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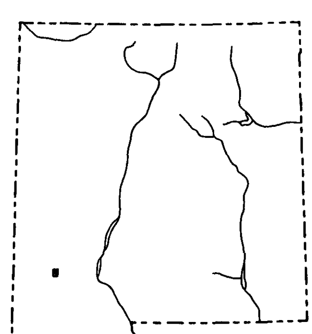
# GEOLOGIC QUADRANGLE MAPS OF THE UNITED STATES

## GEOLOGIC MAP OF THE FORT BAYARD QUADRANGLE GRANT COUNTY, NEW MEXICO

By
William R. Jones, Samuel L. Moore
and Walden P. Pratt



QUADRANGLE LOCATION

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## INTRODUCTION

Geologic mapping of the Fort Bayard quadrangle, under the supervision of William R. Jones, was nearly completed in 1955, and a preliminary geologic map was released in open files in 1963. Jones planned a comprehensive report on the quadrangle, but had written only the introductory parts at the time of his death in June 1965. The present report has been modified from Jones' draft manuscript by W. P. Pratt. During 1958–62 Pratt studied the petrography of some of the intrusive rocks of the Fort Bayard quadrangle, and the results of this study have been incorporated in the map explanation.

We are indebted to the late L. E. Foster of Silver City, consulting geologist and engineer, and Robert Mathis of Silver City, who were helpful in many ways. We acknowledge also the cooperation of the Empire Zinc Company, Hanover Division; the United States Smelting, Refining, and Mining Company; and the Kennecott Copper Corporation, Chino Mines Division.

## GEOLOGY

A few comments on features of the geology may aid the reader in interpreting the map and explanation. The geologic history of the area is discussed by Jones, Hernon, and Pratt (1961), Jones, Hernon, and Moore (1967), and Pratt (1967).

### GENERAL FEATURES

Visible country rock of much of the Fort Bayard quadrangle consists of andesite breccia and the Colorado Formation. The andesite breccia, which includes interbedded arkose, sandstone, and shale, lies with marked disconformity on shale and sandstone of the Colorado Formation. In areas deeply beveled by early Tertiary erosion, the breccia was preserved where it fills canyons in the Colorado Formation, where it had been downwarped, and where, laced with ribs of igneous rock or toughened by metamorphism, it was resistant, forming monadnocks. These modes of occurrence of the andesite breccia explain the pronounced irregularity of its basal contact in the region.

The irregular patches of Colorado Formation, which appear wherever the breccia and younger strata have been removed, lie in a 2- to 3-mile-wide arcuate belt that extends across the south half of the quadrangle. The concavity of this belt to the north suggests the presence of a broad northward-plunging syncline or downwarp. However, the attitudes of the Colorado beds in the western half of the belt show no evidence of such a structure, and the concave contact simply marks the south margins of an irregular topographic basin cut in the Colorado Formation and subsequently filled with andesite breccia and clastic sedimentary rocks.

On the other hand, the arcuate outcrop pattern of the Colorado, Beartooth, and Syrena Formations in the east-central part of the quadrangle results from erosional beveling of a domal structure whose center is a mile east of the quadrangle near Copper Flat.

The complete Paleozoic section is not exposed in the Fort Bayard quadrangle, but the rocks may be presumed to underlie the entire area except where intruded by discordant igneous bodies. Because the Paleozoic rocks are favorable to ore deposition in adjacent areas, and will be intersected in deep explorations, their characteristics are summarized in table 1.

Abundant post-Precambrian intrusive igneous activity was concentrated in the Laramide, mostly between deposition of the Colorado Formation in Late Cretaceous time and the period of erosion that preceded deposition of Oligocene volcanic rocks. Much of the Laramide intrusive activity preceded an earlier volcanic episode represented by the andesite breccia, but intrusive activity continued with renewed vigor after the andesite breccia and before the later (Oligocene) volcanic episode.

### AGE GROUPS OF INTRUSIVE ROCKS

The intrusive rocks are classified into four age groups:

(1) Quartz diorite sills, laccoliths, and irregular masses, thought to be older than the erosional interval that preceded the andesite breccia.
(2) Mafic and intermediate dikes and irregular masses, forming a complex sequence thought to be genetically related to, and only slightly younger than, the andesite breccia (Jones and others, 1967, p. 61–62).
(3) Intermediate dikes and hornblende quartz monzonite stock, generally younger than the andesite breccia and related intrusives but older than the erosional interval that preceded the Oligocene volcanism, and also older than the base- and precious-metal veins and accompanying hydrothermal alteration.
(4) Rhyolitic, intermediate, and basaltic andesite dikes and plugs, in part related to the Oligocene volcanism and in part older, but definitely younger than the rocks of groups 1–3.

Some relations within the age groups are not evident from the map and deserve some clarification:

*Age group 1.*—Age relations between the quartz diorite porphyry (Kep) and hornblende quartz diorite (Klp) are well established in the Santa Rita quadrangle. The hornblende andesite porphyry (Kpd), a single mass in the extreme northwest corner of the Fort Bayard quadrangle, was assigned to this oldest group

TABLE 1.—*Paleozoic and Mesozoic sedimentary rocks in the Silver City region*

| Age | Formation | Lithology | Approximate maximum exposed thickness (ft) |
|---|---|---|---|
| Late Cretaceous | Colorado Formation | Interbedded sandstone and shale | 2,200 |
| Late(?) Cretaceous | Beartooth Quartzite | Massive orthoquartzite, minor shale | 140 |
| | ———————— | — Unconformity ———————— | |
| Early Permian | Abo Formation | Red calcareous mudstone and shale | 265 |
| Pennsylvanian | Syrena Formation | Gray limestone, silty in part; thick shale lenses in lower part | 390 |
| Pennsylvanian | Oswaldo Formation | Massive limestone; shale bed at base | 490 |
| | ———————— | — Disconformity ———————— | |
| Mississippian | Lake Valley Limestone | Slabby to massive limestone; chert lenses in many beds | 480 |
| Late Devonian | Percha Shale | Upper part: shale with limestone nodules<br>Lower part: black fissile shale | 410 |
| | ———————— | — Disconformity ———————— | |
| Silurian | Fusselman Dolomite | Massive dolomite | 300 |
| Late and Middle Ordovician | Montoya Dolomite | Dolomite; interbedded chert in middle part; sandstone at base. | 350 |
| | ———————— | — Disconformity ———————— | |
| Early Ordovician | El Paso Dolomite | Slabby dolomite and limestone | 520 |
| Ordovician and Late Cambrian | Bliss Sandstone | Dark massive orthoquartzite locally hematitic or glauconitic; minor dolomite. | 190 |
| | ———————— | — Unconformity ———————— | |
| Precambrian | | Granite, quartzite | |

by the senior author for reasons presumably valid but not recorded.

*Age group 2.*—The field relations in group 2 are complex, and the geologic events must have been equally so, but we can infer three rather distinct magmatic episodes. The first was the eruption of the andesite breccia (TKab) as a vast mafic pyroclastic outpouring that covered tens and probably hundreds of square miles. Regional extension then opened abundant north- to northeast-trending fractures that permitted invasion of the bulk of the mafic porphyry dikes, the second episode. (Calculation of the approximate total space occupied by mafic dikes (Tda) along section *A–A'*, excluding areas of less than 20 percent dike, indicates a crustal extension of over 7,000 feet.) Intrusion of the plugs (Tpa through Tpe, in order) and a few more mafic dikes constitutes the third episode. The rocks of all three episodes are of the same general mafic composition, and though they may not have come from a single magma chamber, it does not seem rash to conclude that they must have been related both structurally and genetically. In fact there seems to be little question that these plugs and dikes represent the roots of a volcanic complex, but the exact nature and orientation of the complex are a matter of speculation.

The sequence of plugs (Tpa through Tpe) is established by mutual crosscutting relations. The mafic porphyry dikes (Tda) cut the first three ages of plugs (Tpa through Tpc). Plugs of all five ages, as well as the dikes, are intrusive into the andesite breccia, yet similar rocks are found in the breccia as fragments.

*Age group 3.*—Dikes of dacite or andesite porphyry (Tdb) are considered younger than the mafic porphyry plugs of group 2 because the dikes crosscut all but the youngest plugs (Tpe) and because there was a fundamental change in magmatic composition between the youngest plug and the dikes of group 3. With one exception diorite dikes (Tdc) cut the dacite or andesite porphyry dikes (Tdb).

The hornblende quartz monzonite porphyry of the Pinos Altos stock and its apophyses (Tpf) cuts the earlier dikes of group 3 (Tdb and Tdc) but is cut by dikes of group 4 (Tdd and Tde). Because of its known age relations and its petrographic and structural similarity to the Santa Rita, Hanover-Fierro, and Copper Flat plutons of the Santa Rita quadrangle, the Pinos Altos stock is considered nearly contemporaneous with those three intrusives. If this is true, its age is Eocene, on the basis of Rb-Sr ages of 53±13 m.y. and 53±18 m.y. on biotite from the Santa Rita and Hanover-Fierro stocks, respectively (Moorbath and others, 1967). A detailed study of joints in the Pinos Altos stock was made by D. A. Brew as an adjunct to the mapping of the quadrangle. He infers from this study that the stock was intruded upward along an axis plunging about 80° N. 13° W., and that the veins in and around the stock occupy a local fracture set that may have developed very late in the intrusive sequence, possibly in response to combined intrusive and regional stresses.

Two dikes of hornblende quartz latite porphyry (Tcf) are considered to be contemporaneous with the Copper Flat pluton, which lies a few hundred feet to the northeast, and are therefore regarded here as approximately contemporaneous with the Pinos Altos stock (Jones and others, 1967, pls. 1, 3, and p. 74–77).

The granodiorite porphyry dikes (Tg) do not cut the Pinos Altos stock, but they are inferred to be the next youngest because similar dikes cut the Hanover-Fierro stock.

*Age group 4.*—The dikes of granodiorite and quartz monzonite porphyry (Tdd) in the western part of the quadrangle and the dikes of quartz latite (Tli) in the southeastern part of the quadrangle are considered approximately contemporaneous. The quartz latite dikes (Tli) extend into the Santa Rita quadrangle, where they are grouped with a rhyodacite porphyry plug and dikes that are demonstrably younger than postore quartz monzonite porphyry dikes. That these quartz monzonite porphyry dikes are equivalent to those in the Fort Bayard quadrangle is suggested by their general trend, their relation to the stocks, and their composition. If they are equivalent, then the quartz latite dikes are in part younger than the quartz monzonite dikes (Tdd). In any case, these intrusives are considered to represent the final igneous pulse of the Laramide revolution in the Fort Bayard quadrangle.

The age of the rhyolitic intrusive rocks (Tpg, Tpi and Tde) is not precisely determinable except that individual masses cut rocks as young as the diorite dikes (Tdc) and the Pinos Altos stock; but these intrusives are grouped together because they signal a fundamental change to dominantly silicic magmas intruded at shallow depths, and they are assumed to be contemporaneous, and genetically related to the various rhyolitic volcanic rocks.

A basaltic andesite dike (Tdf) cuts rhyolitic tuff at the north center of the quadrangle, and is hence the youngest intrusive rock in the quadrangle. A dike of similar composition cuts an apophysis of the Pinos Altos stock near its south end. These two dikes and the small plug (Tpj) in the center of the Pinos Altos stock are correlated with the basaltic andesite flows.

## OLIGOCENE VOLCANIC ACTIVITY

The eruption of the latite and rhyodacite flows of the Rubio Peak Formation, in the Oligocene, marked the resumption of extrusive igneous activity that resulted in the broad volcanic field now known as the Mogollon-Datil volcanic province (Elston and Coney, 1968). In the Fort Bayard quadrangle this volcanic field is represented by flows and tuffs of formations from the Rubio Peak up through the basaltic andesite flows (Tbab). The only K-Ar age applicable to volcanic formations definitely correlative with those in the Fort Bayard quadrangle is an age of 33.4 m.y. for the Kneeling Nun Tuff, about 10 miles southeast of Santa Rita (W. E. Elston, written commun., 1967). This date places at least part of the volcanic epoch clearly within the Oligocene, and the designation of "Miocene(?)" used by us in recent publications should be revised accordingly.

## DIKE SWARM

By far the most pervasive group of igneous rocks in the quadrangle, and certainly the quadrangle's outstanding geologic feature, is the swarm of mafic porphyry dikes. Early in the mapping of the quadrangle it became evident that to map the dikes individually would be impossible at the publication scale of 1:24,000. Most of them are less than 15 feet thick and many are less than 10 feet, and on an east-west traverse it was not uncommon to walk for 1,000 feet or more without seeing one sliver of country rock among the surface or gully exposures of dike rock. Therefore, the dikes had to be shown by a symbol or pattern that would indicate their average trend, and to some degree, their profusion. Fortunately, throughout much of the swarm, the dikes are nearly parallel, or loosely braided, so that it was not difficult to establish and depict local trends in the dikes.

It is impracticable to have trend lines much closer than 0.05 inch, representing 100 feet on the base map, or any farther apart than 0.2 inch lest the reader think few dikes are present. Therefore, it is difficult to show variations in profusion—variations that may be quite significant, for where no country rock can be seen at the surface between dikes, one could hardly expect to find the situation less complex at depth where the preferred limestone host rocks of ore are to be found. The method of depiction finally selected was to divide the dike complex into areas of different estimated total percentages of dike rock, in increments of 20 percent, on the basis of percentages noted at frequent intervals along east-west traverses spaced 800–1,000 feet apart or closer. The dashing and spacing of lines in the dike pattern differentiate between areas containing 0–20 percent dikes, 20–40 percent, and so forth, and the trend of lines in the pattern indicates the general trend of the actual dikes. We stress that the pattern is diagrammatic, and that branching or intersecting pattern lines indicate generally diverging *trends* of dikes and do not represent individual dikes that branch or intersect. Boundaries between the areas are gradational at best and arbitrary at worst, and therefore are not shown as contacts but are indicated only by changes in the dike pattern.

A few mafic porphyry dikes, mostly in the west-central part of the quadrangle, were both thick and continuous enough to be mapped individually, and are shown on the map as individual dikes in the same color as that used for the diagrammatic pattern for the dike swarm.

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