report was first mapped by Sidney Paige and described in the Silver City folio.\(^1\) It was later included in the more detailed map made in 1934 by Spencer and Paige\(^2\) (Fig. 1).


Lasky\(^3\) mapped the area to the south and southwest. The southern boundary of the area included in the present study corresponds roughly with the western quarter of the north boundary of Lasky's map. The Geological Society of America's field trip guidebook prepared by R. M. Hernon\(^4\)

\(^3\) Lasky, S. G., Geology and Ore Deposits of the Bayard Area, Central Mining District, New Mexico: U. S. Geol. Survey Bull. 870, 144 pp., 1936.

\(^4\) Hernon, R. M., Geology and ore deposits of Silver City region, New Mexico; West Texas Geol. Soc., and Southwestern N. Mex. section Am. Inst. Min. and Met. Eng.; Guidebook Field Trip No. 3, Nov. 6-9, 1949.

gives a resume of the geology, structural features and ore deposits of the Santa Rita quadrangle and surrounding region. No other publications deal with the area described in this report, although much unpublished information exists in the files of mining companies.
General Description

Description of the geographic position, topography, climate, and vegetation of the region has been presented by Spencer and Paige.\(^2\)

\(^2\)/ op. cit., pp. 3-5.

The area covered by this report is in Grant County, New Mexico between meridians 108°8' and 103°6' west longitude; and parallels 32°49' and 32°52' north latitude. It lies about 10 miles northeast of Silver City, the county seat.

Streams in the region drain southward into a desert basin in which the town of Doming is situated. Streams within the mapped area are intermittent and subject to sudden floods during summer thunderstorms.

Altitudes range from 6,250 feet in Yellow Dog Gulch to 7,569 feet on Hermosa Mountain (Plate 1).

The climate of Grant County is semi-arid. At Fort Bayard the mean annual temperature is 54.7°F. and the mean annual precipitation is about 16 inches according to Lasky.\(^6\)

\(^6\)/ op. cit. p. 9.

The trees within the area are largely juniper, pinon pine, and live oak, although a few white or yellow pine grow on the upper flanks of Hermosa Mountain; cottonwoods grow along the lower stream courses. Much of the vegetation consists of brushy and thorny plants such as mountain mahogany, cat's claw, century plant, and yucca.
Field Work and Acknowledgments

Field work started in early February and ended in August of 1950. The country south of the Barringer fault was mapped with the aid of plane table and alidade. Secondary control was established from four bench marks on Hermosa Mountain, Humboldt Mountain, the hill west of the Three Brothers mine, and the hill west of the Hobo mine. Instrument stations were determined by resection, using three or more control points; field locations were made by pace and compass traverse from the instrument. North of the Barringer fault the geology was plotted directly on aerial photographs of approximately the same scale as the topographic base (1:12,000).

The contributions made by this study consist of: (1) The recognition and mapping of the complex series of dikes and stocks in the area north of the Barringer fault; (2) the dating of the andesite breccia as later than the Hermosa intrusive and the oldest dikes, hence presumably of post-Colorado age; (3) the estimation of the probable thickness of Colorado formation in North Star Basin and the hypothesis as to the significance of the facies changes within it; (4) the evidence for the probable laccolithic form of the Hermosa intrusive; (5) additional evidence for the direction of movement on the Barringer fault and (6) a more detailed mapping of the fault pattern south of the Barringer fault.

This work was done under the auspices of the U. S. Geological Survey and is being placed on open file by permission of the Director. Mr. R. M. Hemon, who supervised the field work, spent several days in the field with the author giving him counsel and advice. Mr. A. F. Shride examined part of the area and helped with suggestions on stratigraphy. Thanks
are due to ranchers Mr. Crumbley, Mr. Anse, and Mr. Roos, and to the United States Smelting and Refining Company for allowing access to their land on which the work was carried out. I would like especially to express appreciation to Mr. Stearns Cook, resident geologist of the United States Smelting and Refining Company, for making available information on a drill hole which penetrated part of the Colorado formation (Table 1).

Professors J. A. Anthony, D. L. Bryant, G. A. Kiersch, J. L. Lance, E. D. McKee, and M. N. Short, members of the faculty, Department of Geology, University of Arizona, reviewed the manuscript; the resulting improvement is greatly appreciated.
STRATIGRAPHY

General Features

Rocks ranging in age from Devonian to Upper Cretaceous are known to occur within the mapped area. Although the oldest formation cropping out is Lower Pennsylvanian in age, older rocks have been penetrated by diamond drill holes. South of the Barringer fault, Paleozoic rocks are exposed over most of the area where domed by the Copper Flats laccolith. North of the Barringer fault only Upper Cretaceous sedimentary rocks crop out. Table 1 summarizes the sedimentary formations shown on the accompanying map and section (Plates 1-2).
TABLE 1

Sequence of stratigraphic units in the western portion of the Santa Rita quadrangle.

<table>
<thead>
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<th>Age</th>
<th>Name</th>
<th>Member</th>
<th>Thickness</th>
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<tbody>
<tr>
<td>Quaternary</td>
<td>Quaternary alluvium</td>
<td></td>
<td>0- 20</td>
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<td></td>
<td>Quaternary terrace gravels</td>
<td></td>
<td>0- 20</td>
</tr>
<tr>
<td>Upper</td>
<td>Colorado formation</td>
<td>Sandstone member</td>
<td>600</td>
</tr>
<tr>
<td>Cretaceous</td>
<td></td>
<td>Shale member</td>
<td>200</td>
</tr>
<tr>
<td>Upper</td>
<td>Beartooth quartzite</td>
<td></td>
<td>60</td>
</tr>
<tr>
<td>Cretaceous(?)</td>
<td>Abo redbeds</td>
<td></td>
<td>0- 45</td>
</tr>
<tr>
<td>Cretaceous</td>
<td>Magdalena group</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permian</td>
<td>Syrena formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Don limestone</td>
<td>100-150</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Mountain Home shale</td>
<td>60-130</td>
</tr>
<tr>
<td></td>
<td>Oswaldo formation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>*Upper Blue limestone</td>
<td></td>
<td>300</td>
</tr>
<tr>
<td></td>
<td>+*Middle Blue limestone</td>
<td></td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>+*Parting shale</td>
<td></td>
<td>20-30</td>
</tr>
<tr>
<td>Lower</td>
<td>Lake Valley limestone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pennsylvanian</td>
<td></td>
<td>Hanover (crinoidal) limestone</td>
<td>80-175</td>
</tr>
<tr>
<td>Mississippian</td>
<td>Upper Blue limestone</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hanover (crinoidal) limestone</td>
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<td>80-175</td>
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<td></td>
<td>Lower Blue limestone</td>
<td></td>
<td>240</td>
</tr>
<tr>
<td>Devonian</td>
<td>Percha shale</td>
<td></td>
<td>200</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>1,950-2,260 feet</td>
</tr>
</tbody>
</table>

*After Lasky, op. cit. pp. 17-19, 1936
+Not exposed in mapped area
Paleozoic Formations

Percha shale (Devonian)

The Upper Devonian Percha shale, although not exposed within the area mapped, crops out a few miles to the east near Hanover. It was recognized in the cores from diamond drill holes in the vicinity of Copper Flats. This formation grades gradually from a black fissile shale near the base through a gray calcareous shale to a fossiliferous shaly limestone at the top. It underlies the Mississippian Lake Valley formation and has an average thickness of 200 feet.

Lake Valley limestone (Lower Mississippian)

Although this formation does not crop out within the limits of the mapped area, its presence is verified by drill hole information and it appears at the surface near Hanover to the east. It has been locally subdivided into two members: the Lower Blue limestone member at the base and the Hanover (crinoidal) limestone at the top. The Lower Blue limestone, about 250 feet thick, is gradational at the base with the underlying Percha shale but consists largely of a massive slate-gray limestone of varying texture containing a few chert lenses. Above the Lower Blue limestone are 80 to 175 feet of white, fossiliferous crinoidal limestone containing numerous beds of white chert. These rocks are locally designated the Hanover limestone member. It constitutes the chief ore horizon in the Hanover mining district.

Magdalena group (Lower Mississippian)

A series of limestones and shales belonging to the Lower Pennsylvanian Magdalena group rests disconformably upon the Lake Valley limestone. This
group was first described in 1907 by C. H. Gordon from its type locality in the Magdalena Mountains of central New Mexico. There it overlies the Mississippian Kelly limestone and has a total thickness of about 1000 feet. In the Santa Rita quadrangle the total calculated thickness of the Magdalena group is approximately 700 feet, although the full section is not exposed in any one locality and facies changes make exact correlation difficult. The group has been subdivided locally by Spencer and Paige into the Oswaldo formation, predominantly limestone, and the overlying Syrena formation, predominantly shale. The type locality of the Oswaldo formation is the Oswaldo mining claim about one mile south of the Hanover Post Office. This formation is locally subdivided into the Upper Blue limestone at the top, the Middle Blue limestone and the Parting shale member at the base.

The Upper Blue limestone consists of about 300 feet of thick-bedded, fossiliferous limestone containing a few shale beds. A sill of quartz diorite 40 feet thick, called the Marker sill, separates it from the lithologically similar Middle Blue member about 90 feet thick. At the base of the Middle Blue is a bed of shale 10 to 50 feet thick which contains abundant plant remains and is called the Parting shale. This shale lies unconformably on the Lake Valley formation of Mississippian age.

The Syrena formation, which conformably overlies the Oswaldo, was
named from its exposure on the Syrena claim. It consists of two members: the upper Don limestone member, about 100 feet thick in the mapped area, and the lower Mountain Home shale member, some 70 feet thick in its type locality on Humboldt Mountain.

Oswaldo formation - Only the upper part of the Upper Blue member of the Oswaldo formation crops out within the mapped area. Here it is about 150 feet thick, its best exposure is where Beartooth Canyon crosses the western boundary of the Santa Rita quadrangle (Plate 1).

Upper Blue limestone member - A. F. Shride measured the thickness of this member in Beartooth Canyon; there it is composed of 153-1/2 feet of interbedded nodular, silty limestones and nearly pure limestones and is a prominent cliff-former. The purer limestones range in color from dark brownish gray to light gray on fresh surfaces and weather light gray or pale olive; some are crystalline but others are very fine grained. The silty limestones are pale yellowish brown where fresh and dark yellowish orange to dusky yellow on outcrop. They contain irregular nodules of purer limestone. The nearly pure limestone beds vary from thin- to thick-bedded, and the silty limestones in most places are thick-bedded, and have rough surfaces from differential weathering of the nodules, in contrast to the nearly pure limestone beds which weather

*Color descriptions throughout are in agreement with the Rock Color Chart (1943) distributed by the National Research Council, based on the Munsell System of color identification.
smooth. The nearly pure beds commonly contain irregular nodules of dark-gray chert as much as a foot long and several inches thick; many of them contain an abundant faunal assemblage which includes crinoid stems, bryozoa, unidentified brachiopods, a few cephalopods and corals. Some horizons contain fusulinids. Few of the silty beds contain either chert or fossils.

The Upper Blue member contains numerous shale units in the eastern part of the quadrangle but these are absent in the area mapped.

Syrena formation - In the area mapped the Syrena formation has a thickness of about 170 feet. The lower 70 feet comprise the Mountain Home shale member; the upper part (100 feet) is tentatively correlated with the Don limestone member described by Spencer and Paige, although the boundary sill they described is absent here. The abrupt facies changes, which are common in this part of the stratigraphic section, make it difficult to establish an exact boundary between the Mountain Home shale member and the Don limestone member where the marker sill does not appear. The author arbitrarily chose the top of a thick shale bed, which is well exposed on the southern flank of Humboldt Mountain as the boundary horizon. Mr. R. M. Hernon thinks that there is very little Don limestone present in the area covered by this report. Its absence could readily be accounted for by an erosional unconformity at the base of the overlying Abo formation.

Mountain Home shale member - The Mountain Home shale mem-
ber consists of gray to green, thin-bedded shales, some of which are fissile, totaling 70 feet in thickness. This unit weathers to gentle slopes covered by greenish-gray soil. Some layers are calcareous with nodules of impure limestone as much as three inches in diameter. Fossils are very rare and consist of a few poorly preserved brachiopods.

In some localities thin discontinuous beds of gray algal limestone occur near the base of the shale. These limestone beds are well exposed on the flats just south of Humboldt Mountain (Plate 1) and also about 500 feet east of the Hanover-Central highway at a point half a mile northeast of the Three Brothers bench mark.

Don limestone member - Above the Mountain Home shale is 100 feet of limestones with some interbedded shales, locally called the "Don limestone." The limestones are bluish gray, grading to pale buff where impure. They are finely crystalline, thin- to medium-bedded. The impure limestones contain layers and nodules of silty material and are similar to those in the Oswaldo formation. The shales are greenish gray, very fine grained, and fissile, except in the uppermost unit which is made up of 10 to 20 feet of red and green shale which is very fine grained, fissile to thick-bedded, and nodular.

This unit, where stained red and somewhat metamorphosed, is very similar to the shales in the overlying Abo redbeds. This similarity makes the upper contact difficult to establish, consequently, the boundary between the Syrena and Abo formations has been mapped as "questionable."

Abo redbeds (Permian)

In 1909 W. T. Lee named and described the Abo redbeds of the lower
Permian Manzano group from their type locality in the Abo Canyon near the north end of the Manzano range. E. H. Wells (1923) measured a 200 foot section of redbeds cropping out five miles southeast of Santa Rita. He correlated this section with the Abo redbeds to the north on the basis of lithology and stratigraphic position.

Within the mapped area the Abo consists of from 20 to 40 feet of mudstones and shales which typically weather to a gentle slope of red soil. The shales range in color from reddish gray to purplish red, are very fine grained, partly fissile and partly thin-bedded. They contain a few lenses of reddish gray limestone conglomerates. Fossil remains are limited to a few poorly preserved brachiopods and echinoid spines in limestone pebbles within these limestone conglomerates. These were probably derived from the underlying Pennsylvanian rocks. As yet no fossils have been found in the mudstones and shales of undoubted Abo age.
Mesozoic Formations

Two Cretaceous formations, the Beartooth quartzite and the Colorado formation, crop out within the Santa Rita quadrangle. Both have been described in the Silver City folio by Paige and by Spencer and Paige.

The Beartooth quartzite is presumed to be of Upper Cretaceous age, although no index fossils are known; its areal distribution coincides closely with that of the overlying, Upper Cretaceous Colorado formation. The Beartooth quartzite may correlate with the Dakota sandstone which underlies the Mancos shale, since Spencer and Paige, on faunal evidence correlated the lower shale member of the Colorado formation with the Upper Cretaceous Mancos shale of western Colorado.

Beartooth quartzite (Upper Cretaceous?)

The Beartooth quartzite caps Humboldt Mountain and crops out in a small area south of the Barringer fault opposite the head of Ansones Creek (Plate 1). It lies unconformably on the Abo redbeds and appears to be conformable with the overlying Colorado shale. The Beartooth quartzite consists of light-buff orthoquartzites, approximately 60 feet thick within the area mapped, and is a prominent cliff-former. It is fine grained and thick bedded; individual beds as much as 20 feet thick are separated by thin lentil-like bodies of sandy shale.

The rock typically has a rough, pitted, weathered surface. Individual
grains are thoroughly cemented by clear silica and the rock breaks across the grain. Some horizons contain irregular worm-like markings of uncertain origin and a few silicified fragments of fossil wood. At the head of Beartooth Canyon a conglomerate about two feet thick overlies the quartzite and has been included as the uppermost part of the Beartooth formation. This conglomerate is composed of well-rounded quartzite pebbles, ranging from one to six inches in diameter which are firmly cemented by a fine-grained siliceous sand matrix.

**Colorado formation (Upper Cretaceous)**

The Colorado formation was subdivided by Lasky\(^1\) into a basal shale member, with a thickness of approximately 200 feet, and an overlying sandstone member, with a measured thickness in Gold Gulch of 130 feet. Lasky mentions the occurrence of higher sandstones overlying the quartz diorite sill in the northeastern part of the Bayard area and gives the member a total thickness there of at least 450 feet.

**Shale member** - The basal shale member of the Colorado formation crops out on a small flat saddle between the head of Beartooth Canyon and Ansones Canyon (Plate 1.) It occupies the trough of an open syncline which plunges northwesterly and is cut off to the north by the Barringer fault. This member is a dark gray (almost black) fissile shale with a few thin sandy lenses; its maximum exposed thickness is about 50 feet. No fossils were observed.

**Sandstone member** - North of the Barringer fault the only sediments
exposed in the area between the saddle at the head of Ansones Creek and the quadrangle boundary are a thick succession of buff-colored sandstones alternating with olive-green or gray shales and a few thin limestones which weather brown. These rocks were assigned to the sandstone member of the Colorado formation because of their stratigraphic position and lithologic similarity to rocks of known Upper Cretaceous age cropping out elsewhere in the quadrangle. Two sandstone units could be traced to the Hermosa intrusion and to the Barringer fault in Ansones Creek just east of the Crumbley ranch. Two similar beds crop out just east of the saddle at the head of Ansones Creek and were traced northeastward to the Pierson shaft. A drill hole bored at this point by the United States Smelting and Refining Company showed a stratigraphic section of 425 feet above the Beartooth quartzite. The collar of the hole was located 23 feet stratigraphically below the lowest sandstone marker horizon or at about the same position as the oldest rocks cropping out in Ansones Creek. The drill hole failed to penetrate a thick sandstone series comparable to the series described by Lasky from Gold Gulch. The Gryphaea horizon

\[^{18}\text{op. cit. pp. 24.}\]

Lasky described as 100 feet above the Beartooth quartzite and at the top of a 20-foot sandstone bed was penetrated 36 feet above the quartzite; the horizon was in a black shale series without any accompanying sandstone.

Outcrops in Ansones Creek and North Star Basin were so widely separated that it was impossible to measure accurately a full section;
several incomplete sections were measured and correlations attempted by using marker horizons consisting of thin brown limestones or massive sandstones. These measurements indicate a total thickness of 393 feet of shales and sandstones between the lowest marker sandstone and a coarse arkosic conglomerate horizon at a locality just west of the quadrangle boundary and not far from the andesite breccia contact (Plate 1). These observations indicate the thickness of the Colorado formation in North Star Basin to be not less than 450 feet nor more than 700 feet (Table 1).

Quaternary Alluvial Deposits

Terrace Gravels

West of Humboldt Mountain, at an elevation of approximately 50 feet above the present bottom of Beartooth Canyon, is a broad bench covered by terrace gravels, which has been mapped as Quaternary terrace gravels. This material consists largely of rounded to subangular pebbles, cobbles and boulders of Beartooth quartzite with a few fragments of limestone; fragments of igneous rocks are very scarce. The cobbles and boulders occur in a matrix of poorly-sorted coarse sand and range from one-half to approximately one foot in diameter. The nature of the exposures does not permit accurate determination of the thickness of these deposits but it probably is not more than 20 feet.

Alluvium

A low terrace between the Barringer fault and Ansones Creek near the western boundary of the mapped area was designated as Quaternary alluvium. This terrace is made up of coarse to fine sand which occurs in cross-bedded lenses; much organic matter is in the upper five to 10 feet. The material extends above the present bed of Ansones Creek some 10 to 20 feet to the top of the terrace.
## Table 2

Stratigraphic column of Colorado formation north of Barringer fault

<table>
<thead>
<tr>
<th>Colorado formation: (top not exposed)</th>
<th>Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>*1. Conglomerate (arkosic) and sandstone, buff-colored, medium-grained</td>
<td>20</td>
</tr>
<tr>
<td>2. Sandstone, light-buff, medium-grained</td>
<td>20</td>
</tr>
<tr>
<td>3. Shale, dark-gray, fissile</td>
<td>5</td>
</tr>
<tr>
<td>4. Sandstone, light-buff, medium-grained</td>
<td>15</td>
</tr>
<tr>
<td>5. Shale, dark-olive-green, fissile</td>
<td>3</td>
</tr>
<tr>
<td>6. Sandstone, light-buff, medium-grained, cross-bedded</td>
<td>15</td>
</tr>
<tr>
<td>7. Shale, olive-green, fissile; grades upward to siltstone, light-buff, micaceous with calcite-centered concretions</td>
<td>22</td>
</tr>
<tr>
<td>8. Shale, with some sandy lenses, dark greenish</td>
<td>20</td>
</tr>
<tr>
<td>9. Siltstone, light-buff, sandy</td>
<td>15</td>
</tr>
<tr>
<td>10. Sandstone, light-buff, medium-grained, petrified wood fragments</td>
<td>5</td>
</tr>
<tr>
<td>11. Shale, dark-gray, fissile</td>
<td>15</td>
</tr>
<tr>
<td>12. (Covered) limestone near bottom weathers brown</td>
<td>35</td>
</tr>
<tr>
<td>13. Shale, gray, fissile</td>
<td>10</td>
</tr>
<tr>
<td>14. (Covered)</td>
<td>100</td>
</tr>
<tr>
<td>15. Sandstone, light-buff, medium-grained, massive clay inclusions</td>
<td>15</td>
</tr>
<tr>
<td>16. (Covered) probably shale or siltstone</td>
<td>15</td>
</tr>
<tr>
<td>17. Sandstone, light-buff, medium-grained</td>
<td>8</td>
</tr>
<tr>
<td>18. Shale, dark-greenish-gray, fissile</td>
<td>7</td>
</tr>
<tr>
<td>19. Sandstone, light-buff, medium-grained, massive (upper marker bed)</td>
<td>20</td>
</tr>
</tbody>
</table>
Table 2 (continued)

| 20. | Shale and mudstone, olive-gray to buff, thin-bedded | 30 |
| 21. | Sandstone, buff, fine-grained, thin-bedded (lower marker bed) | 10 |
| *22. | Shale and siltstone, olive-gray, very thin-bedded | 23 |
| **23. | Mudstone, gray, fine-grained | 24 |
| 24. | Sandstone, gray to buff, fine-to medium-grained | 23 |
| 25. | Mudstone, dark-gray, locally sandy | 14 |
| 26. | Mudstone grading to sandstone near top, gray, fine-grained | 11 |
| 27. | Sandstone (arkosic) buff and light-gray, medium-grained | 16 |
| 28. | Shale or mudstone, medium-to dark-gray, locally sandy | 101 |
| 29. | Sandstone, light-to medium-gray, fine-grained, silty | 31 |
| 30. | Shale; light-gray, fine-grained, sandy | 15 |
| 31. | Shale, dark-gray | 22 |
| 32. | Shale, dark-gray, contains Gryphaea | 2-1/2 |
| 33. | Shale with some limy beds, medium-to dark-gray | 9 |
| 34. | Porphyry sill | 5-1/2 |
| 35. | Shale, medium-gray | 2-1/2 |
| 36. | Porphyry sill | 1 |
| 37. | Shale, medium-to dark-gray, locally sandy | 33 |
| 38. | Sandy shale and shaly sandstone, buff to dark-gray | 24 |
| **39. | Shale, dark-gray | 10 |

**Beartooth quartzite:** 362-1/2 feet
Table 2 (continued)

* (Units 1-22) Generalized composite column measured by eye height at various places southwest of Pierson shaft in Ansones Creek and North Star Basin (Totals 433 feet).

** (Units 23-39) Log of diamond drill core from hole No. CF-16 of American Smelting and Refining Company located just west of Pierson shaft (Totals 429-1/2 feet).
IGNEOUS ROCKS

The igneous rocks may be subdivided areally into two groups: those occurring to the south and those to the north of the Barringer fault. Most of the intrusives south of the Barringer fault resemble those described by Lasky. North of this fault a long and complex history of stock and dike intrusion is revealed. The intrusion series was interrupted by the extrusion of andesitic flows. With two minor exceptions the igneous rocks in this province are unlike any found elsewhere in the quadrangle and appear to be related to a separate intrusive center. All of them are older than the overlying Tertiary flows.

All igneous rocks were classified on the basis of field identification with a hand lens, aided by petrographic examination of the phenocrysts as crushed fragments. All rock names used conform with the classification of igneous rocks according to Short and McKee with terms used in the district in quotations.

Igneous Rocks South of the Barringer Fault

Dacite porphyry, "Late quartz diorite"

The "late quartz diorite" or dacite porphyry which Lasky described
is intruded as a thick, sill in the Syrena formation near the southern boundary of the mapped area (Plate 1).

This rock is described by Lasky as a mottled greenish-gray, fine-grained, nearly equigranular rock that weathers to a dull pink. It contains a few phenocrysts of white plagioclase and laths of black hornblende in a fine-grained groundmass. Quartz occurs as sparse rounded grains.

Quartz latite dikes

Three highly altered dikes which crop out in the area are probably equivalent to the quartz latite dikes described by Lasky. Two dikes crop out in the eastern part of the zone of fracturing that extends east and west just south of the Copper Flats intrusive. The third dike, which has a northwesterly strike, crops out on the south side of Beartooth Canyon half a mile west of Humboldt Mountain. All three dikes have been deeply weathered to a clayey material on the outcrop; fresh specimens for study were unobtainable.

Roos ranch dike (quartz latite porphyry)

A fresh quartz latite porphyry dike crops out in a gulch about half a mile north of Roos ranch (Plate 1). This dike is approximately 20 feet wide with chilled borders as much as 18 inches thick. It strikes north-easterly and was traced for about 500 feet. The border facies is fine-grained and pale yellowish-red. Near its center the dike is bluish-gray, weathering to light gray and its texture is decidedly porphyritic. The rock contains abundant chalky plagioclase phenocrysts approximately 5 millimeters in diameter, and long biotite books, with an occasional hornblende lath or rounded grain of quartz. Orthoclase crystals as much
2 millimeters in diameter occur but are rare. A few grains of quartz, flakes of biotite, and many small pyrite cubes are visible in the fine-grained groundmass which consists largely of plagioclase.

Granodiorite dikes

Two granodiorite dikes with an easterly trend crop out for a distance of approximately 200 and 400 feet, respectively, south of the Copper Flats granodiorite stocks (Plate 1). The southern dike may be traced continuously from the driveway north of the Anse ranch house westward to the bottom of Yellow Dog Gulch. It is about 200 feet longer than the northern dike.

Megascopically the dikes are rather different in appearance. The northern dike is pale pink on the fresh surface with large rounded quartz grains and fairly abundant small flakes of altered biotite in a fine, uniform matrix consisting of orthoclase and plagioclase. The southern dike is pale yellowish-brown to light gray, highly altered, with a few scattered biotite flakes and many tiny acicular crystals of a dark mineral, probably an amphibole, in a light-gray to chalky-white groundmass of altered feldspar. Rounded quartz grains occur but are rare; epidote is fairly abundant.

Microscopically the two rocks look remarkably similar. Both contain euhedral and subhedral laths of albite and orthoclase up to 5 millimeters in length, embayed quartz grains, numerous small apatite crystals, and occasional allanite crystals, some of which are partly altered to epidote. In both dikes the original mafic minerals are altered to epidote, calcite or chlorite. In the northern dike the quartz grains are larger and more
widely scattered than in the southern dike. These dikes appear to be genetically related to the Copper Flats granodiorite stock to which they are closely related in composition.

Porphyritic quartz monzonite dike

One quarter of a mile northeast of the North Star tunnel, just west of the Gila National Forest boundary, is a small altered porphyritic quartz monzonite dike. This dike strikes approximately north-south, and is highly altered. It contains a few large orthoclase phenocrysts, up to 2 centimeters long by 1 centimeter wide, long biotite books, and scattered quartz bipyramids in a clay groundmass.

Copper Flats stock (granodiorite-quartz monzonite)

The composite granodiorite-quartz monzonite stock at Copper Flats was mapped in detail by Lasky. His map was copied in a generalized form to give continuity. This stock is also described by Spencer and Paige.

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23/ Unpublished map.

Igneous Rocks North of the Barringer Fault

North of the Barringer fault the Hermosa intrusive is the oldest and also the largest igneous rock mass. This intrusive is cut by many dikes striking northwesterly which range in composition from hornblende diorite through augite andesite to kersantite (ouachitite). It is also intruded in the northwest by two small stocks from which the dikes appear to radiate. One of the stocks is a pigeonite diorite, the other has the composition of a diopside diorite porphyry. The extensive andesite breccia in the northwestern part of the area is discussed by Spencer and Paige;\(^{25}\)

\(^{25}\)op. cit. pp. 32-33.

It is younger than the Hermosa intrusive which it partly overlaps along its western border. It is also younger than the oldest dike cutting this intrusive, but older than the rest of the dikes and stocks that cut the Hermosa mass. The igneous sequence from oldest to youngest is as follows (Fig. 3):

1. (Hermosa intrusive) porphyritic quartz diorite laccolith or stock
2. Older andesite dikes
3. Andesite breccia flows
4. Diopside diorite stock
5. Diopside diorite porphyry dikes
6. Augite andesite porphyry dikes
7. Augite felsite porphyry dikes
8. Pigeonite diorite porphyry stock
9. Kersantite dikes
10. Pigeonite andesite dikes
11. Dacite dikes
In addition to this sequence several small isolated dikes occur whose position in the sequence could not be determined. These include the following:

1. A felsite dike cutting the sandstone member (?) of the Colorado formation a quarter of a mile north of the junction of the Ansones Creek and North Star Basin roads,

2. A granodiorite dike cutting the sandstone member (?) of the Colorado formation and the south edge of the Hermosa intrusive about halfway between the Crumbley ranch and the head of Ansones Creek.

3. A porphyritic quartz monzonite dike cutting the Colorado sandstone member (?) and Hermosa intrusive in the saddle at the road junction on the northeast edge of North Star Basin.

4. A hornblende andesite porphyry dike cutting the diopside diorite porphyry stock and a diopside diorite porphyry dike about 500 feet west of the shaft located within this stock.

The intrusives north of the Barringer fault differ from those in other parts of the Santa Rita quadrangle in that they are nearly all pyroxene rich. Elsewhere in the quadrangle pyroxene is very scarce.

Hermosa porphyritic quartz diorite intrusive

The Hermosa porphyritic quartz diorite intrusive was first described by Paige. Later it was re-mapped and called a stock by Spencer and Paige.

Although little direct evidence is available as to the form of this mass at depth, some indirect evidence leads to the belief that it is laccolithic rather than stock-like: (1) the presence of pebble dikes and
breccia zones containing indurated shale fragments well within the intrusive; (2) the presence of outliers of the intrusive conformable with the underlying sediments and of inliers of unmetamorphosed sediments within the intrusive; (3) the lack of contact metamorphism around the borders of the intrusive; (4) the contacts with the surrounding sediments are conformable wherever well exposed; and (5) the hornblende laths in the intrusive show flat or gently dipping lineations both near the borders and well within the mass. It is true that on a broad scale the intrusive contact transgresses the bedding in the Colorado formation to some extent, but this fact alone does not seem to eliminate the possibility that it is a laccolith. An excellent petrographic description of this rock is given by Spencer and Paige.\textsuperscript{28} This rock is light gray and porphyritic with abundant laths of hornblende and pyroxene in a medium-grained groundmass consisting largely of white plagioclase with subordinate quartz and magnetite.

Petrographic examination of this rock shows that augite, although subordinate to hornblende, is still present in moderate amounts. It appears to have been partly replaced by the hornblende.

Older andesite dikes

These dikes cut the Hermosa intrusive and the Colorado formation. Some of them attain a thickness of 20 feet and may be traced continuously for a mile or more. These dikes nowhere penetrate the andesite breccia, and in at least one locality the breccia lies unconformably upon a dike.
The dikes are light greenish gray on fresh surfaces, altering to various shales of gray and brown on weathered outcrops. They are fine-grained, and occasionally show an ophitic texture. The phenocrysts consist of small plagioclase crystals and a few scattered hornblende laths. Magnetite in minute grains is a common accessory and epidote is prevalent. In the area south of the Barringer fault, Spencer and Paige[^29] identified epidote in all igneous rocks of pre-Miocene age but observed none in rocks of Miocene and younger age, beginning with the quartz latite dikes. Their observations were later confirmed by Lasky[^30] in the Bayard area. If the same relationships hold north of this fault, then all of the rocks in this area are of pre-Miocene age except the pigeonite dikes, the dacite dikes and possibly the felsite and hornblende diorite porphyry dikes. It is noteworthy that all dikes of the sequence younger than the older andesite dikes, with one minor exception, carry augite or some other pyroxene as a major constituent, but no primary hornblende. The older andesite dikes, on the other hand, contain hornblende but little pyroxene, whereas the Hermosa laccolith carries both pyroxene and hornblende. In one or two places the dikes have amygdules of calcite which suggests that they were intruded under low confining pressure and probably at shallow depths.

**Andesite breccia**

Paige and Spencer[^31] described the andesite breccia and were of the
opinion that the flow breccias were interbedded with the Colorado sediments and consequently were of Colorado age. This theory seems untenable, at least for the flow breccias exposed in the western part of North Star Basin. There the breccias unconformably overlie the Colorado formation and the Hermosa intrusive, and truncate the andesite dikes which cut that intrusive. Pebbles of both the Hermosa intrusive and the diorite occur in the flow breccia itself.

The aphanitic matrix carries numerous small plagioclase phenocrysts and a few scattered crystals of augite. Epidote is common as small blebs and scattered grains. The light-olive-gray matrix weathers to various shades from chocolate brown through tan to medium gray. Inclusions vary widely in composition. A list of the rocks found as pebbles in the basal andesite breccia includes: Hermosa porphyritic quartz diorite, diabase, vesicular basalt, chert, shale, and limestone. Dikes of both augite andesite and diopside andesite, similar in appearance to the inclusions of these types, also cut the flows. This would suggest that those dike types were nearly contemporaneous with the flows. Neither the hornblende andesite, diabase or basalt, nor any of the sedimentary rocks mentioned above were found cropping out in this vicinity.

**Diopside diorite stock**

A mile and a quarter north of the Crumbley ranch house (Plate 1) a small stock of diopside diorite intrudes the Hermosa laccolith and the andesite breccia flows. This stock is roughly elliptical in plan with the long axis trending northeast. The extent of the outcrop is about 1700 feet from northeast to southwest and about 1000 feet from northwest to southeast. The rock is deeply weathered near the surface and breaks
down to gray sand in which comparatively fresh diopside phenocrysts may be seen.

Near the center of this intrusive is a large shaft, now abandoned. On the waste dump fresh specimens of the intrusive are exposed but no other rock was identified. The fresh rock is medium gray, weathering to a slightly lighter shade of gray. Diopside phenocrysts make up about five percent of the rock. The rock has a sugary groundmass of mafic minerals and feldspar with sparse epidote. This stock is cut by dikes of similar composition as well as by augite andesite porphyry dikes, kersantite dikes, and the small hornblende andesite-porphyry dike mentioned previously.

**Diopside diorite porphyry dikes**

Dikes very similar in composition to the stock described above occur in its vicinity; some of these dikes invade the stock. They differ from the stock only in having a much higher proportion of phenocrysts to groundmass, and presumably bear a close genetic relationship to it. These dikes are narrow, short, and relatively rare.

**Augite andesite porphyry dikes**

Dikes of augite andesite porphyry are the most common and widespread of all the dike-rocks north of the Barringer fault. They form a veritable network cutting the Hermosa intrusive, the Colorado formation, and the andesite breccia. They are so closely spaced and intricate in many places that it was not practical to map them all individually; they were therefore patterned as short segments where well exposed in gulches. One or two of the larger dikes were then mapped to indicate the trend of the group. These dikes range in width from a few inches to 15 feet.
and some of the larger ones can be traced unbroken for more than a mile. They are brown on weathered surfaces and dark gray on fresh fractures. The groundmass is fine grained. A few of the larger dikes have narrow longitudinal leucocratic bands. The presence of black euhedral phenocrysts of augite up to 1 centimeter in length is the most conspicuous feature of this rock. Secondary epidote is common in most of these dikes and a few of the dikes have vesicles filled with calcite.

**Augite felsite porphyry dikes**

Dikes of augite felsite porphyry are similar in both distribution and general appearance to the augite andesite dikes described above. The only noticeable difference in the hand specimen is that the augite felsite porphyry dikes have a groundmass of lighter olive-gray than the older augite andesite dikes. Since it seemed impractical to attempt a differentiation between the two in field mapping, the same symbol was used for both (Plate 1).

**Pigeonite diorite porphyry stock**

West of the diopside diorite porphyry stock a slightly smaller stock of pigeonite diorite porphyry crops out. Its outcrop is rudely horseshoe shaped with the arms of the horseshoe pointing north. The eastern limb of the shoe is longer and wider than the western one, and is separated from it by a narrow neck of Hermosa intrusive. This pigeonite diorite porphyry stock cuts the Hermosa intrusive, the diopside diorite stock, and andesite breccia. It truncates the augite andesite and the augite felsite dikes.

The rock is light gray on a fresh surface and yellowish-orange to
pale orange-brown on the outcrop. It weathers into large rounded boulders as do many granites. The rock has a fine-to medium-grained, gray groundmass consisting entirely of andesine (Ab65-An35). Conspicuous in its matrix are both large and small euhedral crystals of pigeonite, which make up about 30 percent of the volume of the rock.

Kersantite dikes

Several large, persistent dikes, containing abundant biotite books and plagioclase laths in a highly altered fine-grained groundmass, crop out in North Star Basin. Dike rocks of this composition and porphyritic texture are termed ouachitites by Grout;\(^{32}\) and if sugary and granitoid, are called kersantites by Grout\(^{32}\) and Harker.\(^{34}\) The dike rocks weather olive-tan to orange-brown and break down to rounded outcrops. Fresh exposures are olive-gray. In addition to the biotite and plagioclase, thoroughly altered euhedral crystals of pyroxene occur locally; epidote is nearly everywhere abundant.

Pigeonite andesite dikes

Dikes of pigeonite andesite, differing only slightly in appearance from the older andesite dikes, cut all the intrusives previously described as well as the andesite breccia. The chief megascopic difference is that these dikes contain fairly abundant phenocrysts of pigeonite, whereas the


older dikes contain no visible pyroxene. The pigeonite andesite dikes are medium gray where freshly exposed and weather to a light olive-brown. In addition to the pigeonite phenocrysts, which make up about five percent of the rock, there are phenocrysts of plagioclase and minute, slender, black crystals which were too small to identify in the hand specimen. The plagioclase gives some of these rocks an ophitic texture.

**Dacite dikes**

A few small dark dikes, very similar in appearance to the augite andesites, cut the diopside andesite dikes. They are too small to show on the scale of the map (Plate 1). These rocks are very dark gray and contain a few augite phenocrysts and very sparse rounded quartz grains in a cryptocrystalline groundmass. No epidote was visible in these rocks. They may represent feeders of the Tertiary flows.

**Miscellaneous dikes**

*(Felsite dike)* A felsite dike ten feet wide and 300 feet long cuts the Colorado formation a quarter of a mile north of the intersection of the Ansones Gulch and North Stark Basin roads. It is light tan on fresh exposures and weather to a chocolate-brown. The texture is felsitic and there is a suggestion of flow banding in places.

*(Quartz diorite "granodiorite" dike)* A small granodiorite or quartz diorite dike similar to a rock described by Lasky\(^{35}\)/ cuts the southern edge of the Hermosa intrusive half a mile east of the Crumbley ranch house. The rock consists of chalky-white feldspar phenocrysts in a
medium-gray aphanitic groundmass. Quartz, hornblende, and biotite are in minor amounts.

(Porphyritic quartz monzonite dike) A porphyritic quartz monzonite dike crosses the North Star Basin road in the saddle between North Star and Hanover Basins. In composition this dike is similar to the granodiorite dike described above, but is coarser grained and contains large phenocrysts of orthoclase, some of which are over an inch long.

(Hornblende andesite porphyry dike) A small dike of hornblende andesite porphyry crops out in a gulch 500 feet west of the shaft sunk in the diopside diorite stock. This dike is about 50 feet long and less than two feet wide and cuts both the stock and a diopside diorite porphyry dike. It is noteworthy chiefly because it indicates a state of primary hornblende later than the pyroxenes which predominate in the post-andesite breccia intrusives. The rock is light gray, weathering to a pale yellowish-gray. Small laths of hornblende and plagioclase are scattered in a very fine-grained groundmass, which seems to consist primarily of the same two minerals.

Tertiary Volcanic Rocks

A thick series of Tertiary volcanic rocks crops out at the head of the North Star Basin and forms the northern boundary of the area mapped. These volcanics cover thousands of square miles to the north of the area shown on Plate 1. Within the area mapped, the volcanics rest unconformably on the sandstone member of the Colorado formation, on the Hermosa intrusive, and on the andesite breccia. The series consists of several hundred feet of flows and tuffs which dip gently to the northwest.
FIG. 2 - MAP SHOWING REGIONAL STRUCTURE OF THE SANTA RITA AREA, NEW MEXICO

(Modified from Hernon, GSA Guidebook Field Trip No. 3, Nov. 1949.)

EXPLANATION

Edge of Tertiary lava flows

Edge of Quaternary Valley fill

Cretaceous or Tertiary stocks

Fault, showing downthrown side

Strike and dip of beds

Area mapped

FIG 2 - MAP SHOWING REGIONAL STRUCTURE OF THE SANTA RITA AREA, NEW MEXICO

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EXPLANATION

Edge of Tertiary lava flows

Edge of Quaternary Valley fill

Cretaceous or Tertiary stocks

Fault, showing downthrown side

Strike and dip of beds

Area mapped
STRUCTURE

General Features

The area lies on the eastern limb of a broad shallow syncline, the axis of which may be traced from Pinos Altos on the north to Hurley on the south (Figure 2). Consequently, the regional dip is westerly throughout the western part of the Santa Rita region. This dip is interrupted by a broad arch trending northeasterly through Copper Flats (Figure 2); the arch has been modified by emplacement of a quartz diorite porphyry laccolith in the lower part of the Oswaldo formation (structure section Plate 2). The northeasterly-trending Barringer fault throws Upper Cretaceous sediments in the northern part of the area against Paleozoic rocks to the south. North of the Barringer fault a network of dikes radiates from the vicinity of two small stocks in the upper part of the North Star Basin. These dikes fill small faults and fractures in the surrounding rocks, and are the latest intrusives in the region.

Folds

The folds throughout the area mapped, and also in the surrounding region, are broad and gentle. Their spatial relations and genesis were initially reviewed by Spencer and Paige. They concluded that the larger structural trends were caused by regional compression prior to igneous intrusion but were later warped and modified by intrusion of the stocks and laccoliths. Subsequent detailed mapping has not appreciably changed their conclusions.
Faults

Faults south of the Barringer fault

South of the Barringer fault there is a broad belt of minor north-easterly trending faults lying to the east of the axis of the Copper Flats arch and almost parallel to it. Where they cross the crest of this arch the faults strike more easterly. These faults all have very steep or vertical dips and in the area north of Copper Flats the downthrown side is uniformly to the northwest. In the small area between Copper Flats and Roos ranch (Plate 1) a number of prominent northeasterly-trending faults show the opposite relationship with the downthrown side on the southeast. Between Humboldt Mountain and the Hanover-Central highway, a weak but persistent zone of northwest faulting and fissuring appears. The downthrown side on these faults is northeast and the zone may be traced as far as the Barringer fault.

Barringer fault

This fault trends slightly north of east from the western boundary of the Santa Rita quadrangle to the saddle at the head of Ansones Creek. At this point it joins the northeasterly zone of faulting and continues in that direction beyond the limits of the map. It has been described by Spencer and Paige in bulletin 859. From the saddle at the head of

\[37/\text{op. cit. pp. 47-49.}\]

Ansones Creek to the western edge of the quadrangle, the fault appears to be relatively uniform. The few good exposures of the fault zone show a little drag in either the Cretaceous sandstones on the north or the
older rocks lying to the south. This part of the fault zone is from 20 to 100 feet wide and is essentially unmineralized. Where the fault swings northeast it shows a gossan zone nearly 200 feet in width, which effectively obliterates all structural details. Southwest of this point the gossan gradually tapers off along a southwesterly split from the main fault. No structures or contacts could be mapped across the Barringer fault, and the full amount and direction of displacement along it could not be accurately determined; however, it must have been at least 500 feet, the stratigraphic interval cut out by the fault. The following evidence suggests that the northwest side moved southwestward relative to the southeast side: (1) the fault "tightens" as the strike changes from northeast to easterly; (2) fragments of Beartooth quartzite occur in the fault breccia several hundred feet west of the nearest Beartooth outcrop; (3) a small syncline on the south side of the fault is truncated by it and a similar syncline appears on the north side nearly 3,000 feet to the west as was pointed out by Spencer and Paige.38

38 op. cit. p. 49.

The exact age of the Barringer fault is controversial. It seems probable that movement began before the intrusion of the Hanover granodiorite stock and has recurred intermittently until recent time.

Faults north of the Barringer fault

Faults traversing the area north of the Barringer fault are relatively small and trend northerly or northwesterly. Many of these faults have been invaded by dikes which radiate from an intrusive center located near the western edge of the quadrangle approximately a mile north of Ansones Creek. One remarkable feature of these dikes is that they may
Figure 3. DIAGRAMMATIC SECTION OF ROCKS NORTH OF THE BARRINGER FAULT.
be traced continuously for a mile or more, uninterrupted by any faults. Nearly all of them carry epidote, and this mineral is regarded throughout the region as an indication of pre-Miocene age. It thus appears that what little faulting took place within this part of the area mapped, occurred prior to Miocene time.
GEOLOGIC HISTORY

Pre-Cretaceous

The Paleozoic and early Mesozoic history of this region is well described by Spencer and Paige, and may be briefly summarized as follows: During the long interval of pre-Cambrian time, old mountain ranges were raised and granitic rocks intruded at their cores. These crystalline rocks were exposed at the surface by long erosion which had reduced the land to a peneplain before inundation by the Cambrian seas. The area was probably occupied by shallow seas during Cambrian, Ordovician, and most of Silurian time. The hiatus between the Silurian and Upper Devonian, as well as the abrupt change from limestone to shale, suggests a gentle uplift during early Devonian time. Conditions of shallow water deposition prevailed throughout the Upper Devonian, much of the Mississippian and Pennsylvanian and possibly some of the Permian also. The Abo redbeds suggest a gradual withdrawal of the seas and a change to continental conditions during Permian time. During all of Triassic, Jurassic, and Lower Cretaceous time this land was emergent. The unconformity at one base of the Upper Cretaceous suggests a broad regional uplift toward the southwest with very little folding or faulting.
Cretaceous

The transgressing Upper Cretaceous seas deposited sands over a considerable region, which later formed the Beartooth quartzite. The source of this sand presents an interesting problem which is somewhat beyond the scope of this report. We can only assume that rivers reaching back into the old crystalline highlands, from which the Paleozoic limestones and shales had already been stripped, transported primarily sand to form large deltas. These were further reworked and sorted by the sea as it encroached on the gently sloping land surfaces.

The abrupt transition from sandstones and conglomerate to black and green shale at the top of the Beartooth quartzite probably represents a change to deposition in deeper water farther from shore, a normal sequence for a transgressing sea. These shales could well represent the reworked clastic material furnished by the Paleozoic sediments. The Gryphaea horizon near the base of the sedimentary section represents a marine environment. A gradual withdrawal of the seas and a change to continental deposits in Upper Colorado time is indicated by the thick series of mudstones and sandstones grading upward into coarse arkosic conglomerates.

After the cessation of sedimentation the Hermosa laccolith was intruded. After solidification it was fractured and subsequently intruded by andesite dikes as were also the surrounding sediments. After these early intrusions, erosion cut deeply enough to expose the Hermosa mass before the andesite flows and flow breccias were extruded.

Late Cretaceous or Early Tertiary (pre-Miocene)

The flows and breccias contain epidote which suggests a pre-Miocene age. They rest unconformably upon rocks of the Hermosa laccolith which was intruded at some depth into Upper Cretaceous sediments. Thus they
are apparently of early Tertiary age. Volcanism initiated another long period of igneous activity during which time the two small stocks and the series of dikes younger than the diorite were emplaced.

Late Tertiary (post-Miocene)

The early Tertiary activity was followed by another interval of erosion. Sometime during this late Tertiary period, probably near its end, weak mineralization formed copper, lead, zinc, and gold-bearing fissure veins. Following this, several thousand feet of andesite and basalt flows were extruded to cover a vast region to the north.

Quaternary

During Quaternary time, erosion stripped the lavas. The overloaded streams formed broad terraces which have recently been uplifted and trenches by the present erosion cycle.

Sequence of Events

<table>
<thead>
<tr>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paleozoic</td>
<td>1. Area submergent, deposition of sediment.</td>
</tr>
<tr>
<td>Triassic</td>
<td>2. Area emergent, undergoing erosion.</td>
</tr>
<tr>
<td>Jurassic</td>
<td>3. Beartooth quartzite deposited.</td>
</tr>
<tr>
<td>Early Cretaceous</td>
<td>4. Colorado shale member deposited.</td>
</tr>
<tr>
<td>Late Cretaceous</td>
<td>5. Gradual withdrawal of seas. Change to continental conditions.</td>
</tr>
<tr>
<td>Colorado</td>
<td>Colorado sandstone member deposited.</td>
</tr>
<tr>
<td>Montana (?)</td>
<td>6. Intrusion of Hermosa laccolith, formation of Ft. Bayard arch (?)</td>
</tr>
<tr>
<td></td>
<td>7. Copper Flats dome formed, initial movement on Barringer fault (?)</td>
</tr>
<tr>
<td></td>
<td>8. Intrusion of andesite dikes</td>
</tr>
<tr>
<td></td>
<td>9. Erosion of sedimentary cover from laccolith</td>
</tr>
</tbody>
</table>
Late Cretaceous or
Early Tertiary
(pre-Miocene?)

10. Extrusion of andesite flow breccia.
11. Diopside diorite porphyry stock intruded.
12. Diopside porphyry dikes intruded.
15. Pigeonite diorite porphyry stock intruded.
17. Pigeonite diorite (diabase) dikes intruded.
18. Erosion.
19. Mineralization—copper, lead, zinc.
20. Dacite dikes intruded.
22. Erosion, terraces of older gravels formed.
23. Slight uplift, stream cutting, alluvium deposited.

Late Tertiary
(post-Miocene)
Quaternary

MINERALIZATION

South of Barringer fault

Two small mining districts lie south of the Barringer fault within the area mapped (Plate 1). Both are now abandoned and production figures are not available. The Copper Flats district, belonging to the Peru Mining Company, produced mainly zinc and iron ore from a tactite body surrounding a small stock. Activities in this district were suspended shortly after the close of World War II.

The Mountain Home district lies on the western flank of Humboldt Mountain and produced some high grade silver and lead ores from fissure veins and replacement deposits in limestones of the Syrena formation. Many of these deposits were capped by a heavy manganiferous gossan. The ore bodies seemed to be localized at the intersection of weak fissures and small faults within favorable limestone horizons. There was no evidence of strong faulting within the mineralized district.

North of Barringer fault

In the upper part of North Star Basin an easterly trending vein
system has localized several small ore deposits in the sandstone member of the Colorado Formation, in the Hermosa intrusive, and in two small stocks; none is known in the extrusive andesite breccias. Two deep shafts were sunk, one within the pigeonite diorite stock and one in the diopside diorite stock; however, the workings are now abandoned. The former appears to have worked a deposit of lead and zinc ore, judging from marmatite and galena in specimens on the dump. The latter shaft showed only pyrite in its dump, as did a caved adit near the contact between sediments and the Hermosa intrusive half a mile farther east. It is inferred that where only pyrite appears on the dump, the values occurred chiefly in the form of gold. None of the other workings was deep enough to penetrate the sulfide zone, but some secondary malachite and chrysocolla, were found on several of the dumps. The veins cut pigeonite dikes and consequently must be younger than all dikes of the sequence, with the possible exception of the small late dacite dikes. Their age relations to these latter dikes are not known.

It has not yet been possible to correlate the intrusives north of the Barringer fault with those to the south of it; hence, the relative ages of mineralization in the two areas remain in doubt. In the region to the south of this fault Lasky\(^{40}\) concluded that the main period of economic mineralization occurred between the emplacement of the granodiorite dikes and that of the quartz latite dikes. In the North Star Basin (Plate 1) mineralization took place sometime between the intrusion of the pigeonite diorite dikes and the extrusion of the thick series of flows.

\(^{40}\) op. cit. pp. 13-14.
BIBLIOGRAPHY


EXPLANATION

SEDIMENTARY ROCKS

- Quaternary alluvium
- Quaternary terrace gravels
- Colorado sandstone member
- Colorado shale member
- Bearlodge quartzite

Permian

- Abo red beds

Pennsylvanian

- Spruce formation
- Otero formation

Mississippian

- Lake Valley formation

Devonian

- Paracho shale

IGNETIC ROCKS

- Quaternary alluvium
- Quaternary terrace gravels
- Colorado sandstone member
- Colorado shale member
- Bearlodge quartzite

Permian

- Abo red beds

Pennsylvanian

- Spruce formation
- Otero formation

Mississippian

- Lake Valley formation

Devonian

- Paracho shale

SYMBOLS

- Vein
- Fault
- Strike and dip of beds
- North arrow
- Strike and dip of foliation
- Strike and dip of foliation and plunge of linear structure
- Adit
- Shaft
- Prospect
- Benchmark
- National forest boundary
- Line of section

Section showing geology along line A-A'

Geology by TOM G LOVERING, 1950

SCALE 1:2000

CONTOUR INTERVAL 100 FEET

PLATE I. GEOLOGIC MAP OF A WESTERN PORTION OF THE SANTA RITA QUADRANGLE, GRANT COUNTY, NEW MEXICO.