Bulletin No. 106 *Geological Series No. 2*

University of Arizona Bulletin

A Geological Reconnaissance of the Tucson and Amole Mountains

BY

OLAF P. JENKINS AND ELDRED D. WILSON

WITH

Notes on the Southern Section of the Amole Mining District

BY

MILTON A. ALLEN

Entered as second class matter November 23, 1915, at the postoffice at Tucson, Arizona, under the Act of Aug. 24, 1912. Issued semi-quarterly.

PUBLISHED BY THE

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G. M. BUTLER, *Director*

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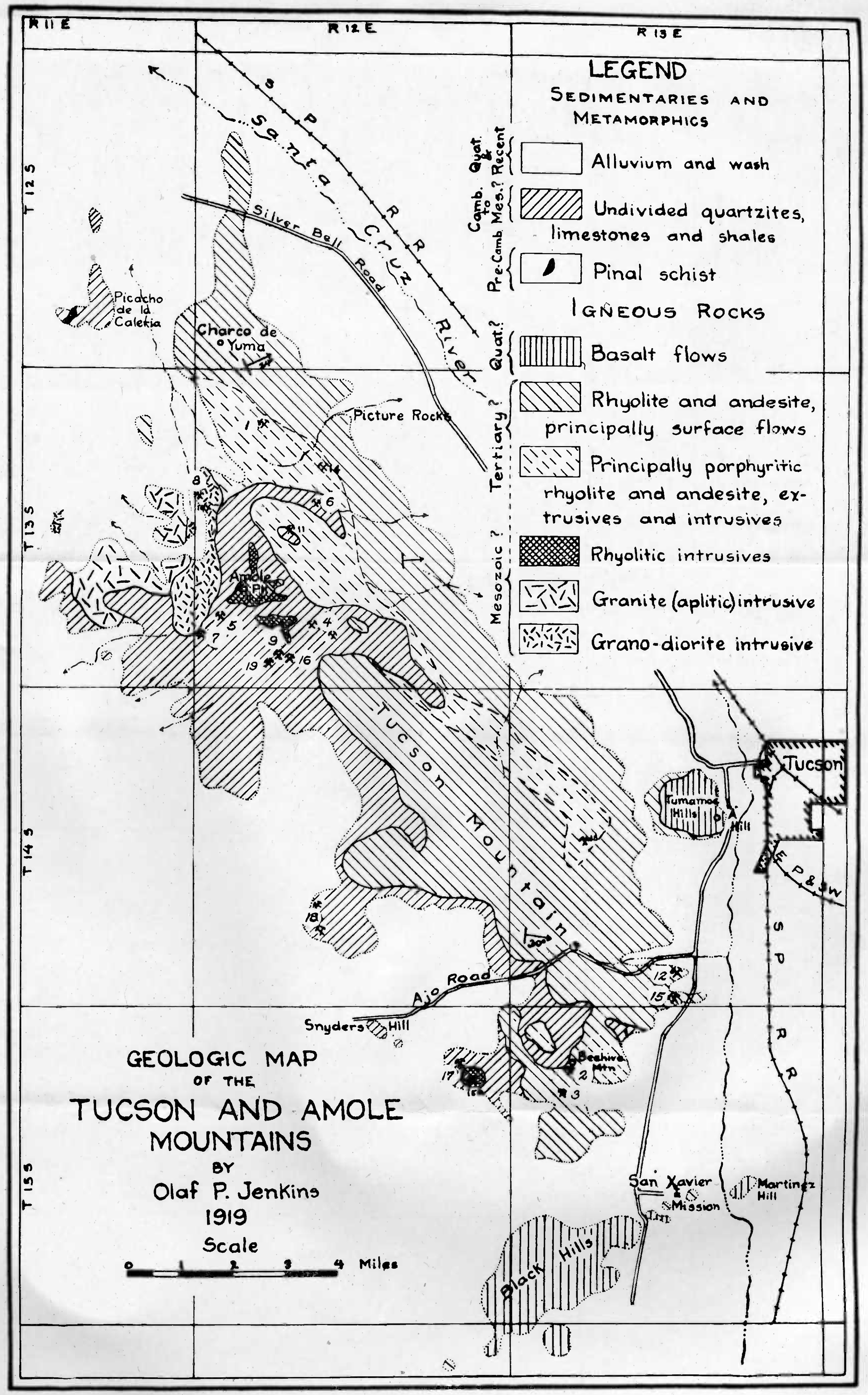

R 11 E
R 12 E
R 13 E
T 12 S
T 13 S
T 14 S
T 15 S
LEGEND
SEDIMENTARIES AND METAMORPHICS
Quat. & Recent
Alluvium and wash
Camb. to Mes.?
Undivided quartzites, limestones and shales
Pre-Camb.
Pinal schist
IGNEOUS ROCKS
Quat.?
Basalt flows
Tertiary?
Rhyolite and andesite, principally surface flows
Principally porphyritic rhyolite and andesite, extrusives and intrusives
Mesozoic?
Rhyolitic intrusives
Granite (aplitic) intrusive
Grano-diorite intrusive
S P R R
Santa Cruz River
Silver Bell Road
Picacho de la Caleria
Charco de Yuma
Picture Rocks
Amole Pk
Tucson Mountain
Tucson
Tumamoc Hills
A Hill
E P & S W
Ajo Road
Snyders Hill
Beehive Mtn
San Xavier Mission
Martinez Hill
Black Hills
GEOLOGIC MAP
OF THE
TUCSON AND AMOLE
MOUNTAINS
BY
Olaf P. Jenkins
1919
Scale
0 1 2 3 4 Miles

PLATE I

PREFACE

The Tucson and Amole Mountains are so accessible for visitors to Tucson that it is believed a brief description of the geology and mineral resources of these mountains will prove welcome. It is perhaps unfortunate that the purpose for which the data incorporated in this report were gathered made it unnecessary or undesirable to go more fully into details; but the general public may find this brief report more interesting and useful than one more voluminous and comprehensive.

The complexity of their geology, the variety of their igneous rocks, and the diversity of their ore deposits all combine to make the Tucson and Amole Mountains a very rich field for students and scientists. The general public, also, find these mountains interesting because of their picturesqueness, the heavy growth of sahuaro cactus existing in portions thereof, and the Indian pictographs and other evidences of a past civilization found at several points therein. In addition, a number of petrified trees of large size have been found near the Ajo road on the west side of the Amole Mountains, and this feature is destined to attract increasing attention.

The Arizona Bureau of Mines is now expending most of its efforts upon the completion of a Reconnaissance Geological Map of the entire State, and, besides the Tucson and Amole Mountains, has now mapped all of the Jerome Quadrangle, most of the Chiricahua and Verde Quadrangles, and certain areas in the neighborhood of Ajo and Gunsight. In addition, Mr. N. H. Darton of the United States Geological Survey, who has been working cooperatively with the Bureau, has mapped an extensive area along the eastern boundary of the State. Until the map mentioned is completed, the Bureau will not attempt to issue *complete and detailed* reports on the geology and mineral resources of restricted areas; but hopes to publish many preliminary bulletins similar to this one. Detailed economic work will doubtless eventually constitute a large part of the work of the Bureau, but it is felt that a generalized geological map of the whole State should be completed before much attention is given to smaller areas. It is hoped, therefore, that the brevity and incompleteness of this and subsequent bulletins will be overlooked, and that these publications will be regarded as incidental to the greater work that the Bureau has undertaken.

G. M. Butler, *Director*.

May 15, 1920.

University of Arizona Bulletin

GEOLOGICAL SERIES No. 2 MAY, 1920

A GEOLOGICAL RECONNAISSANCE OF THE TUCSON AND AMOLE MOUNTAINS

BY

OLAF P. JENKINS AND ELDRED D. WILSON

PURPOSE OF THE REPORT, AND ACKNOWLEDGEMENTS

The mapping of the Tucson and Amole Mountains was done by Olaf P. Jenkins with the assistance of Eldred D. Wilson and C. Y. Hsieh. It represents the beginning of the general mapping of the geology of Arizona for use in the construction of a geological map of the entire State that the Arizona Bureau of Mines is at present engaged in making. It was thought advisable to publish the data collected in advance of the State map, even though it is not as complete as it doubtless would have been if the original end in view had been something more than simply collecting data for the general map. The state map is being drawn to the scale of 1:500,000, or approximately eight miles to the inch, and it, therefore, will not be large enough to show greater details than appear on the map that accompanies this report.

A considerable portion of the area of Arizona, including districts previously examined and described by F. L. Ransome, Waldemar Lindgren, and other members of the United States Geological Survey, was studied before attempting to map the Amole District. It was through information thus secured that the geologists were able to distinguish certain features in the Amole district.

The geology of a series of hills just west of Tucson, known as the Tumamoc Hills, has been described by C. F. Tolman, Jr.* These hills are conspicuous by reason of a large figure "A" upon one of them, which was placed there by students of the University of Arizona. All the various flows of basalt and one bed of rhyolite tuff have been carefully mapped and described by Mr. Tolman in his report.

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*Geology of the Vicinity of the Tumamoc Hills; Carnegie Institute, Wash.. Publ. No. 113, pp. 67-82, 3 pls. (including map), 1 fig., 1909.

The following key-list gives the names corresponding to the numbers of the mines referred to on the map (Plate I, frontispiece):

1. Arizona Consolidated
2. Arizona Tonopah
3. Arizona Tucson
4. Bonanza Park
5. Copper King (Mile Wide)
6. Geo. Daily
7. Gould
8. Haskins
9. Jimmy Lee
10. Mexicana
11. New State
12. Old Bat (Mission Group)
13. Old Pueblo
14. Old Yuma
15. Pellegrin (Arizona Group)

15a. Papago

16. Ramage
17. Saginaw
18. Sam Pesano
19. Silver Moon

At an earlier date F. N. Guild* published a short paper on the petrography of the Tucson Mountains. In his paper, as in Tolman's, only the rocks of the southern portion of the region covered by the present report were discussed.

Included in a book on the botanical features of North American deserts by D. T. McDougal, a short account of the geology of the Tucson Mountains, by W. P. Blake†, is given.

None of these reports, however, attempts to explain in any way the major features of the complicated structure and geology of the entire range. No geographic map was available other than that of Pima County made by George J. Roskruge in 1894; hence the geologist and his assistants had to make their own map, as here represented, largely by the use of a Brunton compass.

LOCATION

The Tucson Mountains lie about a mile directly west of Tucson, and extend at least seven miles westward and twelve miles southward in a west of north and east of south direction. The continuation of this range to the northward and westward for seventeen miles from Tucson has been known for many years as the Amole Mountains, Amole Peak being the highest point in the entire range. This peak has, however, been designated Wasson's Peak on the map of Pima County by George J. Roskruge‡.

This last name, however, is unfamiliar to the people of the district, and is, therefore, not used in this report. The region immediately surrounding Amole Peak is known as the Amole Mining District, and this name has been extended to include all of the mines and prospects of the region described in this paper. Any part of the mountain range may be easily reached from Tucson over roads that are for the most part good enough for automobile traffic.

TOPOGRAPHY AND STRUCTURE

One of the most striking topographic features in the vicinity of Tucson is the decidedly serrated character of the Tucson Mountains. Their outline against the sky is so jagged and tooth-like that the effect is almost uncanny. This particular serrated type of topography seems to be confined almost entirely to the upturned and sharply

*Am. Jour. Sci., vol. XX, pp. 313-318, 1 pl., Oct., 1905.

†Carnegie Institute, Washington, Publ. No. 99, pp. 53-56, 1908.

‡The location of "Wasson's Peak" is given by the U. S. Geological Survey as latitude 32° 16′ 18.6″, longitude 111° 08′ 51.7″, but no elevation is recorded. (Personal communication). An aneroid measurement by E. D. Wilson gave it an elevation of 4700 feet above sea level.

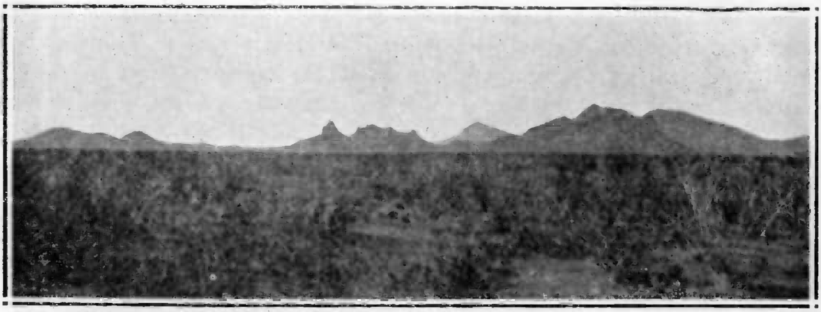

Fig. 1. The Tucson Mountains' sky-line. Looking northwest from the Tucson-San Xavier road. The prominent spire is Beehive Mountain, a volcanic neck.

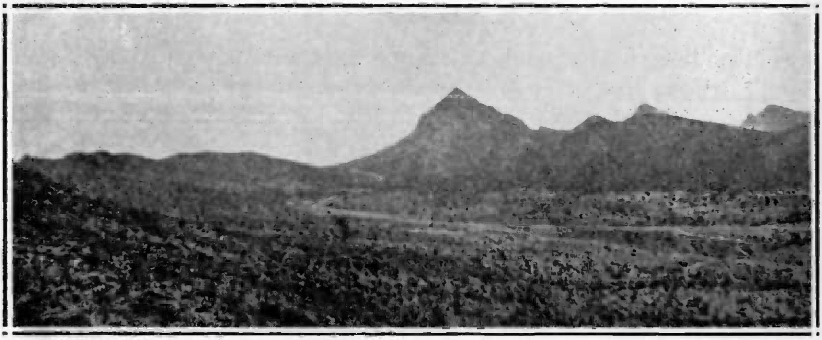

Figure 2. The serrated peaks of the Tucson Mountains. Looking northwest along the Ajo road.

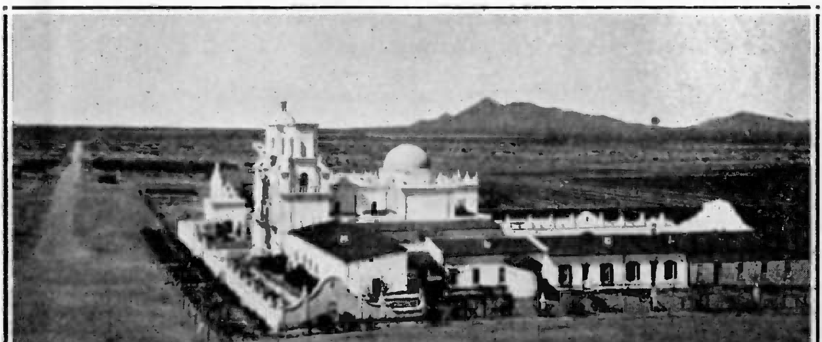

Figure 3. San Xavier Mission, which was founded in the latter part of the 17th Century. The Tucson Mountains are in the background.

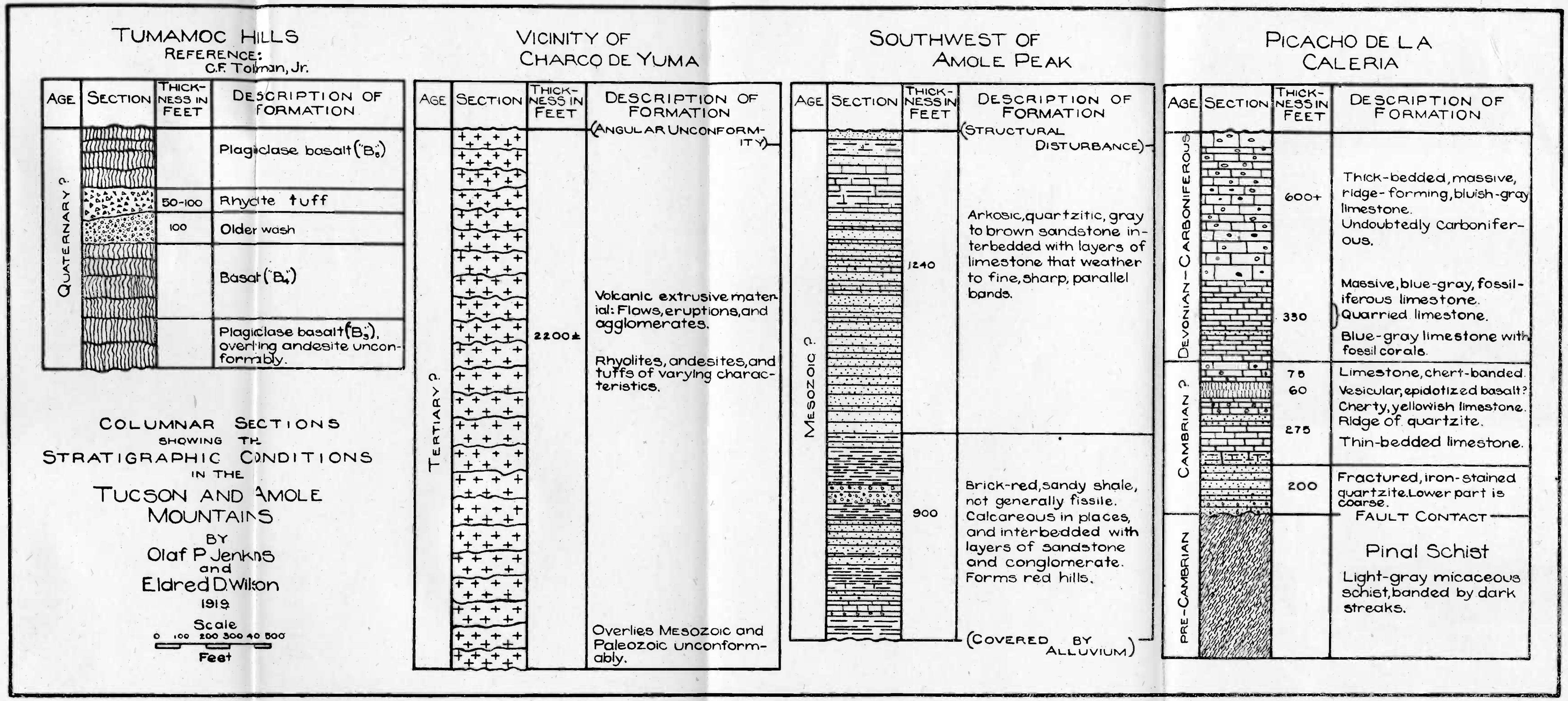
TUMAMOC HILLS
REFERENCE: C.F. Tolman, Jr.
AGE
SECTION
THICKNESS IN FEET
DESCRIPTION OF FORMATION
QUATERNARY ?
Plagioclase basalt ("B6")
50-100
Rhyolite tuff
100
Older wash
Basalt ("B4")
Plagioclase basalt ("B3"), overlying andesite unconformably.
VICINITY OF CHARCO DE YUMA
AGE
SECTION
THICKNESS IN FEET
DESCRIPTION OF FORMATION
(ANGULAR UNCONFORMITY)
TERTIARY ?
2200±
Volcanic extrusive material: Flows, eruptions, and agglomerates.
Rhyolites, andesites, and tuffs of varying characteristics.
Overlies Mesozoic and Paleozoic unconformably.
SOUTHWEST OF AMOLE PEAK
AGE
SECTION
THICKNESS IN FEET
DESCRIPTION OF FORMATION
(STRUCTURAL DISTURBANCE)
MESOZOIC ?
1240
Arkosic, quartzitic, gray to brown sandstone interbedded with layers of limestone that weather to fine, sharp, parallel bands.
900
Brick-red, sandy shale, not generally fissile. Calcareous in places, and interbedded with layers of sandstone and conglomerate. Forms red hills.
(COVERED BY ALLUVIUM)
PICACHO DE LA CALERIA
AGE
SECTION
THICKNESS IN FEET
DESCRIPTION OF FORMATION
DEVONIAN-CARBONIFEROUS
600+
Thick-bedded, massive, ridge-forming, bluish-gray limestone. Undoubtedly Carboniferous.
350
Massive, blue-gray, fossiliferous limestone. Quarried limestone.
Blue-gray limestone with fossil corals.
CAMBRIAN ?
75
Limestone, chert-banded.
60
Vesicular, epidotized basalt?
Cherty, yellowish limestone.
Ridge of quartzite.
275
Thin-bedded limestone.
200
Fractured, iron-stained quartzite. Lower part is coarse.
FAULT CONTACT
PRE-CAMBRIAN
Pinal Schist
Light-gray micaceous schist, banded by dark streaks.
COLUMNAR SECTIONS
SHOWING TH
STRATIGRAPHIC CONDITIONS
IN THE
TUCSON AND AMOLE MOUNTAINS
BY
Olaf P. Jenkins
and
Eldred D. Wilson
1919
Scale
0 100 200 300 40 500
Feet

PLATE II

carved edges of rhyolitic and andesitic lava flows, and also to the once connected, but now eroded, volcanic necks, from which they came.

The Tumamoc Hills and also the Black Hills exhibit an entirely different type of topography. They are more or less flat, or, rather, plane-topped and steep-sided, due to the fact that the lava beds composing them lie horizontal instead of being tipped-up at a sharp angle. Besides, these hills are of a different rock, largely cellular basaltic material, and are affected differently by erosion.

Amole Peak, the highest point in the range, and its immediately surrounding mountains are sharp and rugged; but their outline is more rounded than that of the Tucson range, and their color is lighter. The rocks here are of an entirely different character; they are not simply flat-lying beds that have been regularly turned up on edge, as with the Tucson Mountains proper, but they consist of highly distorted and metamorphosed sedimentary rocks such as quartzites, shales, and limestones, intruded by masses of various igneous rocks. The whole region about Amole Peak as a center has evidently been heaved upwards to a great height, faulted in many places, and the lava flows that once covered this region have been entirely stripped off by erosion so as to leave the underlying rocks clearly exposed for many miles around.

Farther to the north of Amole Peak and skirting along the eastern flank of the entire range in such a way as to connect with the rhyolite and andesite beds of the south are hills quite similar to the Tucson Mountains. They are composed of the same rocks as the Tucson Mountains, and also lie in a tilted position with the upturned edges carved and serrated in the fashion previously described.

The structure, therefore, consists of a tremendously upheaved and intruded region about the center of Amole Peak with a flanking rim of extrusive volcanic flows: those to the southeast dipping to the southeast; those to the east dipping toward the east; and those to the north dipping toward the northeast.

It is clear, therefore, that the oldest rocks may be found under the uptilted and eroded edges of the volcanic beds. The region where these rocks are exposed is, therefore, on the western edge of the range. It was not surprising, then, to find a patch of pre-Cambrian rocks, namely the Pinal schist, occurring on the extreme northwestern edge of an outlying twin hill of sedimentary rocks known as Picacho de la Caleria, and underlying the upturned and faulted edge of Cambrian quartzite.

Accompanying the great distortion of the western side of the range, especially in and about Amole Peak, is a complicated system of faulting. No attempt was made to represent any of these faults on the map because of their complexity. The sedimentary series is represented by several different ages, but is faulted in such a complicated manner that the whole is shown on the map without differentiation, since only the general features of the geology can be represented on a map of the scale of the state map in preparation.

GEOLOGY

General Features.

In the Tucson and Amole Mountains there are exposed sedimentary, metamorphic, and igneous rocks of various types. The sedimentary and metamorphic rocks for the greater part consist of quartzites, sandstones, conglomerates, shales, slaty rocks, limestones, and their metamorphosed products.

These sedimentary rocks, especially the limestones, are of importance economically because of the fact that ore deposits occur in them in a number of places where they are closely associated with intrusive igneous rocks. In the region around Amole Peak and immediately south thereof large amounts of epidote and garnet have been developed in the limestones and quartzites.

The igneous series consists of plutonic, porphyritic, and cellular rocks of nearly every imaginable texture, structure, and composition. With the exception of younger basaltic flows, most of the igneous rocks are of acid types.

There is an excellent field for petrographic study in the region; and it is a matter of regret that lack of time made it impossible to use anything but field criteria for classifying the rocks.

The Sedimentary and Metamorphic Series.

The accompanying columnar sections, besides showing the igneous flows, show more clearly than can verbal descriptions the character and sequence of deposition of the sediments and their relation to each other.

The oldest formation in the region is probably the pre-Cambrian schist, which occurs on Picacho de la Caleria as previously stated. It resembles closely the old Pinal schist of other regions in Arizona, which have been more carefully worked out. It underlies, by a fault contact on Picacho de la Caleria, a conglomeratic phase of the upper 200 feet of the Cambrian quartzites.

The Cambrian quartzites are apparently the oldest rocks of unquestionably sedimentary origin in the region. They are very hard and dense, but are generally fractured. They resemble closely the *Bolsa quartzite* of the Bisbee section. The quartzites of Mesozoic age, although more arkosic and different in some other lithologic characteristics, may be confused with this formation.

The upper member of the Cambrian consists of a highly metamorphosed siliceous limestone impregnated throughout with finely divided epidote. This rock also shows a characteristic banding, and exposed surfaces have a cherty appearance. The rock of this horizon resembles in many respects the *Abrigo limestone** of the Bisbee district and the *Mescal limestone*† of the region near Globe and Roosevelt. It is also similar to portions of the *Longfellow formation*‡ (Ordovician) at Clifton.

Overlying the Cambrian beds is a series of limestones which are more or less fossiliferous. Undoubtedly most of these limestones are of Carboniferous age. The lower portion may, as in other places in Arizona, be Devonian. No attempt, however, was made to collect the poorly preserved fossils of these beds, or to determine their age. Typical Carboniferous fossils, such as remains of *Productus,* were seen in many of the more massive beds. These limestones resemble closely the Devonian and Carboniferous limestones of other districts studied in southern Arizona. They consist of characteristic bluish-gray limestones which contain cherty nodules, some of which are siliceous replacements of once calcareous fossils. Portions of these limestones when situated near or intersected by intrusives are often replaced by metallic minerals.

Southwest of Amole Peak there is a remarkably thick series of conspicuous red shales and sandstones overlain by a section of arkosic sandstones of buff color. These are faulted into the positions they occupy in such a manner that their exact relation to the other sedimentaries is not clearly exposed. Acid igneous dikes intrude them in many places. Stratigraphically, they may be the equivalent of the formation mapped by Schrader** in the Santa Rita Mountains as Mesozoic.

With the exception of more or less sedimentary phases in the tuffs of the rhyolite and andesite series, the only other sedimentary deposits worthy of mention are those deposited by streams in the form of alluvium, and the roughly unstratified or stratified gravels

*Ransome: U. S. Geol. Surv. Folio 112, 1904; Prof. Paper 21, 1904. Bonillas, Tenney, and Feuchere: Trans. A. M. Inst. Min. Eng., vol. 55, pp. 284-355, 1917.

†Ransome: U. S. Geol. Surv. Prof. Paper 98-k, 1916.

‡Lindgren: U. S. Geol. Surv. Folio 129, 1905; Prof. Paper 43, 1905.

**Mineral Deposits of the Santa Rita and Patagonia Mountains, Arizona: U. S. Geol. Surv. Bulletin 582, 1915.

and boulders washed down by torrential storms from the sides of the mountains. These form sloping deposits of great thickness, and partially cover the older rocks at the base of the mountains so as to give the latter the appearance of islands in a sloping sea of desert.

The Igneous Rocks.

The greater portion of the Tucson and Amole Mountains is composed of igneous rocks. These rocks consist of a series of intrusives, of both granitic and porphyritic texture, that occur largely on the western side of the range, and principally in the region of Amole Peak. Overlying the entire series of rocks and flanking the eastern, northern, and southeastern sides of the range are a series of bedded flows of rhyolite and andesite, and tufaceous forms of both of these types. Still younger than these rhyolite and andesite flows are overlying basalt beds, remnants of which are well represented in the Tumamoc and Black Hills. In the Tumamoc Hills a tufaceous bed of light colored rhyolite lies intercalated with the basalts. Owing to the fact that the basaltic hills are composed of flows that occurred at different times, it is not surprising to find in places remnants of older alluvial wash phases between the layers, as explained by Tolman*.

The exact ages of the various igneous rocks have not yet been determined. In Tolman's report the following statement relative to the age of the extrusive rocks is made: "The Tumamoc Hills are the products of the final (probably Quaternary) stages of the extensive Tertiary volcanic activity of this portion of Arizona." Blake, however, refers to the andesitic and rhyolitic flows as of pre-Tertiary, or Cretaceous age.

It is the opinion of the writers that the exact age of most of the types of igneous rocks found in southern Arizona can only be determined by extended study of the occurrences in many scattered localities. Each mountain range in the southern part of the State is generally separated from other ranges, as far as surface exposures are concerned, by great stretches of alluvial and desert wash material. For this reason alone it is difficult to determine the ages of the different rocks without a considerable amount of comparative study.

It is probable that a certain series of granitic rocks of a granodiorite type, occurring in the belt west of Amole Peak, is the oldest igneous rock of the region. Another granitic series occurs west of this granodiorite intrusion. These granites are quite light colored, and vary in texture from a coarse grained to a nearly felsitic or aplitic form.

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*Op. cit., pp. 76, 77.

A quartz-porphyry intrusion occurs very near the site of the old Saginaw smelter. It is probable that this rock is genetically connected with the copper mineralization existing in this vicinity. Upon the very top of Amole Peak and extending out as arms or apohyses there occurs a very peculiar acid intrusive of rhyolitic type. Whether this intrusion did or did not have anything to do with the general upheaval of which this mountain marks the center, it is difficult to say. It is evident, however, that great metamorphism has taken place in the sedimentaries surrounding this rock. The igneous rock itself has the appearance of silicified sedimentary material, and in some places of a quartzite. On the other hand, the surrounding sedimentary rocks differ so little in appearance from this silicified igneous rock that it is often very difficult to determine just where the line of contact lies.

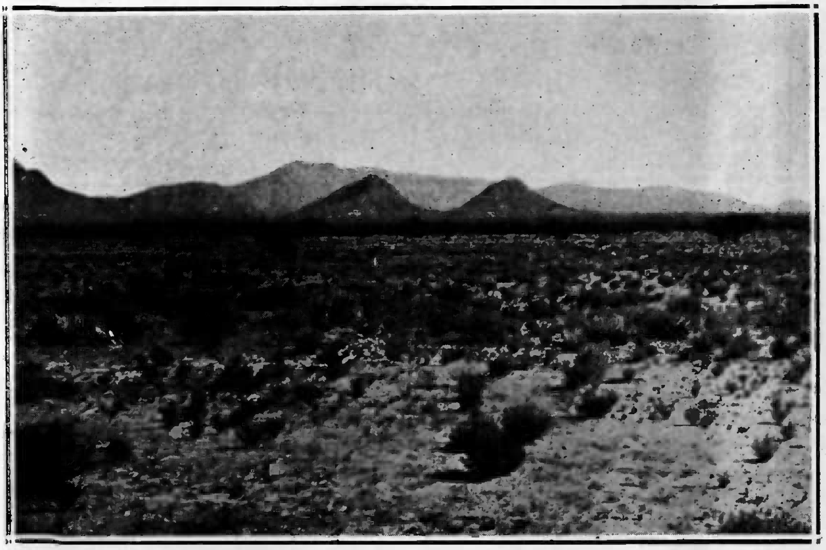

Figure 4. View of the Amole Mountains looking southward. Amole Peak lies in the distance. The twin peaks in the center of the picture are of sedimentary rocks; the one to the right consists of Cambrian quartzites, and the one to the left (Picacho de la Caleria) is of Carboniferous limestone. The higher peak to the left consists of rhyolite and andesite, dipping eastward. The desert region in the foreground is characteristic of that which surrounds the entire range.

Beneath the rhyolite and andesite flows and exposed to the west of their upturned edges is a series of igneous rocks that are generally of rhyolitic or andesitic natures. Their texture is porphyritic, and their structure evidently complex. Some exposures may represent the interiors of flows, but elsewhere they are undoubtedly intrusive. It is quite evident that in some localities these porphyritic rocks form the necks to which the extrusive flows were attached. In other words, they fill the channels through which the surface flows arose.

The differentiation of the various igneous rocks is a matter of detailed work and its consideration is not necessary in the making of a general map of the State, for the reason that such differentiation could not be shown in any practicable way upon a map of so small a scale as eight miles to the inch. It was thought, however, that the information obtained in the field should be presented as far as it went. For that reason the writers have expressed these views in regard to the intrusive rocks, although much work must still be done before the ideas set forth can be considered established or discredited.

The overlying lava flows are rather distinct in structure and appearance excepting where they connect with underlying intrusives. Such places are especially interesting, however, and afford splendid problems for future petrographic study.

A small spine-like peak sticks up prominently in the southern end of the Tucson range, and is clearly seen from many points south of Tucson. It is known as Beehive Mountain, and may be reached

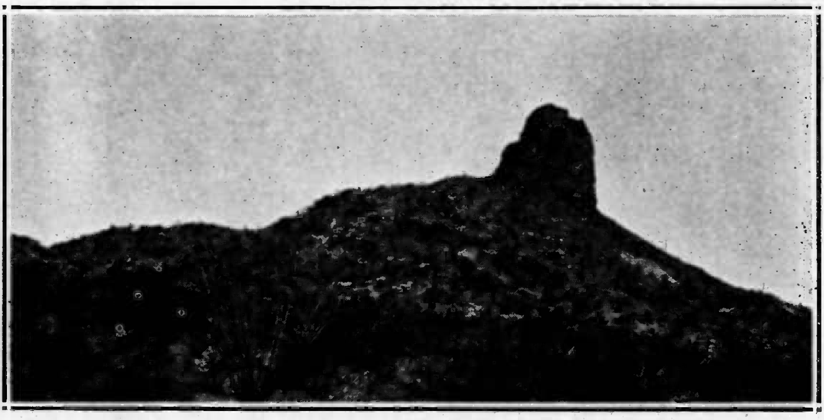

Figure 5. Beehive Mountain, a volcanic neck, situated in the southern end of the Tucson Mountains.

by turning westward on a road that strikes the San Xavier Mission road six miles south of Tucson. This peak and a few other spine-like connecting peaks are undoubtedly volcanic necks. They are not now, and probably never were, necks of eruptive volcanoes, but in all probability represent the conecting material between the surface flows of rhyolite and andesite above and the deep-seated rocks below.

The petrographic description of the rocks of the Tucson Mountains by F. N. Guild includes the rocks of these overlying flows of rhyolite and andesite and the still younger basaltic flows. The following rocks are described in Guild's and Tolman's publications already referred to: *Rhyolite,* the type of rock forming the main line of serrated peaks; *rhyolite tuff* which is associated with the flows; *andesite* of at least three varieties; *basalt* of which there are descriptions of three types, namely: *olivine basalt, plagioclase basalt,* and *quartz basalt.*

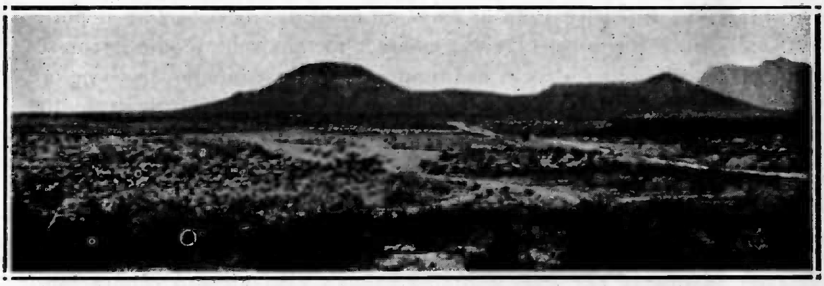

Figure 6. Looking northward toward the Tumamoc Hills. These are composed of basalt with a central, nearly horizontal bed of whitish rhyolite-tuff. To the right and in the far distance are the Santa Catalina Mountains.

The basalts, especially, show considerable textural variation; some are heavy and fine-grained, while others are relatively light and cellular. Cellular rocks that have had the cavities filled with secondary minerals are said to be amygdaloidal; and amygdaloidal basalts are prominent in places in the flows of the basaltic hills. It seems to the writers, however, that the most interesting rock found in these flows is the quartz basalt, a rare rock that occurs rather plentifully in the Black Hills and in Martinez Hill in the region about San Xavier Mission.

ECONOMIC GEOLOGY

Deposits of metalliferous minerals containing copper, lead, silver, gold, and molybdenum, and a considerable variety of structural materials are found in the Tucson Mountains. Rhyolite tuff from the Tumamoc Hills and from the rhyolite-andesite series of the Tucson Mountains has been used to a certain extent for building stone in Tucson. For example, North Hall at the University of Arizona was constructed of this material. Blocks of loose basalt are used in the construction of foundations, stone walls, and ornamental stone-work in many of the structures in the city; and road material is also secured from quarries in the basalt. Limestone from the western side of the range was for many years used for the manufacture of lime, but none has been burned for some time. The limestone from Snyder's Hill was used, however, in the construction of a portion of the Ajo road.

Very little actual mining or extensive development work has been done in the Amole District. The most important ore deposits contain copper or silver and lead minerals, but deposits of other ores have been mined, such, for instance, as the molybdenum ore in the Old Yuma Mine. All the deposits seem to occur in close proximity to contacts of intrusive igneous and sedimentary rocks. The deposits usually have the form of veins, contact metamorphic bodies, replacement deposits in such rocks as limestones, or disseminations. The ore minerals were probably deposited from solutions that arose from the same magma reservoir that was the source of the intrusive rocks. In some cases downward leaching and concentration by meteoric waters has occurred.

A good example of a disseminated mineralization in an intrusive rock is shown in the Papago Mine in the southern part of the range. There a quartz porphyry contains enough disseminated copper minerals to make it a low-grade copper deposit. Near by in the limestones of this same group of claims, formerly known as the Saginaw group, are deposits of lead and silver. These probably represent replacements.

Southeast of Amole Peak in the limestones, badly distorted and cut by dikes of various sorts, occur the replacement deposits of the Bonanza Park Mining Company, which contain lead, silver, and copper minerals, locally of high grade. They are oxidized at and near the surface.

Southwest of Amole Peak are the Gould and Mile Wide mines, but they were inactive when visited. They contain sulphide copper ores, and probably represent the contact metamorphic type of deposit, for they are associated with igneous dikes and altered sediments. Great structural disturbances are also shown in the vicinity.

To the north of Amole Peak is a prospect known as the Mexicana Mine which exposes a steeply dipping fissure vein in a granitic rock, probably granodiorite. Within a few feet of the vein the granodiorite is in contact with quartzite. The ore is primary pyrite and chalcopyrite.

The Old Yuma Mine was operated on a steeply dipping fissure

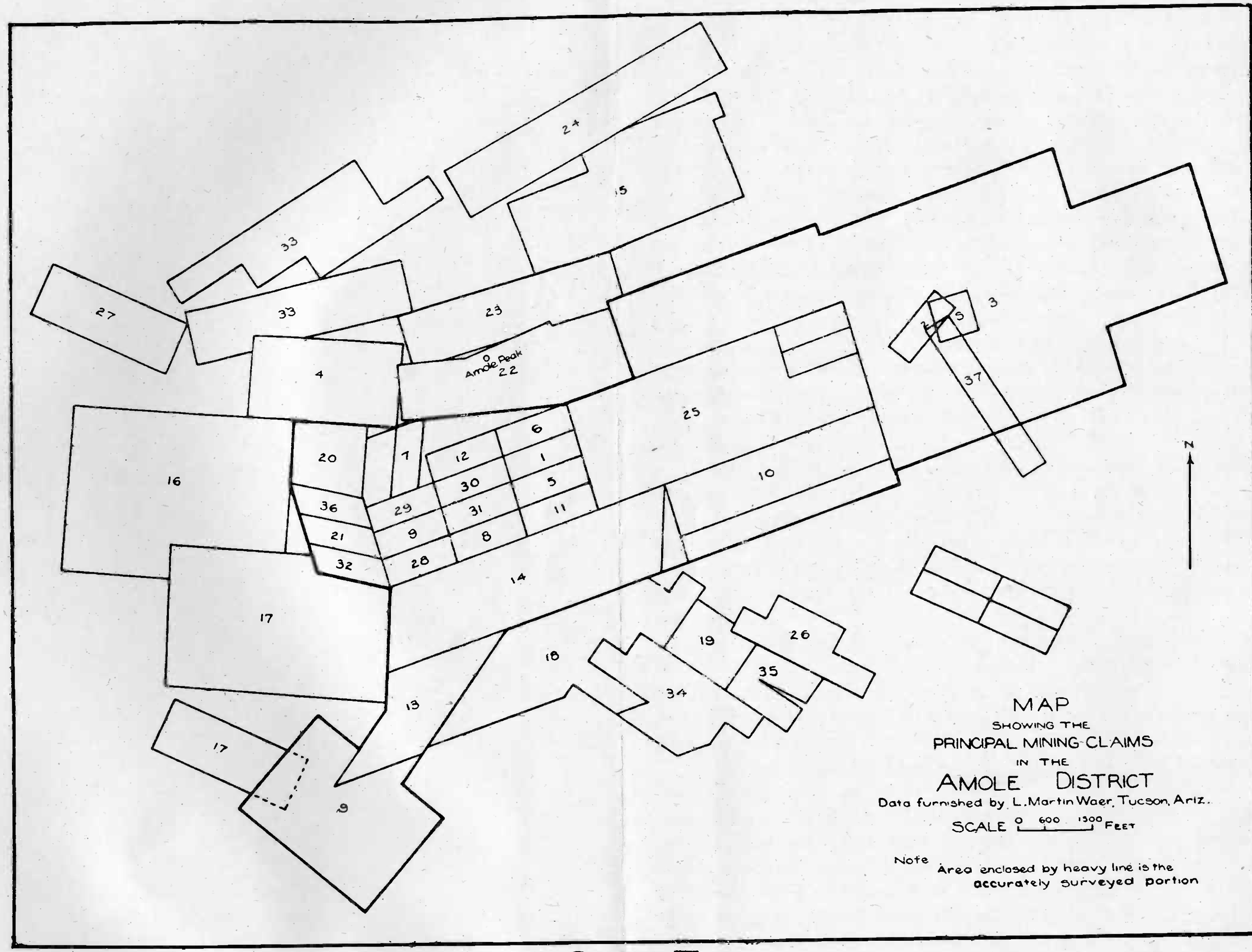
MAP
SHOWING THE
PRINCIPAL MINING CLAIMS
IN THE
AMOLE DISTRICT
Data furnished by L. Martin Waer, Tucson, Ariz.
SCALE 0 600 1200 FEET
Note
Area enclosed by heavy line is the accurately surveyed portion
N
Amole Peak
24
15
33
33
27
23
22
4
16
20
7
12
6
1
30
5
31
11
36
29
21
9
8
32
28
14
25
10
2
5
3
37
17
17
18
13
19
26
35
34
9

PLATE III

vein containing lead and silver ore. The rock in which it occurs is an andesitic lava intruded in places by porphyritic rocks which have suffered from surface oxidation to a considerable extent. Near the surface in this mine, in the oxidized portion of the ore body, several rather unusual minerals, such as vanadinite ($Pb_5Cl(VO_4)_3$), and wulfenite ($PbMoO_4$), are common. Most of these minerals were

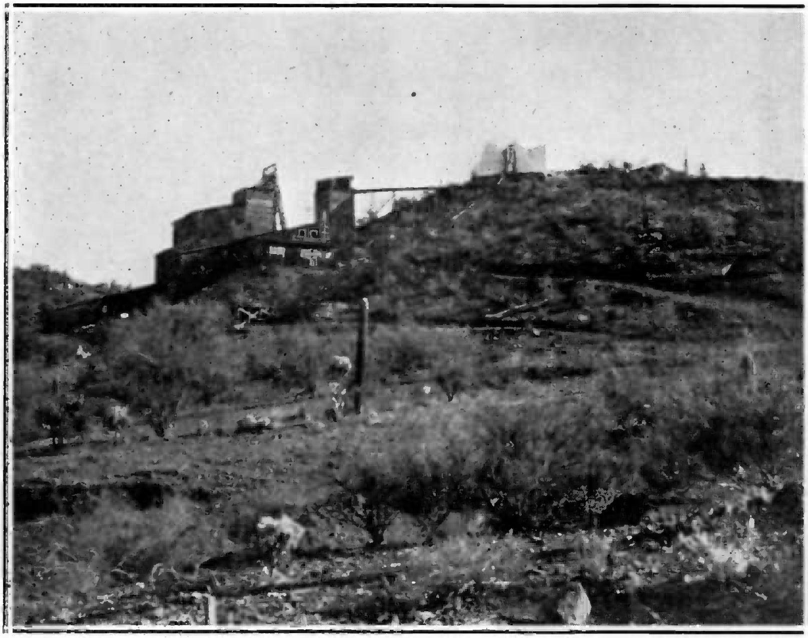

Figure 7. Old Yuma Mine and Mill.

doubtless formed by the alteration of primary sulphides exposed to downward percolating surface water. Quantities of very beautiful and interesting crystallized mineral specimens have been obtained from this property. At one time an attempt was made to concentrate the wulfenite ore at the mine, but the property was idle when visited.

The most promising mineralized area, however, seems to be about Amole Peak, where the sedimentary series has been highly altered, faulted, and intruded by various igneous rocks. In this region are patches of limestones which, where favorably located in regard to the igneous dikes and structural disturbances, may prove to contain replacement deposits of considerable value.

Plate III shows the location of the principal mining claims in the northern portion of the Amole District. The numbers given on the map refer to the claim names as follows:

1.	Alta	20.	L. Martin Waer
2.	Azurite	21.	Margarite
3.	Bonanza Park	22.	McQuane
4.	Bosques	23.	New State
5.	Buena Vista	24.	Old Yuma
6.	Cimaron	25.	Orient
7.	Copper Bell	26.	Ramage
8.	Copper Crown	27.	Ronco Flores
9.	Copper King	28.	St. Louis
10.	Copper Mountain	29.	St. Paul
11.	Copper Queen	30.	San Fernando
12.	Copper Top	31.	San Francisco
13.	Esmeralda	32.	San Miguel
14.	Esperanza	33.	Sibley
15.	Ferguson	34.	Silver Moon
16.	Garcilla	35.	Stinson
17.	Gould	36.	Washington
18.	Henry Waer	37.	Woofenden
19.	Jimmy Lee	S.	Smelter site and buildings

THE SOUTHERN SECTION OF THE AMOLE MINING DISTRICT

BY

MILTON A. ALLEN

INTRODUCTION

The mining properties in this section are located to the south and west of Beehive Mountain (see frontispiece). This prominent landmark is on the property of the Arizona tonopah Mining and Milling Company, about nine miles south of Tucson. The mines may be reached from the Tucson-Ajo or Tucson-San Xavier roads; the properties being about two miles west of the latter road.

The topography of the section is not so precipitous as farther north; in fact, the country is comparatively flat except where small hills of igneous rocks rise abruptly to a height of less than 350 feet above the alluvial flats. Bed-rock lies at shallow depths below the alluvium.

The igneous rocks of this part of the district are rhyolite-porphyry, porphyrites, and andesites. Sedimentary rocks occur within a mile to the north and west of the Arizona Tonopah Company's property and on the Saginaw group, and the igneous-sedimentary contact is easily traceable to the north of the Arizona Tonopah and on the Saginaw properties. Rhyolite flows occur above the sediments at the western edge of the Saginaw group.

Siliceous float that carries appreciable quantities of gold and silver has been found in the alluvium on the flats.

HISTORY

The principal properties in the Southern Amole District are the Saginaw, the Arizona Tucson Copper Company, and the Arizona Tonopah Mining and Milling Company. The Saginaw property was worked for two years commencing in 1898, and the plant included a mill and a smelter. In 1917 a new incorporation known as the Papago Queen Mining Company secured a bond and lease on the Saginaw group, and acquired other claims in the immediate vicinity. The operations of the Papago Queen Mining Company were confined to that part of the Saginaw group known as Gold Mountain.

The Ivy May claim of the Arizona Tucson Copper Company was originally owned by S. W. Purcell of Tucson, who worked the claim to some extent. The Hermosa Copper Company was later formed and located nine claims contiguous to and to the west of the Ivy May claim. Some exploration work was done by the Hermosa Copper Company. In 1919 the property of the last named company and the Ivy May claim were acquired by the Arizona Tucson Copper Company, and considerable development work has since been done by this company.

The Arizona Tonopah Mining and Milling Company is a recent incorporation that commenced operations in the early part of 1919.

SAGINAW PROPERTY

Ore was obtained from several shafts of the Saginaw mine in 1898, 1899, and 1900. These shafts have since partly caved and most of the workings are inaccessible. The dumps show that rhyolite and quartzite carrying pyrite and some chalcopyrite were encountered in the shafts. At the south end of the property the Palo Verde shaft

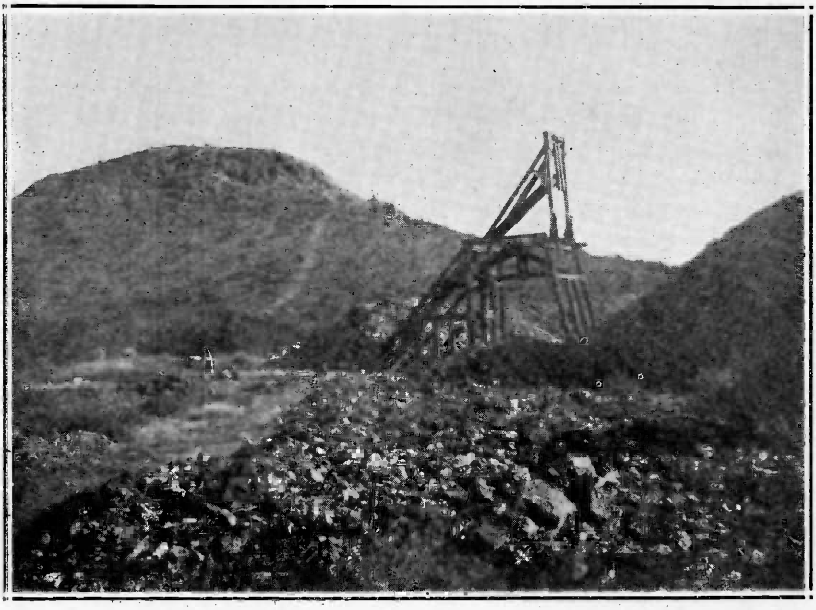

Figure 8. Palo Verde shaft on the Saginaw. Gold Mountain in the background.

was sunk on the rhyolite-limestone contact. Some cerussite and galena carrying silver have been taken from these workings. To the west of the Palo Verde shaft some prospect holes sunk in the limestone show the presence of cerussite and galena occurring as replacements. Considerable epidote is there present.

Northwest of the Palo Verde shaft is found a large amount of limonite float which is highly siliceous. It has been surmised by prospectors that this material came from a so-called outcrop or gossan. As a matter of fact, the considerable amount of work done in this vicinity has been wasted, since the iron oxide float comes from a bed of shale carrying various sized nodules of siliceous limonite.

Gold Mountain, on the eastern end of the Saginaw property, is a porphyritic mass in which occur banded quartz veins that carry copper in amounts up to three percent. The porphyry itself is also copper bearing. The copper occurs as cuprite and malachite; none of the primary sulphides are exposed by the existing workings. The quartz veins are evidently siliceous replacements along fault fissures.

Because of the market for highly siliceous copper ore, this section of the property was worked in 1917 by the Papago Queen Mining Company, which has a bond and lease on the property. Only three carloads of ore were shipped, however.

The 1914 annual report of the Calumet and Arizona Copper Company speaks of exploration work conducted on the Saginaw

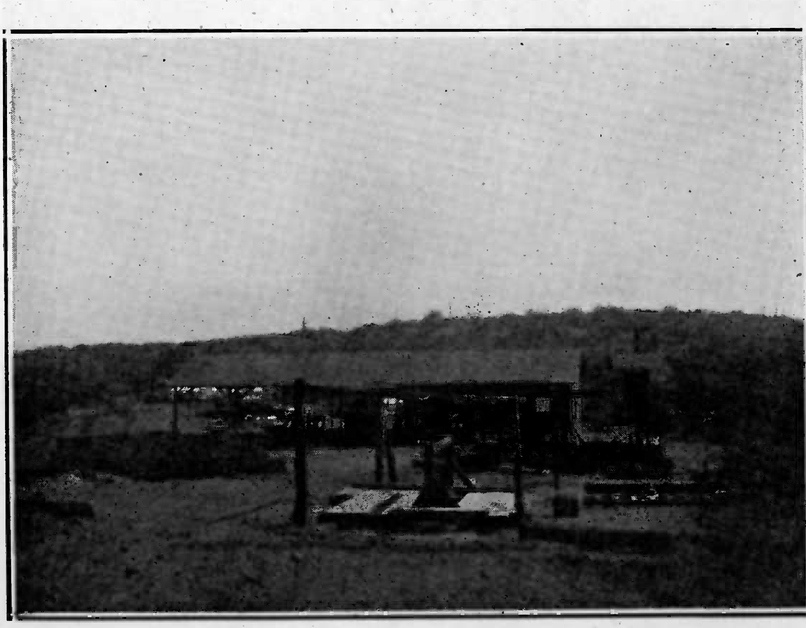

Figure 9. New working shaft of the Arizona Tucson Copper Company

property as follows: "This property, nine miles south of Tucson in Pima County was thoroughly prospected by diamond drilling. Work was started January 15 and stopped April 1. Five holes, totalling 1500 feet, were drilled. The mineralization in this ground is similar to that at Ajo, but is not so intense. All of the holes showed appreciable values in copper, but not enough to make commercial ore."

The drilling was done on what is known as Gold Mountain, and not along the sedimentary-igneous contact.

ARIZONA TUCSON COPPER COMPANY

This company now owns 36 claims, in which are included the Ivy May, and nine others that were the property of the Hermosa Copper Company. All of its operations at the time of the writer's visit (October, 1919) were confined to the development of the Ivy May claim. A machine shop had been erected and equipped, a head frame completed, and a hoist installed. Sinking of a vertical shaft was under way and a depth of over 25 feet had been reached. This shaft was sunk a little to the east of the old shaft which was carried down through the ore to a depth of over 100 feet, but which has

Figure 10. Old shaft and glory hole on the Ivy May claim of the Arizona Tucson Copper Company.

caved. Ore was stoped from this old shaft, and over 200 tons mined from near the surface. This ore is at present on the stock pile, and is said to run $60 per ton in gold, silver, and copper. Most of the value is in gold and silver. The copper occurs as cuprite, malachite, and bornite. Primary sulphides have not yet been encountered. The ore occurs as siliceous replacements (with a maximum width of six feet) along the fractures and flow planes of the porphyrite, and some copper carbonate is found in the porphyrite. Water for present operations is pumped from a prospect shaft west of the main shaft.

ARIZONA TONOPAH MINING AND MILLING COMPANY

The property of the Arizona Tonopah Mining and Milling Company comprises a group of forty claims, some of which are south of the Arizona Tucson Copper Company's property. Active work was commenced in the early part of 1919. At the time of the writer's

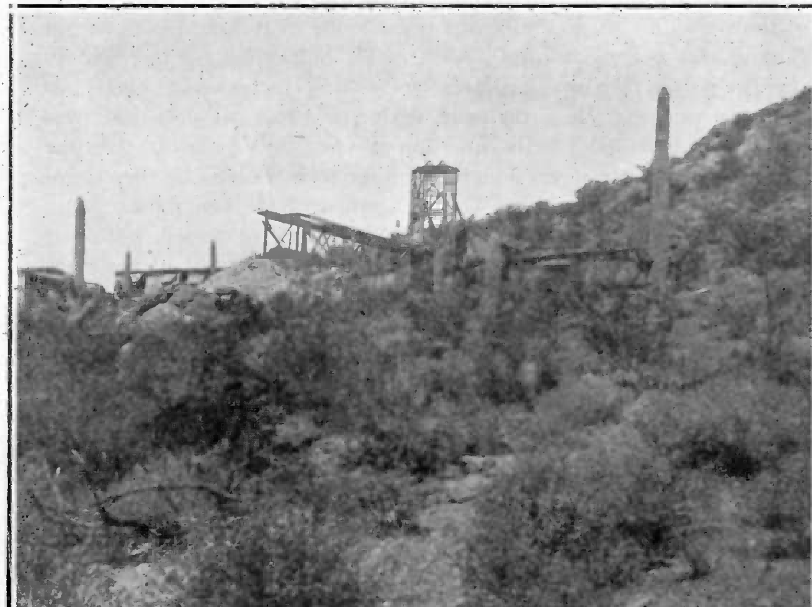

Fig. 11. Shaft of the Arizona Tonopah Mining and Milling Company.

visit to the property (October, 1919) sinking was being done on claim No. 2. The shaft was vertical 9 x 4 feet in the clear, and 73 feet deep. An examination of the dump indicated that the shaft had been sunk throughout its depth through rhyolite-porphyry that carried some pyrite and a trace of copper. At 73 feet the rock was perfectly fresh and to the naked eye showed no evidence of leaching or alteration. It was said to be the intention of the management to cross-cut at the 200-foot level to intersect a winze sunk from a tunnel 100 feet above the collar of the shaft. This 185-foot tunnel was driven into Beehive Mountain. At a point 100 feet in from the mouth of the tunnel a 60-foot winze had been sunk. An examination of the tunnel and dump showed that little or no ore had been encountered. Some pyrite was noticed in the rhyolite-porphyry. Camp buildings, a machine shop, and a power house had been erected at the site of the present sinking operations. The sinking equipment consisted of a crude oil engine for power, a compressor, and a crude oil engine hoist. Fifteen hundred feet northwest of the main shaft a small prospect shaft was being sunk, and had reached a depth of 60 feet. This shaft passed through a silicified rhyolite flow carrying pyrite. This flow is said to run 17 ozs. in silver where it is exposed in the shaft. At the time of the writer's visit no effort was being made to follow this flow, but sinking was being continued. The shaft bottom at 60 feet was in rhyolite-porphyry containing angular volcanic inclusions. Five hundred feet to the south of the main shaft a five-foot prospect shaft was said to have yielded a little ore running one ounce in gold. On the company's property to the south of the Arizona Tucson Copper Company some prospecting on a copper showing had been done.

In March, 1920, sinking at the main shaft had ceased, but some work was being done on the silver shaft to the northwest of the main shaft. During March, 1920, A. J. Harshberger, the Superintendent, wrote that the main shaft had reached a depth of 145 feet and was then in rhyolite porphyry carrying $1.60 in gold, three ounces in silver, and 1.6 percent of copper. In the silver shaft, which had reached a depth of 100 feet, ore had been struck that Mr. Harshberger further claims runs from $14 to $46 in lead, silver, copper, and gold. Thirty feet of drifting had been done on this ore.

CONCLUSION

The most important part of the foregoing report is the map that accompanies it. Upon this map an attempt is made to show the general geological features and the relative location of the ore deposits that have been prospected at one time or another.

The stratigraphy or the succession of sedimentary rocks in the Tucson Mountains is interesting because it is typical in many ways of other districts in southern Arizona.

The occurrence of such a varied series of igneous rocks so close to the city of Tucson should tempt petrographers to further study of conditions existing in this interesting region.

It is rather surprising that so little is known concerning the Amole District, and that the ore deposits existing there have been developed to such a limited extent. It is hoped that this hastily prepared and admittedly incomplete description of the region will stimulate activity there, and will serve as the basis for more detailed and thorough investigations that the Bureau expects to make later.

INDEX