UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

TIN, COPPER, AND URANIUM AT MAJUBA HILL, NEVADA

by

R. H. Thurston
and
F. M. Chace

February 1950

Trace Elements Investigations Report 81-A

USGS - TEI Rept. 81-A
Consisting of ___ pages
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ABSTRACT

Uranium minerals occur with ores of copper, tin, and silver at Majuba Hill, Nevada. During World War I, the Majuba Hill mine produced about 4,000 tons of 12 percent copper ore, and during World War II about 23,000 tons of ore containing 2 to 4 percent copper and enough tin ore to furnish from 10 to 15 tons of metallic tin. No uranium has been produced.

The bedrock geology of Majuba Hill consists of a complex volcanic neck or plug composed of rhyolite porphyry, porphyritic rhyolite, quartz feldspar porphyry, breccia dikes, and irregular breccia masses. This plug intruded Triassic (?) sedimentary rocks, chiefly shale.

The principal loci of ore deposition were (1) parts of the breccia bodies, particularly where they were porous and where they were silicified and tourmalinized, and (2) a few small pre-mineral fractures adjacent to the breccia masses. Intense hydrothermal alteration resulted in the formation of sericite, quartz, and tourmaline in the wall rocks. This was accompanied or followed by deposition of arsenopyrite, pyrite, cassiterite, fluorite, and several primary sulfide minerals of copper.

All of the ore bodies exposed in the mine are highly oxidized, and a profusion of secondary minerals of copper and iron have been found. The only uranium minerals detected are the phosphates torbernite and matatorbernite and the arsenate zeunerite. These are widely disseminated throughout the mine in small amounts associated with the secondary minerals of copper and iron along minor fault surfaces, bedding planes in the shale, and in porous parts of the breccia. A primary uranium mineral has not been found.

The secondary uranium minerals appear to be most abundant where copper ore is highest grade. Although unoxidized uranium ore has not been found, it is inferred from this relation that the deposition of the original uranium minerals favored those areas where primary copper mineralization was most intense. There may have been an intimate association of uranium with silver in the ore, but this has not been established. The U_3O_8 content of samples of copper ore ranges from 0.002 to 0.30 percent.

Because the bottom of the oxidized ore has not been reached in mining or exploration, the downward extensions of the known ore bodies of secondary minerals would appear to be worthy of investigation to determine the grade and extent of the primary ore.

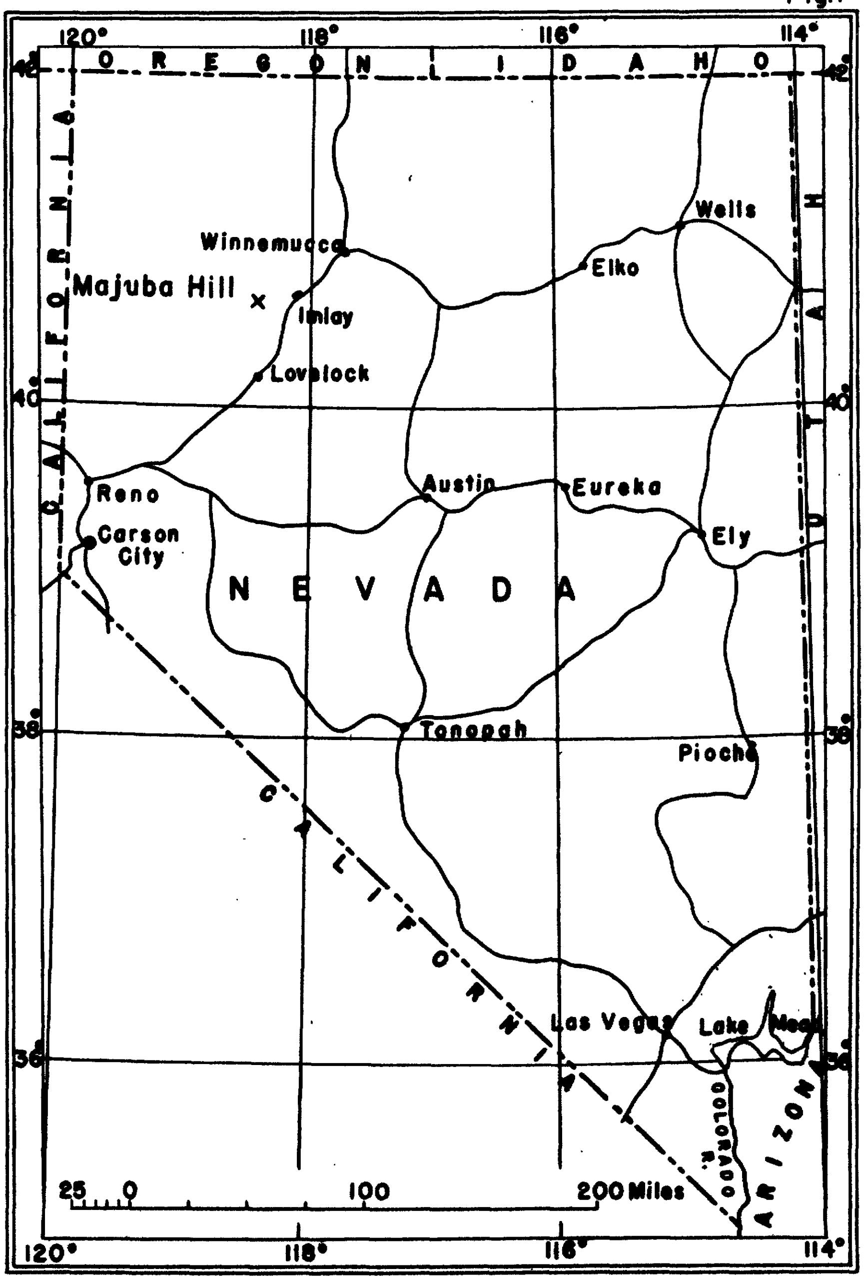
INTRODUCTION

This report is a summary of the results of a brief geological examination made by the Geological Survey of the small uranium deposit in the Majuba Hill mine, Pershing County, Nevada. In this mine the uranium minerals torbernite, metatorbernite, and zeunerite are associated with small irregular bodies of copper, tin, and silver ores which occur in a complex plug or volcanic neck of rhyolite porphyries and intrusive breccias. The association of uranium in small amounts with rhyolitic rocks appears to be fairly widespread in the western United States, but the association of uranium with copper and tin ores of the type present in this deposit may be unique.

The Majuba Hill mine is on the south slope of Majuba Hill in the Antelope Range, about 35 miles north of Lovelock and 20 miles west of Imlay, Nevada (see fig. 1). The mine workings consist of approximately 4000 feet of underground workings on three adit levels.

2a

Fig.1



Index map showing location of Majuba Hill, Nevada

Production of copper and tin from this mine has been small. Approximately 4000 tons of 12 percent copper ore were mined during World War I, and nearly 23,000 tons of 2 to 4 percent copper ore were mined during World War II. Cassiterite mined here during the recent war yielded 10 to 15 tons of metallic tin. No uranium has been produced, but the uranium-bearing minerals are abundant enough to justify an examination of the deposit.

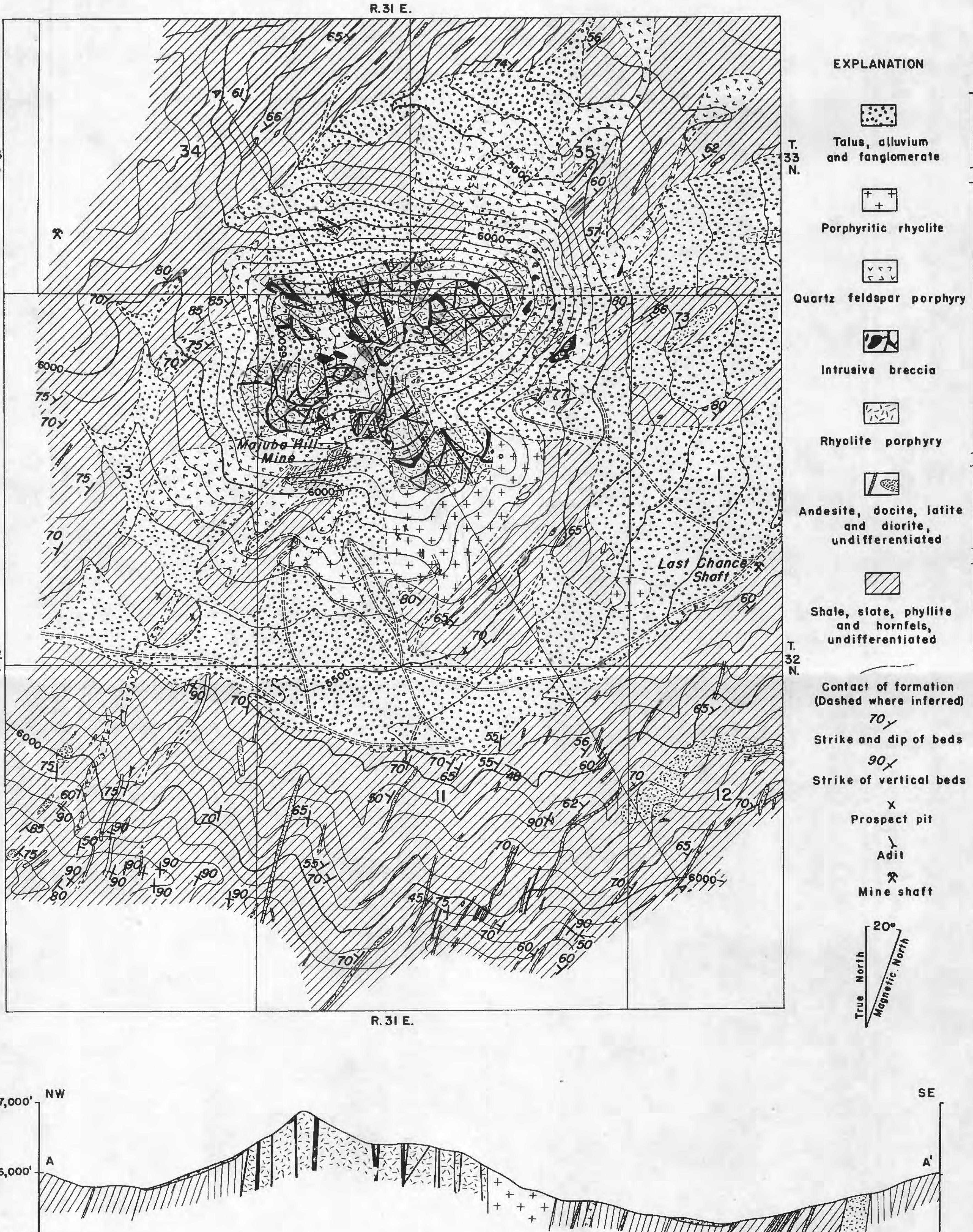
GENERAL GEOLOGY

Lithology

The rocks of the Majuba Hill area include, in order of age, (1) a thick sequence of Triassic (?) shale, (2) numerous dikes and sills of andesite, dacite, and latite, and (3) intrusive bodies of rhyolite porphyry and intrusive breccias which together make up a complex volcanic neck. Alluvium, fanglomerate, and talus, undifferentiated on the surface map, cover extensive areas on Majuba Hill and obscure rock contacts in many places (see fig. 2).

The sedimentary rocks are the oldest rocks in the region and occupy the greater part of the bedrock area. They consist predominantly of shale and subordinately of a few thin beds of quartzite and impure limestone in a rock series that is more than 10,000 feet thick. The beds strike uniformly northeast, and the dip ranges from vertical to about 60° northwest. The shale is altered locally to slate, phyllite, and hornfels where it is in contact with the intrusive rhyolite, and in places along the igneous contacts the shale is highly crumpled.

Fig. 2



GEOLOGIC MAP AND SECTION OF MAJUBA HILL, NEVADA

1000 0 4000 Feet

Contour Interval 100 ft.

Andesite, dacite, and latite dikes and sills, intrusive into the shale, are abundant south of Majuba Hill. These dikes do not crop out in the vicinity of the mine and do not appear to be related to the ore.

Majuba Hill itself is underlain by an irregularly shaped intrusive mass of rhyolite and breccia. The intrusive rocks form a complex plug or volcanic neck with an outcrop area of slightly more than one square mile. The composite intrusive mass is roughly 5,000 to 6,000 feet in diameter, but long apophyses and dikes extend for several thousand feet along the bedding of the sedimentary rocks, northeast and southwest from the main body (see fig. 2).

Three phases of intrusive rhyolite have been distinguished megascopically on the basis of the composition of phenocrysts and the texture of the groundmass. These were designated in the field, in decreasing order of age, as rhyolite porphyry, quartz-feldspar porphyry, and porphyritic rhyolite. The rhyolite porphyry is the oldest and most widespread of the intrusive rocks. It forms bold outcrops on the barren hillside and is exposed on all levels of the Majuba Hill mine. The quartz-feldspar porphyry intrudes the rhyolite porphyry in irregular masses and dikes and the surrounding shale in dikes and sills. It is distinguished from the rhyolite porphyry by a much larger percentage of both quartz and feldspar phenocrysts and a coarser grained matrix. The quartz-feldspar porphyry is less widespread than the rhyolite porphyry and occupies about 15 percent of the total volume of the exposed igneous rocks.

The porphyritic rhyolite intruded the rhyolite porphyry and shale on the southeast slope of Majuba Hill in an irregular plug-like mass, 300 feet to 1,500 feet wide and about 4,000 feet long. This rock body has not been found underground in the mine. The porphyritic rhyolite has smaller phenocrysts and a finer-textured groundmass than either the rhyolite porphyry or the quartz-feldspar porphyry.

Intrusive breccias of several different types and ages are abundant in the Majuba Hill area. They occur in a network of dikes with widely divergent strikes and dips and range from one foot to possibly 250 feet wide and average 10 to 20 feet wide. Irregular masses of breccia occur near the center of the volcanic neck and at the intersection of two or more dikes. The breccia dikes are post-rhyolite porphyry and pre-porphyritic rhyolite in age and are composed of angular to well-rounded rock fragments that differ considerably in composition from place to place. In general they include almost all of the rock types of the area—shale, phyllite, rhyolite porphyry, and quartz-feldspar porphyry—in varying quantities. The breccias also vary considerably in texture, amount of interstial filling, and hydrothermal alteration.

On the basis of composition and age five principal types of breccia have been recognized: (1) A shale breccia with a matrix of finely pulverized shale; (2) a shale breccia cemented by rhyolite porphyry; (3) a shale-rhyolite porphyry breccia with a matrix of finely crushed rocks; (4) a shale-rhyolite porphyry-quartz-feldspar porphyry breccia with a matrix of finely crushed rocks; (5) a shale-rhyolite porphyry-quartz feldspar porphyry breccia cemented by quartz-feldspar porphyry. Some

of the breccia dikes, particularly those composed of shale, rhyolite porphyry, and quartz-feldspar porphyry fragments with a porous matrix, played an important role in the localization of the primary ore bodies.

Majuba Hill must have been a center of intense volcanic activity judging from the abundance of rhyolites and breccias. Formation of breccia in the volcanic vent, probably by explosive forces, was followed by intrusion of rhyolite porphyry which in part cemented the shale breccia and in part formed intrusive masses. Renewed explosive activity with the formation of more breccia then took place; this was followed by intrusion of the quartz-feldspar porphyry. This sequence, explosive activity followed by igneous intrusion, was again repeated with the formation of more breccia and the porphyritic rhyolite body. A complex volcanic vent was thereby formed at Majuba Hill, and a near-surface environment for ore deposition was created.

Faults

The rocks of Majuba Hill are cut by numerous fractures and faults. All, or nearly all, are normal faults with small displacement. The largest and most important is the Majuba fault (fig. 3). This has been traced for several hundred feet through the mine; it strikes N. 50° W. and dips 45° - 60° S. W. Underground, the fault is marked by a zone of sheared rhyolite and gouge which in places is 15 feet thick.

The greater part of the fracturing and faulting probably took place subsequent to the formation of the primary tin and copper ore

bodies. The major amount, and possibly all, of the movement on the faults apparently was later than the emplacement of the ore. If this observation is correct, then the fractures and faults had no control over the localization of the primary ore minerals. Permeable channels in the breccia, rather than the Májuba fault and associated fractures, therefore, provided the conduits for the circulation of the solutions that deposited the primary ore minerals.

Because most of the faults have been observed only within the volcanic neck and many terminate in the rhyolite porphyry or along the intrusive breccia dikes--only a few of the larger extend out into the shale--and because the movement on all the faults observed was normal, it seems probable that most of the faulting was caused by minor block adjustments within the volcanic neck. The movement was probably caused by minor post-volcanic subsidence, and the effect of the faulting in general was to drop blocks of intrusive breccia down between parallel shear planes. The minor fault slips in the shale have not been mapped and probably would not alter this interpretation.

Hydrothermal alteration

Hydrothermal alteration of rhyolite and breccia was widespread within the area of volcanic rocks and resulted in the formation of sericite, secondary quartz, tourmaline, and small amounts of zoisite and pyrite. So intense was the alteration in most places in the mine that it is difficult to find fresh rock specimens. Sericite is the most abundant and widespread of the alteration products and, with

secondary quartz, makes up the groundmass of the porphyries. Tourmaline in prominent crystals and rosettes is widely, but very unequally, distributed in the intrusive breccia, quartz-feldspar porphyry, and in the rhyolite porphyry where it is adjacent to the tourmalinized breccia.

ORE DEPOSITS

The copper and tin deposits

The ore bodies of the Majuba Hill mine consist of irregular masses of ore that formed primarily by filling of interstial openings in porous breccia masses with only minor replacement of wall-rock fragments. The ore bodies are not sharply defined, and the extent of ore in most places is defined by assay limits. Deposition of ore minerals in minable or possibly minable quantities was largely restricted to the breccia bodies, particularly where they are silicified and tourmalinized, to a narrow band of rhyolitic rocks adjacent to mineralized breccia, and to a few small pre-mineral fractures adjacent to the breccia bodies. The ore bodies that have been worked in the mine are best exposed on and above the Middle Adit level and include those in the Copper stope, the Tin stope, the Myler and No. 153 stopes, and the No. 211 stope (fig. 3).

The primary ore and gangue minerals at Majuba Hill are cassiterite, arsenopyrite, pyrite, chalcopyrite, bornite, chalcocite (?), fluorite, and probably a primary uranium mineral as yet unidentified. Much of

the ore contains silver, but a primary silver-bearing mineral also has not been isolated, and it may be that the silver is contained in one of the other primary minerals. In places the products of wall-rock alteration sericite, quartz, and tourmaline also form gangue minerals in the ore bodies.

All the ore bodies exposed in the Majuba Hill mine were oxidized prior to opening of the present mine workings, and the bulk of the mineral species now exposed are secondary deposits. Supergene copper and iron, and to a much less extent silver, minerals occur in profusion; more than 26 oxide minerals of these metals have been identified. These include azurite, malachite, chrysocolla, chalcanthite, chalcophyllite, cuprite, horn silver, brochantite, and tenorite. The rare mineral spangolite has been found in exceedingly small amounts. The secondary minerals occur as efflorescent deposits, encrustations, mammillary growths, and as disseminated crystals coating rock surfaces, in vugs in rhyolite, along bedding planes in the shale, and along many small fractures and fault planes. Many appear to have been deposited from solutions that migrated along fractures and minor fault planes to positions now at a considerable distance from the point of original deposition of the primary minerals.

Cassiterite is widely scattered in small amounts in the mine but is abundant in only one or two shoots where it was deposited as vein fillings in porous breccia and as a replacement of altered rhyolite porphyry fragments in breccia at a late stage in the quartz-sericite-tourmaline mineralization. A shoot in the hanging wall of the Majuba

Hill fault, which has been mined in the Tin stope, has been the source of most of the tin mined. This stope measures about 30 by 50 feet and is irregular in outline. Similar tin-bearing breccia is present in the No. 211 stope. In both stopes the ore contained a little more than 0.5 percent tin, about the same amount of copper, and a little less than 0.002 percent uranium. The amount of tin decreases markedly in wall rock adjacent to the breccia. Cassiterite is associated with copper in places. For example, one 50-ton car of ore from the Copper stope (see fig. 3) assayed 0.74 percent tin.

The primary copper ore was deposited in lenses and irregular bodies in altered breccia. The several small copper stopes include the Copper stope, Myler stope, and No. 153 stope. Most of the copper production of the mine has come from the Copper stope where secondary copper minerals are concentrated along the Majuba fault. This fault zone averages about eight feet thick in the vicinity of the Copper stope, and ore mined from this stope included in part mineralized intrusive breccia, in part mineralized fault breccia, and in part a thin veneer of minerals from the footwall of the fault.

The sample and assay data that were collected during the examination of the mine by the Geological Survey are summarized in the accompanying table. This table gives the approximate location of the samples in the mine, a brief description of the material sampled, and the metal content of the sample.

The uranium deposits

The secondary uranium minerals torbernite, metatorbernite, and zeunerite are widely distributed, although in small amounts, in all of the rock types in the mine. The larger concentrations, however, are in the altered intrusive breccias. They occur in association with the oxide minerals of copper, iron, and silver and are disseminated through the secondary deposits described in the previous paragraphs.

Primary uranium minerals have not been identified as yet, but, judging from the distribution of the oxidation products of both copper and uranium, they are probably associated with the primary copper ore and to a less extent with the tin ore. The relation of uranium to the silver in the Majuba Hill deposit has not been fully determined, but, if conditions here follow observations in other deposits, there may be a fundamental relation between the distribution of uranium and silver and there may be a more or less constant uranium-silver ratio in the primary ore.

The U_3O_8 content of samples from parts of the mine other than the Copper stope ranges from 0.002 to 0.016 percent. In the Copper stope, the content ranges from 0.002 to 0.3 percent.

It is possible that further exploration would find additional ore bodies similar in size and uranium content to those now known. Successful exploration from the Lower Adit level for the downward extension of the known mineralized bodies of breccia would enhance the prospects for finding ore in completely untested ground in depth. Because the bottom of the oxidized ore has not been reached in mining

or exploration, the downward extensions of the known ore bodies of secondary minerals and mineralized breccia would appear to be worthy of investigation to determine the grade and extent of the primary ore.

Sample and Assay Data Majuba Hill Mine, Nevada

(All samples from middle adit level or from stopes and raises adjacent to this level)

Sample number	Location in mine	Material sampled	Assays: Ounces		Assays: Percent		
			Au	Ag	Cu	Sn	U_3O_8
5	No. 211 stope Bulk sample at chute	Complex Cu-Ag-U ore in breccia	0.02	10.58	1.52	0.23	0.003
6	No. 211 stope Bulk sample at chute	Complex Cu-Ag-U ore in breccia	0.02	11.08	0.98	1.14	0.006
7	No. 211 stope Bulk sample at south chute	Complex Cu-Ag-Sn-U ore in breccia	0.02	11.88	1.15	0.78	0.003
14	No. 211 stope 8 ft. cut at head of chute, 35 ft. above sill	Complex Cu-Ag-U ore in breccia	0.02	6.18	0.64	0.13	0.002
15	No. 211 stope 15 ft. cut and bulk sample south wall of stope	Complex Cu-Ag-U ore in quartz porphyry	0.01	0.89	1.10	0.01*	0.002
8	Copper stope 6 ft. channel cut sample on south wall, on sill	Complex Cu-U ore in shale	0.01	0.23	0.15	0.05*	0.012
9	Copper stope 12 ft. channel cut sample on south wall, on sill	Complex Cu-U ore in quartz porphyry	0.02	0.13	0.06	0.10*	0.007
10	Copper stope 14 ft. grab & cut sample on south wall, on sill	Complex Cu-Ag-U ore in quartz porphyry	0.01	1.89	0.50	0.05*	0.040

Sample and assay data continued

Sample number	Location in mine	Material sampled	Assays: Ounces Au	Ag	Percent Cu	Sn	U_3O_8
11	Copper stope 8 ft. cut & bulk on west wall at junction at drift with stope	Complex Cu-Ag-U ore in quartz porphyry	0.01	2.01	0.40	0.01*	0.004
18	Copper stope 3 ft. cut sample from south wall of stope, 28 ft. ± above adit level	Complex Cu-Sn-U ore in quartz porphyry along pre-mineral fracture	0.01	0.11	12.72	0.001*	0.30
19	Copper stope 10 ft. channel cut sample, 28 ft. ± above sill	Complex Cu-U ore in quartz porphyry	0.01	0.77	0.40	0.001*	0.12
20	Copper stope 12 ft. channel cut sample on south side of stope	Complex Cu-U ore in quartz porphyry	0.01	1.38	0.40	0.001*	0.11
21	Copper stope 3 ft. channel cut sample on south wall	Complex Cu-Ag-U ore in rhyolite porphyry	0.015	0.78	2.05	0.001*	0.10
22	Copper stope 10 ft. cut & bulk sample, northwest wall of stope	Complex Cu-Ag-U ore in breccia	tr.	1.70	1.05	0.04	0.004
13	Myler stope Bulk sample from N.W. of stope	Complex Cu-Ag-U ore in breccia	0.01	2.61	7.91	0.09	0.002

Sample and assay data continued

Sample number	Location in mine	Material sampled	Assays: Ounces Au	Assays: Ounces Ag	Assays: Percent Cu	Assays: Percent Sn	Assays: Percent U_3O_8
16	Myler stope 5 ft. cut & bulk sample from raise to Myler stope	Complex Cu-Ag-Sn-U ore in breccia	0.01	2.43	4.75	0.09	0.002
17	Myler stope 6 ft. cut & bulk sample from raise to Myler stope	Complex Cu-Ag-U ore in breccia	0.01	1.09	0.35	0.04	0.002
12	216 cross-cut 6 ft. cut sample	Complex Cu-U ore in quartz porphyry	0.01	0.69	0.10	0.01*	0.016
23	218 cross-cut 9 ft. channel cut sample	Complex Ag-U ore in quartz porphyry	tr.	0.70	0.09	0.09	0.004
24	Tin stope Composite bulk sample	Complex Cu-Ag-Sn-U ore in breccia	0.01	3.51	0.54	0.41	0.002
25	Raise above No. 153 stope. Bulk sample N.E. wall	Complex Cu-Ag-U ore in breccia	0.05	2.75	2.41	0.09	0.002
26	South wall No. 153 stope. Bulk sample	Complex Cu-Ag-U ore in breccia	tr.	1.50	1.77	0.09	0.002
27	201-S drift in raise 15 ft. above sill; 2 ft channel cut sample	Complex Cu-U ore in quartz porphyry	tr.	0.10	4.53	0.001*	0.008

*Data from spectrographic analysis no chemical assay made.