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GEOLOGY AND ORE DEPOSITS OF THE SUPERIOR MINING AREA, ARIZONA

By

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By M. N. Short, F. W. Galbraith, E. N. Harshman, T. H. Kuhn, and Eldred D. Wilson

INTRODUCTION

LOCATION, CULTURE, AND TRANSPORTATION

The Superior mining area is in northeastern Pinal County, Arizona (Fig. 1). The area was officially organized as the Pioneer mining district but is better known as the Superior mining area.

Superior, the principal settlement within the area, in 1940 had a population of about 5,000, depending principally upon operations of the Magma Copper Company. The old town of Silver King, now largely deserted, was at the Silver King mine, in the northern part of the area shown on Plate I.

The Magma Arizona Railroad, 35 miles long, extends from Superior to Magma, a station on the Winkelman branch of the Southern Pacific, 9 miles west of Florence. It is maintained by the Magma Copper Company. Superior is on U.S. Highway 70, about 64 miles east of Phoenix and 20 miles west of Miami. A graveled state highway extends from Superior to Ray, 15 miles south. A graded county road 7 miles long connects Superior with Silver King. Various secondary roads lead to ranches and mines.

PHYSIOGRAPHY

Superior is on the eastern margin of a basin-shaped valley in the mountainous region between the Superstition and Pinal ranges. The Superior mining area, as here considered, consists of a central northward-trending mountainous belt ¾ to 3 miles wide which rises eastward from this valley to a mesa.

The Central Belt ranges in altitude from about 2,800 feet at Superior to a maximum of 4,500 feet below Apache Leap, the rim of the mesa. It consists largely of faulted eastward-dipping limestone, quartzite, and shale, underlain by schist and including areas of intrusive diabase, diorite, and porphyry (Pl. I). Its topography reflects somewhat the bedrock character and structure. Semiarid, rapid erosion has formed cliffs and steep slopes upon resistant limestone and quartzite; medium slopes or rounded hills upon uniformly textured diorite; and gentle slopes upon shale and diabase. The trend of the mountain front follows rather closely the strike of the beds, as shown on Plate I.

The Valley extends west from Superior, along the drainage of Queen Creek, beyond the limits of Plate I. It is bounded on the

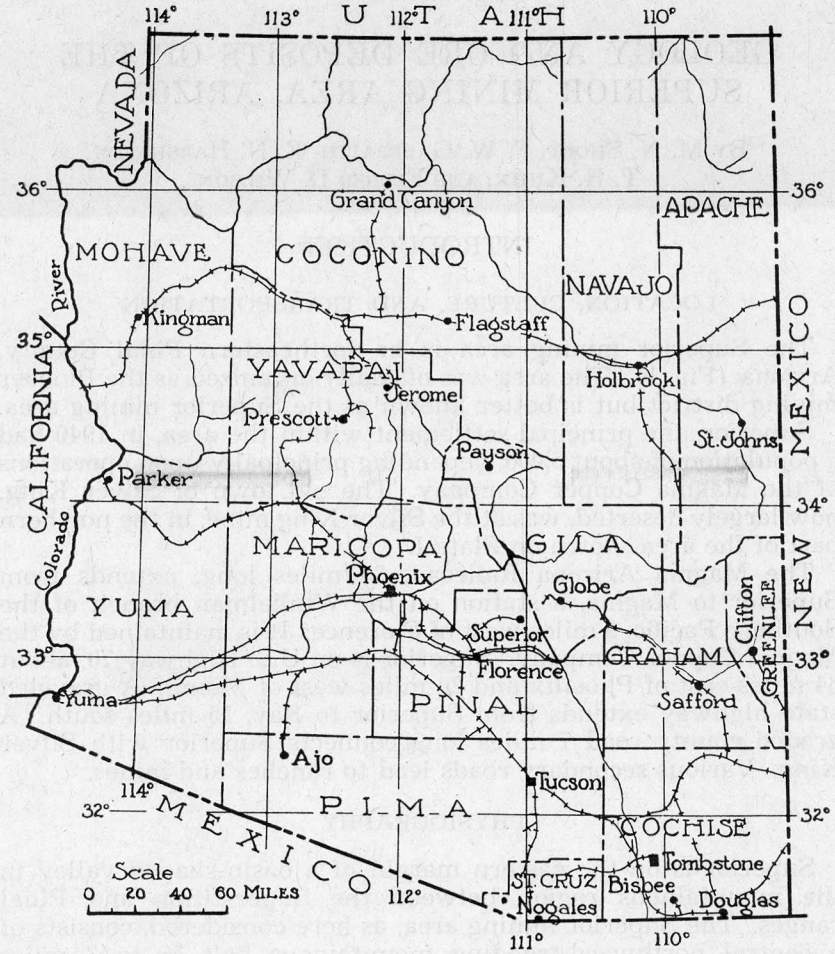

Figure 1.—Index map of Arizona.

east by the Concentrator fault and appears to be of tectonic origin. Its margins are floored by a pediment of dacite conglomerate and older rocks, and its inner area is covered by gravel and silt suggestive of fluviatile and lacustrine deposition. Recent erosion has dissected its surface to a moderate extent.

The mesa extends east from Apache Leap to the Pinal Mountains, beyond the margin of Plate I, and ranges in altitude from approximately 4,500 feet on the southwest to 5,530 feet at King's Crown, on the northwest. This mesa is floored by a thick series of volcanic flows and tuffs overlapping a deeply eroded, beveled surface of the rocks of the Central Belt. In general conformity with its surface structure, the mesa slopes gently eastward for

about a mile from Apache Leap and flattens along the eastern margin of Plate I. In places the rock exfoliates into rounded forms, but more commonly it erodes along vertical joints into pinnacles and cliffs.

The east-west earlier faults and mineralized veins as a rule have little or no topographic expression. Later faults have guided erosion but left few prominent scarps.

Drainage of the Valley, Central Belt, and part of the mesa is by ephemeral streams tributary to Queen Creek, which carries sufficient water during a few months of the year to provide an auxiliary supply for Superior. The drainage pattern on the mesa is determined partly by dip and partly by joints and fissures in the lava. On the Central Belt the drainage is parallel with, or at right angles to, the strike of bedding except where guided by faults. As shown by Plate I, the streams enter the Valley at right angles to the Concentrator fault.

CLIMATE

The climate of Superior is semiarid. The following data are from records kept by the Magma Copper Company:

Total Inches Rainfall

1921	15.60	1932	21.51
1922	18.64	1933	19.14
1923	19.15	1934	10.56
1924	12.59	1935	21.64
1925	17.10	1936	23.30
1926	20.79	1937	16.82
1927	19.49	1938	14.36
1928	15.46	1939	12.45
1929	11.81	1940	18.62
1930	24.00	1941	31.75
1931	28.65		
		Average	18.74

The monthly average rainfall during 1921-41 was as follows:

January	1.70	August	2.56
February	2.30	September	1.45
March	1.97	October	0.96
April	0.94	November	1.56
May	0.36	December	2.43
June	0.32		
July	2.21	Total	18.76

As seen from these data, most of the rains occur in two periods, July to August and December to February. About one half of the rain falls in summer when cloudbursts, accompanied by heavy runoff, are the rule.

Temperatures have been as follows:

Month	Jan.	Feb.	Mar.	Apr.	May	June
Av. max. degrees F.	64	65	72	75	89	97
Av. min. degrees F.	45	46	51	55	56	73
	July	Aug.	Sept.	Oct.	Nov.	Dec.
Av. max. degrees F.	102	100	93	83	73	67
Av. min. degrees F.	76	77	72	61	54	48

VEGETATION AND ANIMALS

The lack of soil and the dry periods separating heavy rains allow only drought-resisting desert type of flora to exist in that portion of the area lying west of Apache Leap. Here are found mesquite, cat claw, desert broom, creosote bush, palo verde, and hackberry bush, as well as many varieties of cacti, such as cholla, prickly pear, hedgehog, and sahuaro.

In the area east of Apache Leap the soil is sufficiently thick and moist to support a moderate growth of scrub oak, manzanita, mescal, and occasional piñon trees.

Wild life is sparingly present. Cottontails and jack rabbits are frequently seen, as are squirrels, chipmunks, pack rats, and mice. Wild pigs, wild cats, coyotes, and deer are rare. Bats frequent many of the abandoned mine workings. During summer sidewinders, centipedes, scorpions, and vinegarroons are common, especially in old prospect holes.

PREVIOUS WORK

The first geologic map of the Magma mine area, covering approximately 1 square mile on a scale of 100 feet per inch, was made by I. A. Ettlinger in 1912. Part of his map was included by Ransome[1] in the first published description of the Magma mine. At the time of Ransome's visit, mining had reached a depth of only 800 feet.

In 1921 Ettlinger extended the map area to the vicinity of the Magma Chief tunnel on the north and the Magma Apex shaft on the west. His map was included in the next published report[2] on the geology of the mine. At the time of that report, mining had reached a depth of 2,000 feet. In 1935, when the Magma mine was 3,200 feet deep, the further geologic developments were summa-

[1]Ransome, F. L., Copper deposits near Superior, Arizona: U.S. Geol. Survey Bull. 540, pp. 39-58, 1913.

[2]Short, M. N., and Ettlinger, I. A., Ore deposition and enrichment at the Magma mine, Superior, Arizona: Am. Inst. Min. Met. Eng. Trans., vol. 74, pp. 174-222, 1926.

rized.[3] In 1938 Short and Wilson published a brief report[4] on the geology of the Magma mine area.

The geology of the mine below the 2,000 level has been mapped by engineers of the Magma Copper Company under the direction of J. F. Flanagan, Chief Engineer.

FIELD WORK

For purposes of description the Superior area is divided into three subareas. The Belmont subarea includes all the area shown on Plate I south of Queen Creek. The Magma subarea includes that part from Queen Creek on the south to the Magma Chief tunnel on the north. The Silver King subarea includes that part north of the Magma Chief tunnel.

Galbraith[5] mapped the topography and geology of about 6 square miles in the Silver King subarea on a scale of 600 feet per inch.

Harshman[6] mapped the topography and geology of the Belmont subarea on a scale of 500 feet per inch.

During 1936-40 University of Arizona students mapped the topography of adjacent areas, mainly on the dacite mesa east of, and on the flat west of, Superior. Wardwell[7] made a topographic and geologic map on a scale of 600 feet per inch of about 4 square miles in the Potts Canyon area, which adjoins the Silver King subarea on the west.

Part of Wardwell's map and all the others mentioned have been incorporated into Plate I of this report. The part of Wardwell's map includes the area west of a line north from U.S. Geol. Survey B.M. 3,023.

M. N. Short has been gathering data regarding the area and mines since 1916-17, at which time he was an engineer for the Magma Copper Company; he has made exhaustive microscopic studies of the ores.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the co-operation of officials of the Magma Copper Company, especially A. J. McNab, Vice-President, the late William Koerner, former General Manager, and E. G. Dentzer, General Manager, during this investigation. The company rendered financial assistance to the extent of half the

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[3]Ettlinger, I. A., and Short, M. N., The Magma mine, Superior: 16 Int. Geol. Cong., Copper resources of the world, vol. 1, pp. 207-13, 1935.

[4]Short, M. N., and Wilson, Eldred D., Magma mine area, Superior, Arizona: Bur. Mines Bull. 145, pp. 90-8, 1938.

[5]Galbraith, F. W., Geology of the Silver King area: Univ. Ariz., Doctorate Thesis, 153 pp., maps, 1935.

[6]Harshman, E. N., Geology of the Belmont-Queen Creek area, Superior, Ariz.: Univ. Ariz., Doctorate Thesis, 168 pp., maps, 1939.

[7]Wardwell, H. R., Geology of the Potts Canyon mining area near Superior, Arizona: Univ. Ariz., Master's Thesis, 1940.

cost of printing the geologic map (Pl. I). The authors are appreciative of the active interest and co-operation of the engineering staff of the company, especially J. F. Flanagan, Chief Engineer, and B. Van Voorhis and Fred Crosby, engineers.

GENERAL GEOLOGY

SUMMARY

A generalized geologic columnar section of the Superior area is shown in Figure 2.

The oldest rock is Pinal schist, of early pre-Cambrian age. The schist is largely of sedimentary origin, but in places it contains greenstone derived from basic igneous rocks, probably lavas. In the Pinal and Mescal mountains, 30 to 50 miles southeast of Superior, the schist is invaded by extensive granitic intrusions of early pre-Cambrian age. They are not exposed in the Superior area.

Unconformably overlying the schist is the late pre-Cambrian Apache group, consisting, from base to top, of Scanlan conglomerate, Pioneer shale, Barnes conglomerate, Dripping Spring quartzite, and Mescal limestone. In places the Mescal is overlain by a basalt flow which is usually included in the Apache group.

Overlying the Apache group are the Cambrian Troy quartzite, Devonian Martin limestone, Mississippian Escabrosa limestone, and Pennsylvanian Naco limestone. The entire sedimentary series is conformable in dip and strike but is separated by at least four disconformities.

Intrusive into the Pinal schist, Apache group, and Troy quartzite are sills of diabase which in the Superior area total more than 3,000 feet in thickness. In places the diabase breaks across the intruded strata. Its age is considered to be post-Cambrian and pre-Devonian.

The Apache and Paleozoic rocks presumably remained horizontal until Laramide time (the interval including late Cretaceous and early Tertiary). No igneous intrusions other than of diabase took place during the Paleozoic era. There is little evidence for faulting during the late pre-Cambrian and Paleozoic eras. No Mesozoic rocks are found in the area; if any were formed, they were removed by erosion.

Presumably in the Laramide interval the region was subjected to compressional stresses which resulted in thrust faulting and possibly in folding and east-west faulting. This deformation was associated with invasion by stocks and dikes of granitic rocks, probably apophyses of the Central Arizona batholith. In the Silver King subarea a stock of quartz diorite intrudes the Paleozoic and earlier rocks. Associated with the undoubtedly satellitic to this stock are numerous dikes, as well as the Silver King quartz diorite porphyry stock which was the locus of the Silver