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Geology of Mohave County, Arizona

Earl Ross Householder

GEOLOGY OF MOHAVE COUNTY
ARIZONA

by

E.Ross Householder

A

T H E S I S

submitted to the faculty of the

SCHOOL OF MINES AND METALLURGY OF THE UNIVERSITY OF MISSOURI

in partial fulfillment of the work required for the

D E G R E E O F

ENGINEER OF MINES

Rolla,Mo.

1930

Approved by C.V. Forbes

Professor of Mining

TERED PROFESSIONAL ENGINEER SURVEYS, REPORTS AND ASSAYS

E. ROSS HOUSHOLDER
MINING ENGINEER
KINGMAN, ARIZONA

April 28th, 1930.

Mr. Noel Hubbard,
Asst. Registrar,
Missouri School of Mines,
Rolla, Missouri.

Dear Mr. Hubbard:

I am making application for the professional degree of Engineer of Mines, and herewith submit my thesis entitled

GEOLOGY OF MOHAVE COUNTY, ARIZONA,

consisting of thirty-three (33) pages, including a Mohave County Road and Mine map; a small photostat of this map; a geological cross-section map along line "A - B"; a photostat of a geological map included in U. S. Bulletin No. 397; and a bibliography.

Respectfully submitted,

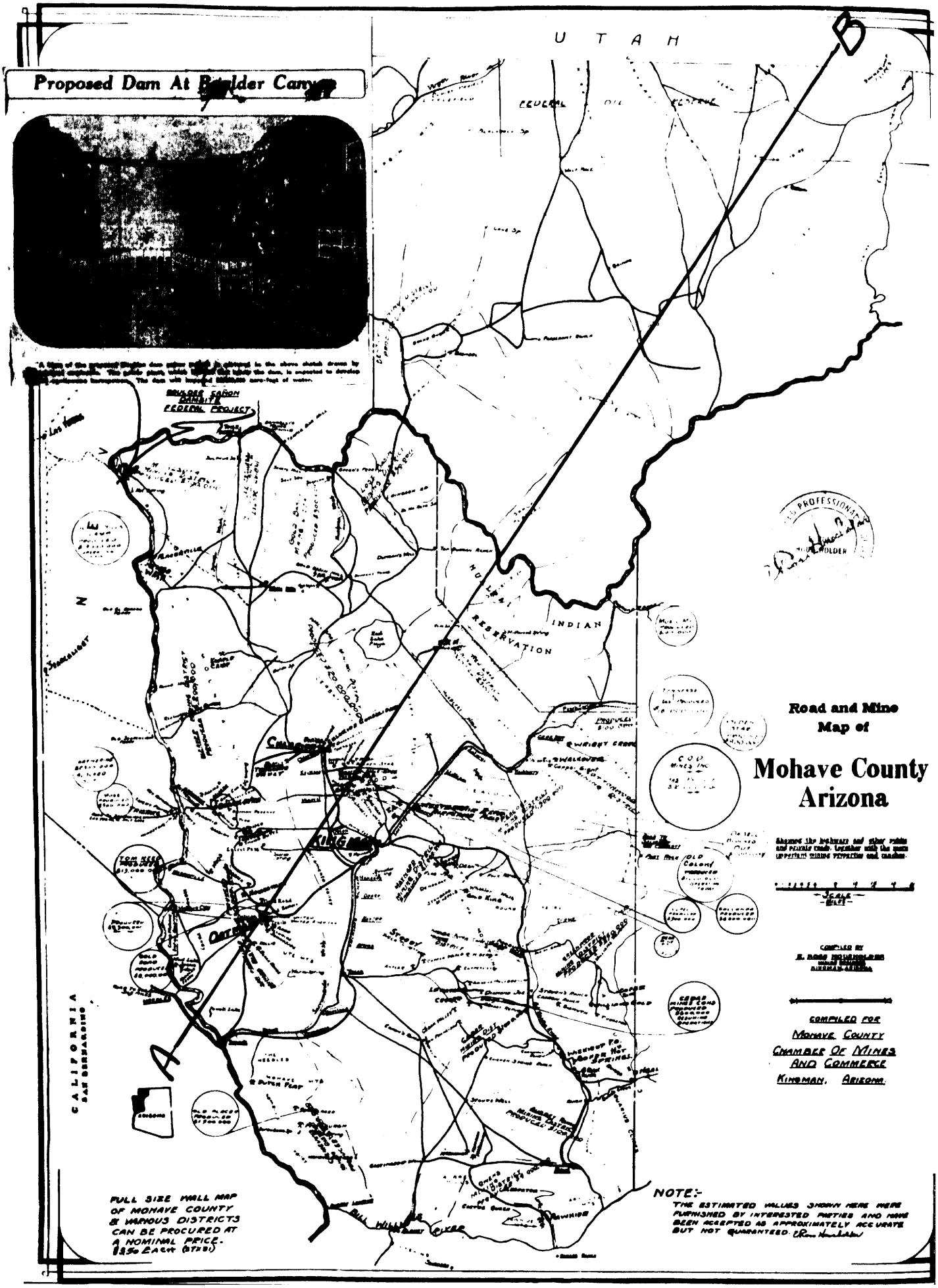
E. Ross Householder

GEOLOGY OF MOHAVE COUNTY, ARIZONA

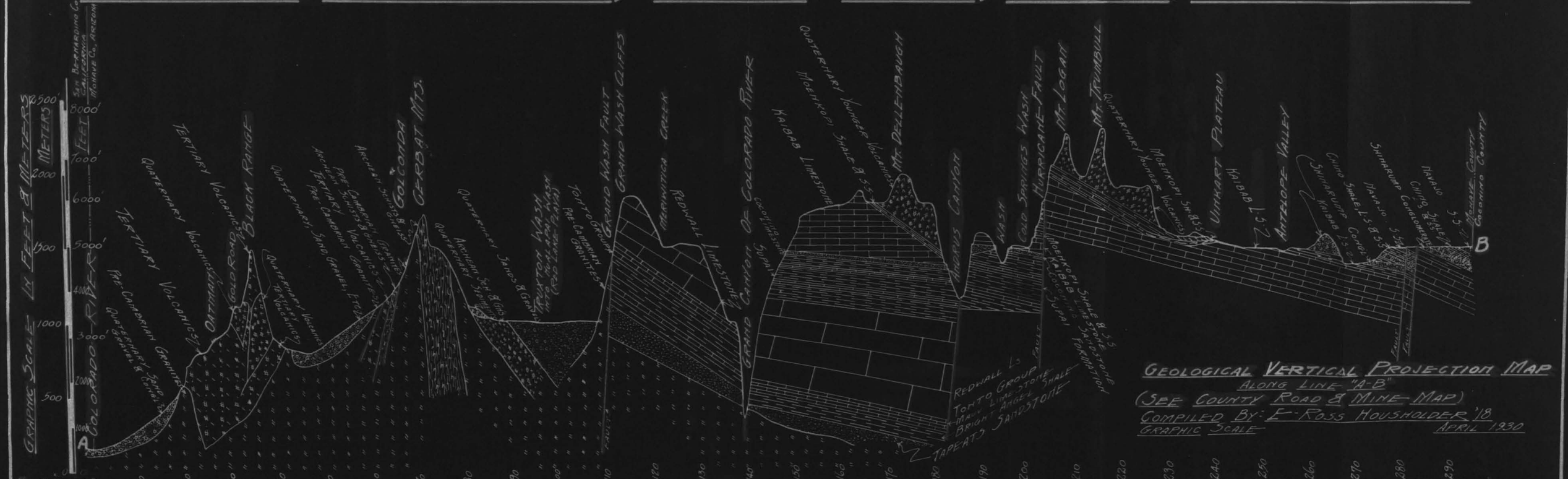
A Thesis By

E. Ross Housholder

This is a photostat copy of the Mohave County Road & Mine Map included in this thesis. This is included to give an idea of where the Vertical Geological Cross-section Map that follows on the next page was taken.



GEOLOGICAL CROSS-SECTION, MOHAVE COUNTY, ARIZONA, ALONG LINE "A-B".



GEOLOGICAL VERTICAL PROJECTION MAP
ALONG LINE "A-B"
(SEE COUNTY ROAD & MINE MAP)
COMPILED BY: E. ROSS HOUSHOLDER '18
GRAPHIC SCALE
APRIL 1930

Diamond Creek canyon is located in the eastern part of Mohave County and opens into the Colorado River. Limestones and sandstones of Carboniferous age are abundently exposed therein.

The upper member consists of the Permian fossiliferous, grey Kaibab limestones lying upon the buff colored Coconino sandstones and the Pennsylvanian brown and red Supai formation, the latter, locally, including the Hermit shales.

Southwest from the junction of Peach Springs wash and Diamond Creek canyon, where the upper member forms the surface of the higher mesas, we find Mississippian limestones designated as the Redwall, and underneath is exposed certain of the Tonto Group of the upper Cambrian labelled the Muav limestone and Bright Angel shale. At the mouth of Diamond Creek, the pre-Cambrian granitic complex is exposed.

Associated with the fossiliferous limestones are horizons of sandy layers and chert beds which are repositories for oxidized copper minerals. Azurite and malachite are the chief copper minerals found in the interstices between the sub-angular fragments of chert and partly as replacements in a fossil layer. Near Mohawk canyon, a specimen of fossil coral had been replaced by malachite.

The Hualapai Indian Reservation covers the northeastern portion of Mohave County. Here copper

deposits occur at three or more horizons in the limestone, which are between seven hundred and thirty five (735) and eight hundred and fifty (850) feet in thickness. As but little work has been done on these copper deposits, their economic importance must be determined by future exploration. Within areas of considerable erosion, the lower limestones contain bedded manganese ore worthy of further investigation. Oxidized copper minerals are found in the Supai sandstone, but these deposits are widely scattered.

East of Peach Springs, we find Mississipian limestones of economic importance in the manufacture of cement and quicklime. The southern branch of the Hurricane fault has caused considerable replacement along Peach Springs wash and the Colorado itself.

West of Peach Springs, and also north of Music Mountain on the Indian Reservation, are exposed areas of volcanic rocks belonging to the Quaternary period. Northwest of Music Mountain, the volcanic rocks are older, probably belonging to the Tertiary period. About twenty miles north from Crozier, sands, gravels, and conglomorates, belonging to the Quaternary and recent periods, are found. Within several areas, these sands and gravels are gold-bearing, particularly, in superimposed ancient stream beds. Prospecting for these placers is warranted, provided sufficient water for subsequent treatment is accessible. The Palaeozoic

sediments are abruptly terminated by the Grand wash fault, an enormous displacement, by which the rocks on the western side have been displaced from six to seven thousand feet. This fault may be traced from the Virgin river, near the Utah line, southward across the Colorado river, along Grapevine wash, past the Diamond Bar ranch, and beyond the Music Mountain mines toward Hackberry. Deposits in the pre-Cambrian granitic rocks west of the fault line in the Music Mountain District have yielded considerable gold and silver ores.

The greater part of Mohave County was covered by the Palaeozic sediments. Beds of altered shales are exposed along the road from Silver Creek to the Moss mine in the Oatman area, where the Tertiary volcanic rocks have been eroded, and are shown by a few outcrops of purplish, black, iron-stained metamorphosed shales which seem to rest upon the pre-Cambrian granite, and represent unremoved remnants of the basal portion of the Palaeozoic sediments of the Grand Canyon series; this was shown in the Tom Reed mine at Oatman, where, on the nine hundred foot level, was found a black, rather soft, fine-grained, shaley rock free of the usual characteristic phenocrysts of feldspar, common on the Tertiary flows of the section. This rock is sedimentary and is intruded by normal andesite dykes.

West of the Grand wash fault, the rocks are designated as the pre-Cambrian granitic complex, Tertiary

volcanics, and large scattered areas of Quaternary sands, gravels, and conglomorates.

An unbroken mountain range, beginning north of Franconia and Haviland on the main line of the A. T. & S. F. Railroad, continues northward one hundred miles to the Boulder Canyon in the Colorado River. These mountains are designated as the River Range, but that portion south of the Pilgrim mine is commonly known as the Black Mountains. The Black Mountains section of the River Range includes the San Francisco Mining District, the largest mining district in Mohave County. Within this district we find Oatman, Warm Springs, Goldroads, Silver Creek, Union Pass, Secret Pass, Burns Springs, Katherine, and other well-known mining localities.

Pre-Cambrian granitic rocks at the base, intersected and covered by a series of Tertiary volcanic rocks of many types, and Quaternary gravels and conglomorates, form the southern half of this range. Large areas of granite gneiss and schists of Archaean age, together with Tertiary volcanics, compose the northern half of the River Range. The northern half of the range includes the Weaver, Minnesota, Jumbo Wash, and Boulder Canyon Mining Districts.

Quaternary volcanic rocks, mostly basalt lava flows, form the rolling area on top of Fortfication Hill, a prominent mountain located at the Bend of the

Colorado River. Sands, Gravels, and limestones, containing thin lava flows and beds of tuff, are found here.

Nearly surrounding Fortfication Hill, but especially in a southwesterly direction from the mountain, and northeast of the federal government's Boulder Canyon dam site, there is a beautiful desert region consisting of exposed strata of various colored formations including clays, gypsum, and manganese minerals. Within this district there is an area of pre-Cambrian granites and reddish crystalline rocks just south of the Boulder Canyon, surrounded by older volcanic rocks of the Tertiary period.

High-grade gold and silver ores have been found in the northerly portion of the range. Most of the veins contain copper minerals in small quantities. At the Cohenour mine, located in Hieroglyphic Canyon, the copper content of the ores promises to become economically important. Turquoise has been mined on the northerly slope of Mount Wilson, a few miles south of Fortfication Hill. This area should attract the conscientious prospector. Between Fortification Hill and Mount Wilson, may be found iron-stained knobs with traces of copper, carrying low values in gold.

Water is scarce; the area is arid, steep, and rough, hence, devoid of vegetation. Non-metallics,

such as high-grade gypsum and natural cement rocks, exist in commercial quantities, but present transportation forbids immediate utilization. South from Mount Wilson to the head of Jumbo wash, few prospects have been uncovered, due largely to the rough and arid nature of the country.

Jumbo wash empties into the Colorado river nine miles westward from Surveyor's Pass. Here we find numerous prospects for gold, silver, lead, and copper. Intermittant shipments of these ores have been made during the last decade.

Coming southward from Jumbo wash, we cross the Gold Bug, Weaver, and Kemple Camp Districts where gold values predominate.

The vein system runs parallel with the range, but further toward the east. Copper values are also found. At the Monster and Leopold claims of the Boulder Mines, at Kemple camp, three per cent copper content with gold and silver values in not uncommon.

West of Kemple camp toward the Colorado, we find that the veins in the River Range carry values in gold and silver only, and are similar in character to the veins of the southern districts, the Dixie Queen, Katherine, Pilgrim, Arabian, Union Pass, Secret Pass, Goldroads, Silver Creek, Oatman, and Goldburg. Gold and silver ores of exceedingly high commercial values have been found within this area from the

surface to the twelve hundred foot levels. The general strike is northwest-southeast, with the usual northeast dip.

In the southern portion of the range, particularly south of Secret Pass, including Oatman and adjacent areas, the granitic rocks are deeply buried by the volcanic series, having a thickness near Goldroads of three thousand feet. Gold predominates with silver alloyed at the ratio of three to one by weight.

The fissure veins are distributed over a wide geographic range and through many types of enclosing rocks, as the zone of oxidation extends to great depths. The gold is free, with no base sulphides to complicate the problem of treatment by the cynanide process.

The free-milling gold ores of the entire range south of Jumbo wash are remarkably similar in appearance and minerological composition, indicating that deposition took place at the same time and from similar magma and that the accident of wall-rock has less bearing upon the size and extent of ore deposits than the characteristics of the fissures. The physical condition of the veins, that is to say, whether they are tight or open, is of more importance than the chemical composition of the wall-rock, which

generally, does not vary in essential elements.

The Tertiary lavas, where best exposed, as in the Oatman section, occur as sheets and flows of dense, compact rock, alternating with more loosely cemented tuffs and breccias, occurring between flows of different character and represent a period of erosion between volcanic activity. Dykes of later periods, such as rhyolite and basalt, cut these beds, forming flows and capping over large areas.

The rocks may be designated as andesites, latites, trachites, and rhyolites, occurring both as sheets and dykes. Veins occur in all classes of rocks, consisting of quartz, calcite, and altered wall-rock. Quartz often replaces and retains the structure of calcite. The quartz, when unmixed with altered country rock, has a peculiar greenish and waxy lustre, characteristic of all ores found in the River Range district south of Jumbo wash. Hematite and adularia indicate a gold content.

The veins occupy fault fissures in the volcanic series as well as in the granites and massive rhyolites, but more rarely between beds of rhyolite where the values favor the more porous beds. The veins in the lavas and granites are extensive, often maintaining a width of twenty to sixty feet over a considerable length.

The Pilgrim mine is located in the eastern foot-hills of the River Range, in the Weaver Mining District. We find here gold and silver ores of high commercial values on the surface, the two hundred ten foot level, and the three hundred sixty foot level. There are two general vein zones, the west, and upper vein, is on the contact of the andesite and rhyolite to the foot-wall, and altered breccia to the hanging-wall. The veins are composed of silicified rock and quartz, some of which is pseudomorphic after calcite: pyrite is sparse; limonite blebs are frequently found in the high-grade ores showing free gold.

The general type of the deposit is similar to that of the Oatman section and other River Range districts. The vein is more than twenty feet thick, and outcrops for more than half a mile, dipping thirty degrees west.

The Cerbat mountains lie east and parallel to the River Range. Together with their southern extension, the Hualapai mountains, their combined length is approximately sixty-six miles and from three to eight miles in width. The area extending from Kingman to a few miles north of Chloride, a distance of twenty five miles, is known as the Wallapai mining district and includes some of the oldest mining camps in Arizona. Within this district we find the

famous gold-silver camps of Mineral Park, Cerbat, Stockton Hill, Todd Basin, Lane Springs, and others of equal importance. The mineral production is gold, silver, lead, zinc, and copper, in the order named. The crest of the range has an average elevation of six thousand feet, and consists primarily of a variety of granitic rocks of pre-Cambrian age, with gneissoid-granites and granite-schists predominating. Associated with the latter are intrusions of granite-porphyry and basic dykes of diabase and vogesite, and to some extent by Tertiary rhyolites. The veins are filled fissures, pitching steeply to the north-east. The strike is generally northwest-southeast. The water-level is ordinarily reached at one hundred feet. The veins have usually undergone strike faulting, and as a rule, have not been disturbed by lateral faulting.

The mines of the Cerbat range have been producers since the early sixties. During early operations, rich, easily extracted surface ores were mined within the oxidized enriched zone. This was followed by a period of experimentation with different kinds of concentrating methods and with various degrees of success. The progress made by the metal-urgists in selective and differential flotation within

the past few years has been remarkable. Present successful treatment of the complex ores of this district is made possible by a flow sheet using fine grinding, classification, and a sub-areated type of flotation machine.

The most important rock, relative to its extent and bearing upon the mineralization of the veins, is an enormous intrusion of granite-porphyry which begins at Stockton Hill and extends across the range to Chloride, containing, west of Mineral Park, disseminated chalcocite, a copper mineral.

The veins are of great depth, and their principal minerals, below the water level, are of primary origin.

Translated into practicable terms, the prospector and operator has reasonable assurance that the commercial ore chutes are deep-seated; for example, the Tennessee and Golconda mines.

The Cerbat range contains non-metallics having commercial values; such as silica, found at the White Elephant mine and near the "63" mine on the eastern slope of the mountains; the Taylor feldspar pits produce an exceptionally high-grade product; mica, barite, lead vanadate, and onyx are a few of the other minerals found in commercial quanity and quality in the Cerbat range.

Productive veins in the different mining districts of Mohave County are persistent in outcrop, varying in width up to ten or twelve feet; a few veins have even a greater width. Surface outcrops can usually be definitely traced from one to three miles. In the Cerbat and the Hualapai mountains, the surface ores are often oxidized. The oxides and carbonates originated from primary sulphide ores which, below the water level, are undisturbed. Gold and silver are found in all the sulphide ores. Silver favors the galena, and in the Hualapais, also the sphalerite. Gold is also contained in the lead and silver minerals, but usually favors those combinations containing copper minerals.

The Hualapai Mountains extend south from Kingman for an approximate distance of forty miles; geologically, they are similar to the northerly extension, the Cerbat range, with this exception--the older volcanics and Tertiary volcanics are not as much in evidence, being entirely lacking on the eastern slopes. Their rugged topography is due to erosion upon a fault block pitching east. Silver, gold, lead, zinc, copper, tungsten, molybdenum, and vanadium are found in the commercial ores, especially in those series of pre-Cambrian age. The veins have the same general strike, dip, and geological characteristics

as those found in the Cerbats.

The prevailing rock near Hualapai Peak (Elevation 8308') is a coarsely crystalline granite consisting of glassy quartz, pink feldspar, and biotite mica, intruded by a variety of granitic and more basic, dark colored intrusives. This area embraces the Maynard, Yaba Yuma, Foothills, McConnico, and Cedar Mining Districts.

The Peacock Mountains, so-called by reason of the varied colored ores found in or near their surface, are located in a southwesterly direction from Hackberry, and extend in a north-south direction for a distance of twenty miles in length, and from two to nine miles in width.

Pre-Cambrian granitic complex, consisting of granites, granitic gneiss and schist, all of which have undergone considerable alteration, compose the greater portion of the range. Tertiary volcanics are in evidence. Ores thus far produced in this district contain silver, gold, copper, and lead.

Kingman, the county seat of Mohave County, is located in the pass between the Cerbat and Hualapai Mountains; within this area, we find a series of volcanic flows, principally rhyolitic, disposed in beds intercolated with water-deposited beds of sandy tuffs and clayey deposits, and in some instances,

capped by basaltic flows.

No commercial ores have been found within the immediate vicinity of Kingman, except chalcedony quartz, used in the manufacture of polished ornaments. Building stone, found two miles west of the town, has been utilized in the construction of the Court House, Elks Hall, and other public and private buildings. This stone is quite soft and easily formed when quarried, but hardens upon weathering, and it is used by the A. T. & S. F. Railroad for track protection. A number of promising feldspar deposits are to be found near Coyote Pass, along the contact of the Tertiary volcanics. North of McConnico and also in the vicinity of Boulder Springs, a number of gold bearing veins have been uncovered to shallow depths, and they are similar to the veins in the Cerbat Mountains. Of the volcanic series, the lower members are water-bearing--hence, are of economic importance to Kingman.

The southern extension of the Grand wash cliffs is the Cottonwood and Aquarius Cliffs. Although the Grand Canyon sediments are not in evidence, the escarpments are primarily due to the continuation of the fault action, known as the Grand wash fault. South of Peach Springs and southeast of Cherokee,

the Tonto group and related rocks of limestones, sandstones, and shales, are found overlain by the Redwall series. Westward to Crozier, the Quaternary volcanic sands, gravels, clays and conglomorates, are exposed, with isolated bulbs of younger Quaternary volcanic rocks, exposed west and north of Cherokee. To the north, there is a contact of Tertiary volcanics with the Quaternary sediments; while to the south, east of Truxton, are found pre-Cambrian granites. There are granite intrusions of a later period which have locally caused regional metamorphism. Next to the granite contact are gold-bearing schists. Along the contact, near the head of Wright Creek, the quartz veins carry gold with varying percentages of copper.

Copper and gold ores, associated with an arsenic pyrite, are produced from veins within the granitic complex near the contact of the Tertiary volcanics southeast of Valentine. Due to heavy overburden, the area between Wright Creek and Trout Creek has not been prospected as the geological conditions warrant. Pre-Cambrian and Tertiary lavas form the rock structure of the mountains north of Trout Creek, as well as the Aquarius mountains to the south. The rock structure on the western slope and foothills of the Aquarius mountains is similar

to that of the Peacock and Hualapai mountains. Along the crest, and over to the eastern boundry of the county, the Tertiary volcanics predominate. A number of gold veins, carrying some silver, have been opened on the west side of the mountains, and are confined largely to areas of pre-Cambrian granites. The gold ore is free-milling. Several tungsten deposits have been found in the fissure veins, along the crest, at the granite and lava contact.

Bismuth, copper, tungsten, gold, silver, vanadium, and molybdenum are found within a radius of ten miles of the Robinson ranch on the Sandy River.

End-lining the Bismuth mine is the Hatch Radio-active mine, which produces heavy ores resembling obsidians; they are polycrase minerals containing titanium, tantalum, yttrium, cerium, and mobium; the ore with the shiniest lustre is samarskite, and the heavy, more crystalline ore, is euxenite, both being radio-active and containing rare earths. This area warrants more prospecting. Along the easterly crests are lavas and basaltic flows.

The Aquarius mountains are located in the southeastern portion of the county and connect with the Artillery and Rawhide mountains; they include the Greenwood, Aubrey, and Cottonwood Mining Districts.

There is an interesting gold bearing district from Burro Creek southwest to Artillery Peak. The Greenwood camp, a few miles north of Signal, produced considerable gold.

Coarse grained rocks of probable pre-Cambrian age extend from the Hualapai and Aquarius ranges into the Artillery mountains. A thick series of Tertiary sandstones, limestones, conglomorates, and shales, all of which are more or less lenticular, follows the pre-Cambrian, and lying in places along the tilted, beveled edges of these beds, and upon the irregularly eroded surface of the granite, are relatively small areas of lava flows of Tertiary age. Capping many of the mesas, are dark stained basalt flows, usually less than one hundred feet in thickness, of the Quaternary age. This series strikes northwest-southeast, and dips to the southwest. Near Alamo crossing, on the Bill Williams river, there is considerable faulting and close folding but elsewhere in the district, faulting is of minor magnitude.

Within the past several months, several hundred claims have been located for manganese-ores between Artillery Peak and the famous old silver-producer, the Rawhide mine on the West.

Most of the manganese within this area occurs in bedded deposits. The richest of these

deposits lie on the surface, or are concealed by angular debris; the lower deposits are those which have not been long exposed to weathering, or are overlain by other beds. The ore is hard, though granular. The most weathered masses of ore are botryoidal and crusted forms, composed of psilomelane, but at shallow depths, pyrolusite predominates.

The manganese in the basal conglomorate consists of veinlets and stockworks of manganese oxide minerals, banded with quartz, calcite, and gypsum. The limestone capping these beds is mineralized, and it is from the limestone deposits that all of the commercial ore shipped to date has been obtained. The whole series of shales capping the limestones is manganiferous, finegrained, compact, and black, resembling cannel coal.

Deposits of manganese oxides in veins and brecciated zones in the basalt and red sandstones are interesting in that they show the manganese veins cutting Quaternary basalt flows.

There are also a great number of strong, parallel, copper stained, silicified fissure veins carrying gold, having a general northwest-southeast strike, and practically a vertical dip, cutting

through sediments and lava flows, indicating a younger age, and found from the Rawhide mountains westward. In addition to the formation found in Artillery Peak, we find Carboniferous limestones, sandstones, and shales, which, in places, have been highly metamorphosed. Azurite and malachite, the oxidized minerals of copper, are found in many of the surface veins.

There are also silicified copper minerals in the gold bearing veins; many of which contain highgrade ores. This area is known as the Owens Mining District.

West of Signal is an isolated range of mountains about ten miles in length and three in width; they are known as the McCracken mountains, and consist of a detached segment of pre-Cambrian granitics related to the Hualapai mountains to the northeast. This area is known as the McCracken mining district.

The formation of the great mineralized zone bisecting the McCracken Mountain from north to south is pre-Cambrian granite; the wavy structure of gneissoid granite is discernible throughout: it's red color is from the preponderance of feldspar having a schistose structure, and resembling Pima schist.

Intrusive diorite is found on the footwall. The ledges, or dykes, of silicious rocks resist weathering. Where black manganese coatings on the rocks occur, the silver values are usually highest. Lead, silver, and gold are found in the upper workings; copper minerals have been found from the four hundred to the six hundred foot levels. Barite is also an important mineral of the vein filling.

Southeast of the McCracken is an area of Quaternary and Tertiary volcanic rocks, including rhyolite, andesite, tuff, basalt, agglomorate, and some associated intrusive and sedimentary material.

Pott's Mountain is the highest peak in this section, where parallel veins, similar to those of the McCracken, are found. The values are largely in lead and silver, with some gold. Manganese is present in all of the veins, and in places, barite and fluorspar.

West and southwest of Pott's Mountain, there are, in addition to the rock formation already described in and about the Rawhide mountains, Tertiary sand, gravel, and limestone, locally containing thin lava flows and beds of tuff.

Further west, we enter the southern end of the Chemehuevis mountains, where the Archaen schists, granites, and granite gneiss outcrop, to-

gether with lavas of Quaternary and Tertiary age. Dry placer gold deposits have been extensively worked. In the Central part, at Crossman Peak, we find granite and porphyry intrusives of importance. Silicious veins, carrying manganese-stained white quartz, contain promising gold ores, particularly in the Mohawk, Gold Wing, and Dutch Flats sections; while southeast of Dutch Flats we find lead minerals. The gold is found in the quartz crystals as well as in the cleavages. Usually the gold ores are free-milling.

The northern portion of this range is generally known as the Mohave Mountains. The rocks of the small hills consist of an older series of gneiss, diorite, and granitic rocks of pre-Cambrian age, and younger basalt and sandstone of the Quaternary and Tertiary ages. Near the Chemehuevis valley manganese deposit, decomposed basalt intrudes the sandstone, and the abundent amygdules are filled with black manganiferous calcite. The deposits consist of veins and brecciated zones which cut the basalt, or lie on the contact of basalt and sandstone. The veins and brecciated zones range in width from a few inches to five feet. In places, the ore and associated minerals are wholly fissure fillings, but breccias predominate. The manganese minerals are

Nevada and Utah. Here are found indications of oil formations. Across the Utah line, producing oil wells have been drilled in formations closely related to the Kaibab limestones and sandstones of Permian age. The Kaibab formations occur from Mt. Bangs north to the Utah line and cover at least one-half the area in this county above the Colorado river. Nearly all the formations found throughout the county are exposed within this so-called "Northern Strip", embracing the basal granites of the pre-Cambrian up through the Quaternary sediments and lavas. The Quaternary younger granitic rocks, including considerable basaltic flows, come next in importance in area: then the Supai formations overlying the Hermit shales in the Grand Canyon region, which are of Permian and Pennsylvanian ages, with Redwall and related limestones of the Mississippian and Devonian ages. Moenkopi, a red, chocolate-colored shale and sandstone formations of the lower Triassic, covers large areas, especially along the Vermillion Cliffs between Cane Beds and Pipe Springs; about Mt. Trumbull; in the Virgin Mountains; south of Littlefield; surrounding and north of Wolf Hole; west of the Hurricane Fault, and south, along the Cold Spring wash.

The Kaibab Indian Reservation lies in the northeastern corner of Mohave County. North and west

of Moccasin, in this district, there is exposed a vast area of Navajo sandstones of Jurassic age; the same formation is found on the southeastern side of the Virgin mountains. Sand, gravel, and conglomorates of Quaternary and Tertiary ages, and volcanic and basalt flows, constitute the remainder of exposed rocks in the Northern Strip.

Northeast of Mt. Trumbull, near Kaibab Creek, there are contacts of sandstones and limestones with igneous flows and intrusions where iron ore deposits have been uncovered. These ores are, for the most part, oxidized and may become economically important in the treatment of the copper ores found in the Kaibab sandstones lying upon the limestones in this area; similar to the copper deposits between Jacobs Lake and Ryan in the Kaibab forest.

The Grand Gulch and Bronzel mines, located in the vicinity of Grand Wash, twelve to fifteen miles north of the Colorado river, have produced considerable high-grade copper; the ores were largely oxidized, although silicious ores were encountered. Charcoals were used in the smelting. When these mines were producing, a large part of the copper was fabricated into utensils. Southeast of Littlefield, in the vicinity of Mt. Bangs, prospectors have

uncovered quartz veins in the igneous rocks containing gold, silver, lead, and some copper.

This Northern Strip, which includes over one-third of the area of Mohave County, reputed to be the sixth largest county in the United States, warrants further investigation. Due to the lack of road communication, it remains an isolated mining area, although assay results indicate commercial values over the entire section.

Enormous deposits of exceptionally high-grade, iron-free gypsum are found near the mouth of Squaw wash, south of Stone Ferry. These deposits are more than fifty feet in thickness. Undoubtedly, deposition took place during the Tertiary or Quaternary periods in an inland saline sea, caused by the natural damming of the Lower Grand Canyon--evidently at Boulder Canyon.

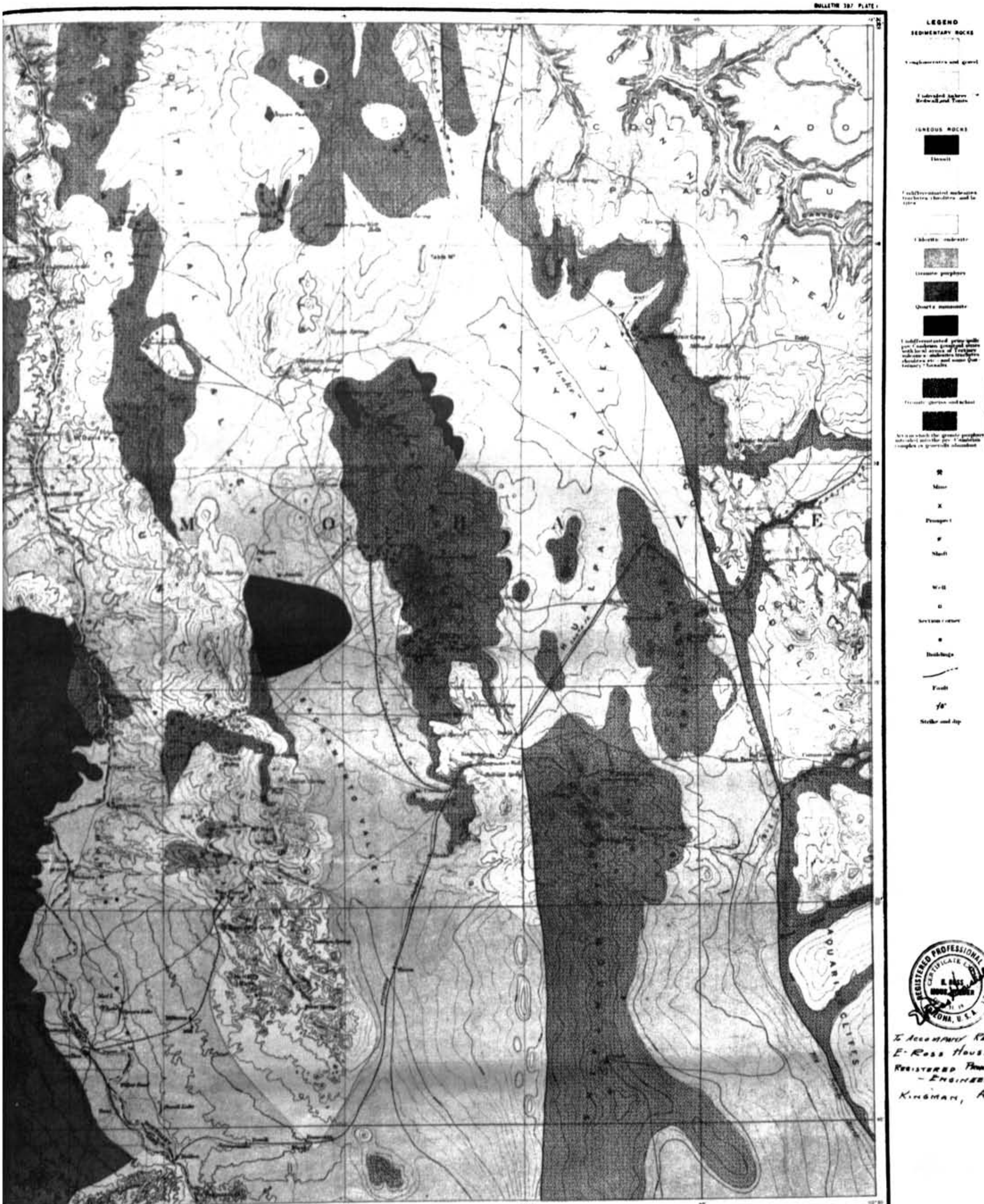
Various types and grades of large clay deposits are also found within this area.

Gypsum, clays, feldspar, silica, and other non-metallics, are known to exist in commercial quantities and quality throughout the entire county, particularly in Squaw wash, north of Jumbo wash, valley of the Sandy River, south of Powell and Franconia, and within the area north of the Bill Williams river. Alunite, a hydrous-potassium-sulphate, used for

fertilizer and refractories, is found along the Sandy river. Most of the commercial deposits of the non-metallics, so far developed within the county, are related to formations originating during the Tertiary or Quaternary periods.

Valuable deposits of ores, non-metallics and gem-stones are found in various formations; in the pre-Cambrian igneous rocks; the lavas; and the sediments of Quaternary age. We find placer gold in the Quaternary gravels, and gravels of the later ages, not only along the Colorado river, but in the interior.

Mohave County is outstanding in the variety of minerals found within its borders; every mountain range includes its mineralization, gold, silver, the baser metals, it's gems; known to the Aztecs and little known to the prospector of today; a wonderful field for the petrographer, the mineralogist, the geologist, and the operator.



GEOLOGIC RECONNAISSANCE MAP OF A PART OF WESTERN ARIZONA

Contour interval 250 feet

To Accompany Report By
E. Ross Householder
Registered Professional
- Engineer -
Kingman, Arizona

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Road and Mine Map of
Mohave County Arizona
Showing the highways and other public and private roads, together with the more important mining properties and ranches.
SCALE
COMPILED BY
E. ROSS HOUSHOLDER
MINING ENGINEER
KINGMAN, ARIZONA
COMPILED FOR
MOHAVE COUNTY CHAMBER OF MINES AND COMMERCE
KINGMAN, ARIZONA.
REGISTERED PROFESSIONAL ENGINEER
ARIZONA, U.S.A.
UTAH
NEVADA
CALIFORNIA
SAN BERNARDINO
ARIZONA
"A"
"B"
GEOLOGICAL SECTION TAKEN ALONG THIS LINE "A-B"
FEDERAL OIL RESERVE
BOULDER CAÑON DAMSITE FEDERAL PROJECT
HUALPAI INDIAN RESERVATION
JUMBO WASH
KINGMAN
BILL WILLIAMS RIVER
TENNESSE HAS PRODUCED $18,000,000
GOLDEN STAR PRODUCED $800,000
C.O.D. MINES INC. HAS PRODUCED $2,000,000
MUSIC MT. PRODUCED $100,000
TOM REED PRODUCED $13,000,000
GOLD ROAD PRODUCED $8,000,000
OLD PLACER PRODUCED $1,500,000
GOLCONDA PRODUCED $4,000,000
NOTE:- THE ESTIMATED VALUES SHOWN HERE WERE FURNISHED BY INTERESTED PARTIES AND HAVE BEEN ACCEPTED AS APPROXIMATELY ACCURATE BUT NOT GUARANTEED.
FULL SIZE WALL MAP OF MOHAVE COUNTY & VARIOUS DISTRICTS CAN BE PROCURED AT A NOMINAL PRICE.

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Eldred D. Wilson and G. M. Butler.

Personal examinations, reports, letters and communications.

E. Ross Householder