TITANIUM

NEVADA BUREAU OF MINES

VERNON E. SCHEID, DIRECTOR

REPORT 3

INVESTIGATION OF TITANIUM OCCURRENCES IN NEVADA

BY LAURENCE H. BEAL

MACKAY SCHOOL OF MINES
UNIVERSITY OF NEVADA

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INVESTIGATION OF TITANIUM OCCURRENCES IN NEVADA

By LAURENCE H. BEAL

ABSTRACT

Titanium minerals (rutile, anatase, ilmenite, and titaniferous magnetite) have been known in Nevada for more than 50 years. Titanium occurrences in Nevada may be placed in two principal categories, rock deposits and unconsolidated sedimentary deposits. Generally, the former types are associated with pegmatites, aplites, and certain basic igneous rocks, and are limited chiefly to small pegmatites or pegmatitic bodies in the southern Virgin Mountains and the eastern flank of the Stillwater Range. Sedimentary deposits, which include placer and beach deposits, have been reported in 11 counties. Most of the placer and beach titanium occurrences contain titaniferous magnetite varying from several percent to nearly 30 percent TiO_2. However, with the exception of the placers in the southern Virgin Mountains, the titaniferous magnetite placers have extremely limited tonnages.

The investigation revealed that within the State there are no known titanium ore deposits, but, in fact, that certain petrographic provinces contain a lower-than-average titanium content.

INTRODUCTION

Purpose

The investigation of Nevada's titanium occurrences was undertaken because of: (1) a national need for domestic ores, (2) the desirability of a local ore source in view of the major titanium metal production within the State, and (3) the need for an evaluation of and the dissemination of data regarding known titanium occurrences within the State.

Historical Summary

Although titanium occurrences in Nevada have been documented for nearly 50 years, until recently little has been done concerning the possibility of either current or future potential titanium resources in the State.

Rutile was first noted by Ransome (1909, p. 55-58) during the early part of the century in the Cottonwood Canyon area, Humboldt County. Subsequent investigations by Ferguson (1939, p. 18-21) and Hand (1955) of the titaniferous albitic dikes have unravelled much of the complex geology and mineralogy of this area.

Shortly after World War II quartz-sericite dikes containing corundum and andalusite with sparse rutile were investigated by the U. S. Bureau of Mines; this complex mineralogical occurrence located in the Buckskin district, Douglas County, contains less than 1 percent TiO_2.

Following the completion of Titanium Metals Corporation of America's titanium manufacturing plant at Henderson, Nev., a number of unsuccessful titanium exploration programs have been initiated by companies, governmental agencies, and individuals.

To date, there have been no known titanium ore shipments from Nevada prospects.

Methods of Investigation

Early in 1954, the Nevada Bureau of Mines inaugurated a program to investigate known titanium prospects and occurrences in the State. Mr. Albert R. Glockzin, then geologist for the Bureau, carried out the preliminary work of the survey, which included: (1) contacting all persons, agencies, and companies thought to have pertinent information regarding titanium occurrences or prospects within the State, (2) advertising in local newspapers throughout the State, (3) reviewing existing literature, and (4) collection of samples from several titanium-bearing occurrences.

In 1957, the author was assigned to the titanium investigation, and the data compiled by Glockzin was reviewed. A comprehensive review of the literature was initiated, including a brief library study of the most reliable analyses available for Nevada igneous rocks. Following the preliminary office study, an aggregate period of nearly three months was spent in the field locating, investigating, and evaluating the many titanium prospects.

Methods for investigating a potential deposit were as follows: (1) preliminary examination to determine probable grade, tonnage, general mineralogy, and geology, (2) preliminary laboratory investigation of minerals and ores, (3) detailed geologic-mineralogic study. Unless a prospect or occurrence indicated economic potential, the investigation terminated with the initial reconnaissance visit.

Most samples, both those collected in the field and those sent in by interested parties, were analyzed for titanium content and the mineralogy and/or petrography determined. Particular attention was given to the heavy mineral fractions of these samples.

Determination of titanium in samples involved one or two laboratory techniques: (1) chemical analysis (modified Weller's [peroxide] method) and (2) mineralogical investigation. Generally, the microscopic mineralogical study was not employed unless the sample contained substantial amounts of titanium or economic "heavy minerals." A comprehensive presentation of all chemical analyses and mineralogical work by the author and Nevada Mining Analytical Laboratory is given in the Appendix, p. 30.

TITANIUM ORE MINERALS AND HOST ROCKS

Minerals

The principal titanium ore minerals are rutile (TiO_2) and ilmenite ($FeTiO_3$). Other minerals which have been mined for titanium ore are ilmenite-magnetite ($FeTiO_3$-Fe_3O_4), ilmenite-hematite ($FeTiO_3$-Fe_2O_3), sphene ($CaTiSiO_5$), perovskite ($CaTiO_3$), and leucoxene (TiO_2). Rutile, a minor constituent of certain metamorphic and igneous rocks, is commonly concentrated along with ilmenite and other heavy minerals in beach and river sands. Rutile ranges in color from red to reddish brown or black, and has a specific gravity of 4.18-4.25 and hardness of 6.0-6.5. Ilmenite, a black mineral with a metallic luster and black streak, has a specific gravity of nearly 4.7 and hardness 5-6. For the most part it occurs as tabular crystals but may be massive. The term titaniferous magnetite (Lydon, 1958, p. 647) includes titanomagnetite, an intergrowth composed of fine ilmenite lamella in a matrix of magnetite. The former term is commonly used for magnetite containing small amounts of titanium in solid solution.

The principal source of rutile (Quirk, 1957, p. 70-72) is from Australian beach sand deposits. Rutile rock deposits are usually associated with alkaline plutonic rocks, certain pegmatites, and quartz veins.

The world production of ilmenite concentrates (including titaniferous magnetite, titaniferous hematite, etc.) comes from the United States (chiefly New York, Florida, and Idaho), India, Norway, Canada, Finland, and Malaya. Large tonnages of ilmenite concentrates originate from both rock deposits (anorthosite, norite, nelsonite, gabbro, and related rocks) and sedimentary deposits (sands of marine origin, placers, and residual deposits).

Host Rocks

Titanium deposits usually fall into one of two principal categories, rock deposits or secondary deposits. Most commercial rock deposits consist of ilmenite and associated magnetite or hematite either in anorthosites and related intrusive rocks or in metamorphic rocks adjacent to that type of intrusive body. Secondary deposits consist of rutile and/or ilmenite that have been concentrated by sedimentary processes. Rutile occurs chiefly in beach sand deposits; those found in Australia have been the most productive but in Florida beach sands are becoming an increasingly important potential source. The extensive black sand deposits of India contain up to 75 percent ilmenite. Additional secondary deposits include placers, sandstone, residual, and related deposits.

From the most reliable analyses available, the average titanium contents of igneous rocks in Nevada is compared with Nockolds' data in table 1.

It is interesting to note that the averages for intrusive and extrusive acid igneous rocks of Nevada show little departure from Nockolds' figures, while averages of the more basic rocks show significant differences. Because of the tremendous volume of basic volcanic rocks exposed in Nevada, the study suggests the existence of large provinces which contain unusually low amounts of titanium.

ECONOMIC ASPECTS OF TITANIUM DEPOSITS

Titanium deposits may be evaluated on the basis of location, mineralogy, mining and beneficiation costs, size, grade, and by-products. The following paragraphs briefly discuss each of these factors and relate them to the largest and most economically productive titanium ore deposits in the country.

Geographic location becomes critical where transportation costs of the low-value raw product from the mine to the fabricating plant are high. The cost of the raw product is only a small fraction of the fabricated product. In the manufacture of elemental titanium the value of the rutile concentrate is less than 4 percent of the metal.

Mineralogy plays a major role with respect to the economics of a deposit, (Miller, 1957, p. 59-60). For example, the value of certain beach sand deposits depends mainly upon (1) rutile content, (2) suitability of their contained ilmenite, and (3) value of the by-product minerals. In the various types of black-sand deposits, each of the several grades of ilmenite must be judged on its individual characteristics. Thus a given deposit may have a large heavy-mineral content and still be unsuitable for industry.

Mining and beneficiation methods are governed noticeably by costs. At present, titanium resources in the United States are restricted mainly to rock deposits of ilmenite and magnetite, and placer deposits of ilmenite and rutile. All producing properties employ low-cost mining and beneficiation methods.

At the MacIntyre deposit, Tahawus, New York, from which comes a large part of this country's production of titanium ores, ore is mined by open-pit methods. The deposit is approximately 900 feet wide and 1,800 feet long. Mining operations require a waste-to-ore ratio of 1.25 to 1.0. In 1955, the total resources of the area were estimated to be 122 million tons.

TABLE 1.

AVERAGE TITANIUM OXIDE CONTENT OF SOME IGNEOUS ROCKS

Rock Type	% TiO_2	No. of Analyses
NEVADA[1]		
Granite	0.32	5
Quartz monzonite	0.57	8
Granodiorite	0.57	5
Monzonite	0.88	4
Felsite	0.68	6
Rhyolite	0.28	37
Dacite	0.50	9
Andesite	0.82	46
Basalt	1.72	11
WORLD[2]		
Calc-alkali granite	0.37	72
Alkali granite	0.20	48
Per-alkaline granite	0.40	53
Average granite	0.32	173
Adamellite	0.56	121
Granodiorite	0.57	137
Monzonite	1.12	46
Calc-alkali rhyolite (rhyolite-obsidian)	0.22	22
Alkali rhyolite (rhyolite-obsidian)	0.17	21
Per-alkaline rhyolite (rhyolite-obsidian)	0.42	39
Average rhyolite	0.27	82
Dacite (dacitic-obsidian)	0.64	50
Andesite	1.31	49
Tholeiitic andesite	2.60	26
Alkali andesite	2.84	37
Average andesite	2.25	112
Tholeiitic basalt	2.03	137
Tholeiitic olivine basalt	1.65	28
Normal alkali basalt	2.63	96
Olivine-free alkali basalt	3.00	22
Olivine-rich basalt	2.12	31
Central basalt	1.10	56
Average basalt	2.09	370

1. Compiled from U. S. Geol. Survey Professional Papers, Bulletins, and unpublished data; and Nev. Bur. Mines data.

2. Compiled from tables by Nockolds (1954, p. 1007-1032).

Florida, the second largest producer of titanium ores in the United States, derives most of its production from beach and dune sands. Dredging methods are used to recover the heavy fraction which constitutes about 25 percent of the beach sands. In certain areas the heavy fraction contains up to 40 percent ilmenite, 4 percent leucoxene, 7 percent rutile, 11 percent zircon, 0.5 percent monazite. In 1955 the Florida reserves were estimated to be approximately 200 million tons.

Beneficiation of the ores varies greatly depending on the deposit. Beneficiation methods include flotation, magnetitic separation, gravity, or a combination of these.

In order to have a positive source of titanium ores, deposits must have long-range depletion. Low-cost mining and beneficiation can only be obtained in most cases for deposits of 100 million tons or more.

Mineable titanium deposits vary greatly with respect to grade (Miller, 1957, p. 33-34). In the United States, recoverable ilmenite can be produced from sand deposits containing as low as 0.8 percent TiO_2. In the Florida sand deposits, the rutile content ranges from 0.5 to 1.5 percent while in the Arkansas and Virginia deposits, the rutile approximates 3 percent. However, there is no current production from these areas. At the MacIntyre deposit, New York, and the Amherst-Nelson County area, Virginia, both rock deposits, the mineable grade is nearly 20 percent TiO_2. In California, Minnesota, Montana, New York, Oregon, Rhode Island, and Wyoming, there is an aggregate of 150 million tons of ilmenite and titaniferous magnetite ranging from 5 to 25 percent TiO_2, yet this material is not considered recoverable under present economic conditions.

Commonly by-product minerals play a minor role with respect to titanium production; however, in the placer deposits of Florida, Idaho, Montana, North Carolina, and Oregon, by-products have noticeably influenced the production of titanium ores.

CURRENT TITANIUM PRICES

During the last several years, there has been a significant production increase in the titanium metal industry. Titanium mill shipments are estimated to be 6,000 short tons in 1962 (Eigo, 1962, p. 97). This figure is an all-time production high for the industry. However with the increased production, ore, sponge, and metal prices have continued to decline. Titanium sponge declined from $3.45 per lb. in 1956 to $1.37 per lb. in 1961.

Current titanium ore prices are as follows:

Ilmenite (59.5% - Atlantic ports)	$23-$26 per long ton
Ilmenite (54% f.o.b. cars)	$21-$21.50 per long ton
Rutile (94% for del. within 12 mos.)	$80 per short ton

The above prices have been steady during the past two years.

CLASSIFICATION AND DISTRIBUTION OF TITANIUM OCCURRENCES IN NEVADA

Titanium occurrences in Nevada may be placed in two principal categories: (1) rock (lode) deposits, and (2) unconsolidated sedimentary deposits.

Rock deposits investigated included pegmatites, aplitic bodies, basic igneous masses, and metamorphic rocks. Sedimentary titanium deposits examined included: placers, beach deposits (littoral and lucustrine), residual deposits, and dunes.

Concentrations of titanium minerals seem to have random distribution throughout the State (see pl. 1). The majority of the more interesting titanium occurrences in Nevada may be related to the following geologic environments: (1) pegmatites and associated rocks containing titaniferous magnetite, ilmenite, anatase, and rutile; (2) ancient beach sands which are usually interbedded with intensely altered tuffs; and (3) recent placer deposits adjacent to titanium-rich pegmatites and Quaternary-Tertiary basic volcanic rocks containing varying amounts of titanium minerals.

Titanium-bearing pegmatites and associated rocks are in general restricted to two localities, the southern Virgin Mountains and the eastern flank of the Stillwater Range, although minor occurrences were reported near Hungry Valley, Washoe County, and northern Jackson Range, Humboldt County.

Titanium-bearing beach sands have been noted near Eureka, Eureka County; East Walker River, Lyon County; and Salisbury Wash, Nye County.

Placers containing chiefly titaniferous magnetite or ilmenite, but in some cases minor amounts of rutile, occur in the Table Mountain district, Churchill County; Gerlach area, Washoe County; Vicksburg district, Humboldt County; Salisbury Wash, Nye County; Peavine district, Washoe County; Belmont district, Nye County; and Forty-nine Range, Washoe County.

In addition, various occurrences of titanium minerals have been reported in metamorphic rocks, quartz veins, aplitic bodies, and sand dunes, but titanium percentages obtained from composite samples from these deposits do not exceed the average 1.05 percent TiO_2 content of igneous rocks (Mason, 1952, p. 83). In order to have a fairly complete record of titanium in the State, nearly all localities visited are recorded in the text regardless of their economic potentials.

DESCRIPTION OF OCCURRENCES BY COUNTY

General Statement

Titanium occurrences have been reported from more than half of Nevada's counties. Churchill, Clark, Douglas, Humboldt, Lincoln, and Washoe Counties have rock deposits which contain varying amounts of rutile, anatase (octahedrite), titaniferous magnetite, and ilmenite(?). The other counties commonly have titaniferous-magnetite placers or beach sand deposits. The so-called "ilmenite deposits" contain chiefly titaniferous magnetite which varies from several percent to nearly 30 percent TiO_2. Microscopic intergrowths of ilmenite and magnetite are rare in the samples studied. Under the microscope (100x) the titaniferous magnetite appears homogeneous; no doubt the titanium is "tied up" chiefly in the crystal lattice. The locations of all known occurrences are shown on plate 1.

Churchill County

SAND SPRINGS AREA

<u>Sand Springs Dune</u>

The Sand Springs Dune (T. 17 N., R. 32 E.) is approximately 30 miles east of Fallon, Nev., and 2 1/2 miles north of U. S. Highway 50 (see no. 8, pl. 1). The tremendous dune, clearly visible from the highway, rests upon and is partially encircled by volcanic ridges.

Locally the dune exhibits superficial concentrations of "heavy" minerals. Samples systematically collected from the dune contain up to 40 percent "heavy" minerals, but the average TiO_2 content was less than 10 percent. The "heavy" minerals include titaniferous magnetite, hornblende, and minor quantities of garnet, hypersthene, tourmaline, rutile, zircon, and limonite. Samples collected at 200-foot intervals along the southeastern edge of the dune yielded an average TiO_2 content of less than 1 percent.

TABLE MOUNTAIN DISTRICT

<u>Corral Canyon area</u>

The Corral Canyon area (T. 24 N., R. 36 E.) is located in the eastern flank of the Stillwater Range and is approximately 53 miles (by dirt road) north of the junction of U. S. Highway 50 and the Dixie Valley road near Frenchman Station. The mineralized area covers about half a square mile and is owned by Glen and Lloyd Shaw of Fallon, Nev.

In 1938, Ferguson (1939, p. 18–19) made what was apparently the first geological investigation of Corral Canyon, although Ransome (1909) studied adjacent areas and determined the regional geological setting. Hand (1955) made a detailed study of the Corral Canyon area and unravelled much of its complex geology and mineralogy.

Gold mining flourished spasmodically in Corral Canyon during the late 1920's and early 1930's. Gold, associated with pyrite and minor sphalerite, occurs in elongated lenticular quartz bodies along the margins of dikes. Following the limited period of gold mining, sporadic prospecting and development work divulged numerous titaniferous dikes or sills containing erratic concentrations of anatase.

The geological setting of the titanium deposits (fig. 1) is a rugged mountain range consisting of folded pre-Cretaceous sediments and volcanics that have been intruded by fine-grained Jurassic(?) diorites (Hand, 1955). Faulting apparently is responsible for the uplift of the range and seems to control many of the canyons cutting through it. Silicified limestone occurs in small patches along the eastern flank of the range. The titaniferous dikes, second most extensive rocks in the area, are fine grained, altered, and composed of albite, calcite, anatase, sericite, quartz, and iron oxides. Concentrations of anatase occur locally in snow-white to buff albitic dikes. These fine-grained dikes which cut the dioritic host rock occur over a northwesterly elongated area of approximately 40 acres. Locally the titanium dioxide content of the albitic dikes and/or other bodies varies from less than 1 percent to nearly 40 percent; the TiO_2 content of all these albitic rocks averages approximately 0.75 percent. Grab samples collected from several of the larger albitic masses assayed from 2.0 to 3.5 percent TiO_2.

Workings include several short adits and discovery pits, either adjacent to or in titaniferous dikes. Persistence of the bodies at depth cannot be predicted with any certainty, owing to the erratic nature of the albitic masses. Several of the larger irregular albitic masses have maximum dimensions of more than 100 feet in width and 600 feet in length.

Last Chance claims

The Last Chance claims (secs. 16 and 17, T. 24 N., R. 36 E.) are located in Dixie Valley along the eastern flank of the Stillwater Range about three miles north of Corral Canyon. The Last Chance claims, owned by Clark Barton and V. S. Baxter of Fallon, Nev., consist of 14 lode claims and one placer claim (160 acres).

The workings include four adits, two of which are 100 feet long; the others, 65 and 45 feet in length.

The property was examined in 1951 by engineers of the E. I. du Pont de Nemours & Co., Inc. A copy of the report made available to the Nevada Bureau of Mines indicated that eight samples were analyzed chemically and petrographically. These samples, which contained ilmenite, leucoxene, and traces of rutile, varied from 0.6 to 9.0 percent TiO_2. According to Barton, a churn-drill hole 150 feet deep was drilled near the discovery monument of the placer claim, and cut placer debris containing from 4.5 to 30 percent ilmenite.

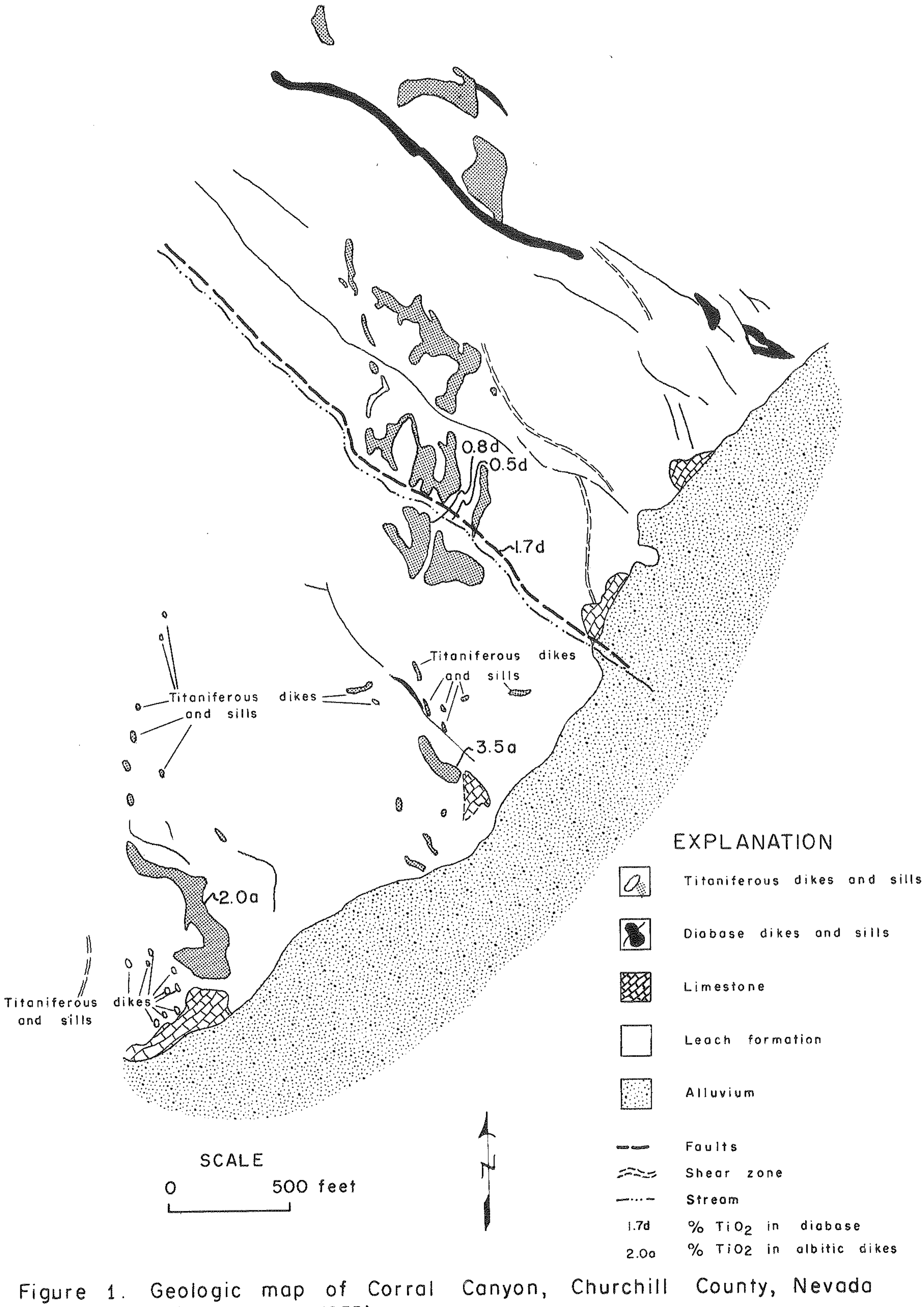

Figure 1. Geologic map of Corral Canyon, Churchill County, Nevada (after Hand, 1955)

RVW

The complex geology of the area is similar to that of Corral Canyon. Hot springs occur more or less continuously along the eastern frontal fault which borders the range. Aplites, syenites(?), diorites, and gabbros (chiefly dikes and sills) cut and are intermingled with andesites and basalts. Within the fault zone which dips steeply to the east, there are narrow vein-like bodies that consist of opalite, limonite, and minor amounts of cinnabar.

During the brief reconnaissance investigation of the property, 10 samples were cut. Three aplite samples containing minor amounts of rutile assayed 0.4 to 1.3 percent TiO_2. Three gabbro samples and one diorite sample assayed from a trace to 0.9 percent TiO_2. Placer samples cut near the surface varied from 0.7 to 1.2 percent TiO_2. Placer samples collected near the discovery monument of the placer claim contained several percent of titaniferous magnetite.

Clark County

BUNKERVILLE DISTRICT

Whitney Ridge

Near the northern end of Whitney Ridge in secs. 16, 17, 18, 20, and 21, T. 16 S., R. 71 E., there are numerous pegmatites in a Precambrian(?) complex. Several of the pegmatites contain titaniferous magnetite in plates and streaks with up to 3 percent TiO_2 content.

GOLD BUTTE DISTRICT

The Gold Butte district, which includes the south end of the Virgin Mountains, encompasses the southern part of the Gold Butte quadrangle, the eastern part of the Virgin Basin quadrangle, and the western portion of the Iceberg Canyon quadrangle.

The mineral deposits in the district were first investigated in 1907, and shortly thereafter ore shipments were made. Gold Butte ore deposits have been classified by Hill (1916, p. 43-54) as replacement deposits in limestone and quartz veins in the Precambrian gneiss and granite. Small lots of copper ore have been mined from the replacement deposits, while the quartz veins have produced limited amounts of gold and silver ore. During the last three decades, mica, uranium minerals, and rose quartz have been mined from several of the larger pegmatites.

The oldest rocks in the district consist of Precambrian granites, pegmatites, gneisses, and schists. Sedimentary rocks found in the eastern and northern parts of the area are of Paleozoic Age. Recent investigations in the area include those of Longwell (1928, 1949) and Ben Bowyer and others (1958).

In the late spring of 1957, the author spent approximately ten days in the southern Virgin Mountains investigating what were reported to be titanium-rich deposits. Ilmenite and/or titaniferous magnetite-bearing pegmatites were found at Whitney Ridge and near Bonelli Peak. Adjacent to several of these pegmatites, "titanium-rich" placers occur along or in stream channels and drainages. Reconnaissance geological mapping in the northwestern part of the Iceberg Canyon quadrangle revealed a distinct pegmatite distribution pattern. The reconnaissance geological map (fig. 2) illustrates definite halos of both simple and zoned pegmatites in the gneiss-schist complexes which enclose granitic masses. Locally, simple quartz and/or feldspar pegmatites are found in granitic rocks far from the granitic and gneiss-schist contacts. The complex pegmatites may contain, in addition to quartz and potassium-soda feldspars, varied amounts of the following minerals: muscovite, tourmaline, ilmenite, titaniferous magnetite, various uranium minerals, and rare-earth minerals. Small to minute pegmatitic zones are common in the gneiss-schist complexes adjacent to the granite-gneiss contacts. In some areas small pegmatitic masses occur in or near faults.

Sharp formational contacts and the doming of invaded rocks indicate that granitic rocks have invaded the older gneisses and schists. However, locally along or near gneiss-schist and granitic contacts the younger rocks grade imperceptively into gneiss, which suggests limited granitization. Granitic rocks in the area include aplite and others varying in composition from granite to granodiorite.

The paragneisses vary greatly in composition, ranging from garnet-cordierite gneiss to granitic gneiss. In Garnet Valley the color of the garnet gneiss varies from a dirty red hue to light gray. In decreasing order of abundance it contains the following minerals: quartz, microcline, garnet, cordierite, plagioclase, and minor amounts of sillimanite, spinel, opaque minerals, and muscovite.

Dark-gray biotite plagioclase gneiss, found near the Windmill mine, contains in decreasing abundance the following minerals: biotite, plagioclase, apatite, garnet, sericite, and montmorillonite(?). Amphibole schists commonly are interlayered with the gneisses. Near Gotchel Springs much of the country rocks consists of quartz-microcline-garnet gneisses. Grab samples of country rock in Jumbo Basin and near the Windmill mine contained, respectively, 1.0 percent and 1.3 percent TiO_2.

Titanium-rich pegmatites or pegmatitic zones have been located at Turkey Springs, near BM 3546, and at Scanlon (between BM 3546 and the Windmill mine). All of these white to light-gray pegmatitic areas contain irregularly shaped or lit-par-lit pegmatites or a combination of both. The pegmatites are irregularly impregnated with ilmenite and titaniferous magnetite plates or blebs. Maximum concentrations of the plates or blebs do not exceed 7 percent in any given pegmatite, and in the pegmatitized areas the country rock constitutes at least 85 percent of the total exposed rock.

Placer deposits of varying size occur along most of the stream courses. Rounded ilmenite and titaniferous magnetite masses attaining a maximum dimension of four inches have been found locally in the washes. Without detailed sampling it is impossible to estimate the grades or tonnages of these placers. However, there are millions of tons of placer material containing from 2 to 5 percent TiO_2.

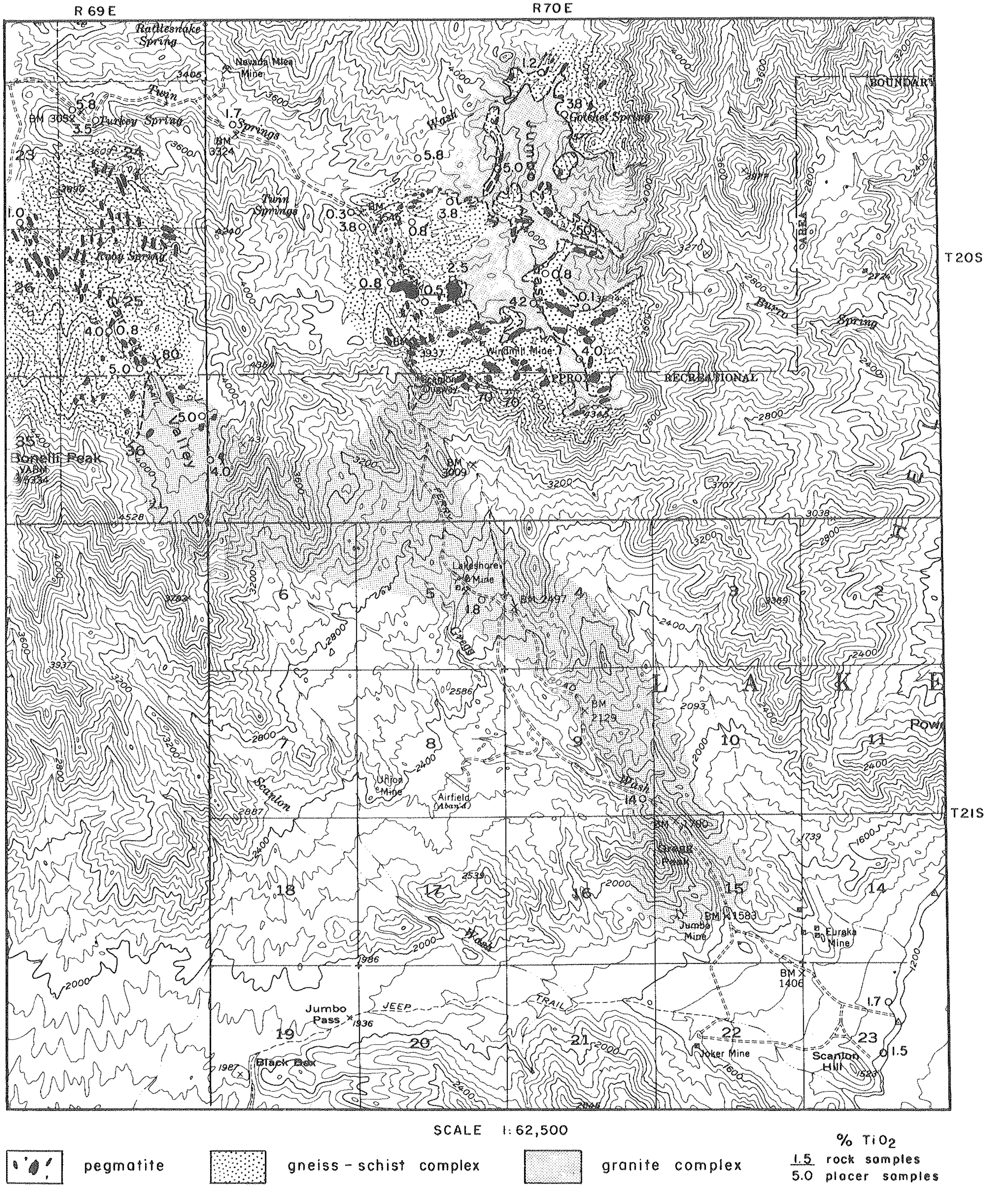

Figure 2. Reconnaissance geologic map and titanium oxide assay map of part of the Gold Butte district, Clark County, Nevada.

Titanium analyses of rock and placer samples cut in the Iceberg Canyon quadrangle vary from less than 1 percent to nearly 6 percent TiO_2 (fig. 2; see appendix for details).

GOODSPRINGS DISTRICT

Boss Mine

The Boss mine is located in the SE 1/4 SE 1/4 sec. 27 and the NE 1/4 Ne 1/4 sec. 34, T. 24 S., R. 57 E., about 10 miles by road west of Goodsprings, Nev.

The Boss (Hewett, 1931, p. 114-116) ore body was located along a minor fault which separates the base of the Monte Cristo Formation from the Valentine member of the Sultan Limestone. A small amount of rutile and octahedrite occurred in the ore body, but no titanium mineralization has been recognized in the wall rocks.

Douglas County

BUCKSKIN DISTRICT

Blue Metal Corundum

The Blue Metal Corundum property (Binyon, 1946; Lawthers, 1954, p. 283) is located in sec. 14, T. 13 N., R. 23 E., on the west slope of the Singatase Range, approximately 20 miles northwest of Yerington, Nev.

The Blue Metal group of claims, comprising five unpatented lode claims, was located by James S. Adams and Alex Castaing of Yerington, Nev. and Judge Clark J. Guild of Carson City, Nev. Originally the area included by the Blue Metal group of claims was prospected for gold.

In 1944, an engineer of the U. S. Bureau of Mines examined and recommended the property for additional geological and beneficiation investigations. Subsequent exploration work by the Bureau of Mines includes the driving of a 200-foot adit and a 23-foot crosscut off the adit. Analysis of a sample taken from a pit over the adit was as follows: 40 percent - Al_2O_3, 0.31 percent - Fe, 0.8 percent - CaO, 0.05 percent - MgO, 50 percent - SiO_2, 0.13 percent - Na_2O, 0.23 percent - K_2O, 6.85 percent - LOI*, and 0.52 percent - TiO_2. Beneficiation tests on the Blue Metals corundum-andalusite ore indicated that at 65-mesh size, poor liberation was obtained. Both corundum and andalusite were recovered in a combined concentrate. For refractory purposes a combined corundum and andalusite product could be obtained from coarse-size material (60 percent Al_2O_3).

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*LOI = loss on ignition

In addition to the development work by the U. S. Bureau of Mines, there are numerous shallow trenches and open cuts scattered over the property. On the Blue Metal No. 3 claims there is a 150-foot shaft and a short adit.

Locally the andesite country rock is extremely altered adjacent to granodiorite-andesite contacts. Corundum and andalusite, intimately associated, occur as tiny aggregates in shear zones 2 to 50 feet wide (Overton, 1947, p. 21-24). Cutting the andesite and granodiorite are several lamprophyric dikes. Silicification with the development of sericite and "talcose" rock is widespread in the vicinity of the claims.

Elko County

GONCE CREEK

Black Beauty claims

The Black Beauty claims (T. 39 N., R. 54 E.), located on the west side of Gonce Creek, 11 miles west of State Highway 43, are owned by Prudencio Elordieta of Reno, Nev.

Sulphur, associated with minor amount of pyrite and ilmenite, and sparse amounts of sphene, occurs in host rocks of black slate and shale. Spectrographic analyses of samples indicate a titanium dioxide content between 1.0 and 1.25 percent.

RAILROAD DISTRICT

Dixie Creek area

According to Day and Richards (1905, p. 1204) a placer sample from Dixie Creek (T. 31 N., R. 54 E.) contained appreciable amounts of ilmenite (5.9 percent) and magnetite (44 percent). Surface samples taken by the Nevada Bureau of Mines contained a maximum of 0.3 percent TiO_2 and little magnetite. The Dixie Creek placer material is derived chiefly from volcanic rocks.

Eureka County

EUREKA DISTRICT

Hunter Ranch ilmenite claims

The Hunter Ranch ilmenite claims are located four miles due east of Eureka, Nev. (secs. 15 and 16, T. 19 N., R. 54 E.). In 1958, Pat Sullivan, Frank McBride, and Delbert Robinson held 12 placer claims along Simpson Creek, De Paoli Canyon, and Newark Canyon.

The oldest rocks in the area are massive brownish conglomerates (probably Newark Canyon Formation, Cretaceous) dipping approximately 30° to the west. Resting unconformably upon the cherty conglomerates are sandy tuffs and tuffaceous sandstones which dip gently westerly. The sandstones and tuffs are capped by basic Tertiary volcanics.

The white to light-gray sandy tuffs and tuffaceous sandstones, which rest unconformably upon the conglomerates, display noticeable cross-bedding throughout the area. Concentrations of titaniferous magnetite occur in lenses of some of the sandstones and tuffs. Adjacent to these lenses, titaniferous magnetite and magnetite have weathered out. These heavy minerals are concentrated mainly in the alluvium, nearby gullies, and rills.

Black sands are concentrated along tiny water courses in the dark-brown soil adjacent to sandstone lenses rich in titaniferous magnetite. These concentrations extend or are exposed over approximately 20 acres.

Minor faulting, which occurred during or following the deposition and weathering of the tuff, complicates the local structural features.

Black sand concentrates sent to the Nevada Mining Analytical Laboratory by the owners contained 9.2 percent TiO_2. Samples collected by the Nevada Bureau of Mines varied from 0.5 to 8.2 percent TiO_2. The average TiO_2 content in the exposed titaniferous magnetite-enriched areas is 1 to 2 percent.

Humboldt County

PINE FOREST RANGE

Gridley Lake ilmenite placer

The Hummel and Low placer property (T. 44 N., R. 27 E.) is located along the west flank of the Pine Forest Range approximately 20 miles southwest of Denio, Nev.; the placer deposit is situated about one mile east of Gridley Lake between Alder and Knott Creeks.

The "ilmenite" placer property was claimed in 1954 by Walter Low and Fred Hummel of Winnemucca, Nev. Several uranium lode claims subsequently have been staked in the area. The lode and placer claims overlap in part.

Throughout the region, gently westerly dipping andesitic-dacitic rocks cap intensely altered interbedded tuffs, tuffaceous sandstones, and conglomeratic sandstones. Locally the sandstones are cemented with small amounts of greenish autunite(?). Titaniferous magnetite and magnetite probably derived from the volcanic rocks are concentrated in black sands along small gullies and rillets; concentrations of titaniferous sands and gravels occur over an area of several square miles.

Samples of the titaniferous sands vary noticeably in TiO_2 content. A sample of the black sands sent to the Nevada Mining Analytical Laboratory by Mr. Low contained 9.4 percent TiO_2, while several grab samples collected by the Nevada Bureau of Mines along narrow stream beds assayed less than 3 percent TiO_2. It is doubtful that the alluvium in the gulches and alluvial fans would contain more than 1 percent TiO_2.

Other Occurrences

In the Ashtown and Vicksburg districts of the Pine Forest Range and several miles directly south and slightly west of Bartlett Butte (Peak), ilmenite-rich biotite hornblende gneisses and schists have been reported. A brief reconnaissance investigation of the area failed to reveal any noticeable concentrations of titanium minerals.

SAND CREEK OCCURRENCE

Along the northwestern flank of the Jackson Range, sec. 13, T. 41 N., R. 31 E., massive rutile-bearing skarns are associated with a granitic-contact metamorphic complex. Small deposits of iron, copper, lead, silver, and gold occur in and adjacent to the margins of the granodiorite.

In the vicinity of Sand Creek, gray granodiorite and hybrid rocks are the pervasive country rocks.

Dark-gray rutile-rich skarn zones up to 30 feet thick occur locally near Sand Creek. These skarns exhibit little or no continuity. A sample of the hornblende-rich skarn contained 6.75 percent TiO_2. The associated country rocks contain between 0.5 and 1.0 percent TiO_2.

Lincoln County

PANACA ILMENITE PLACERS

Several miles east of Panaca, Nev., there are stream placers containing minor amounts of titaniferous magnetite and magnetite. The country rock consists of altered volcanic tuffs and flow rocks. Apparently the black sands have been derived from these altered volcanic rocks. Assays from grab samples indicate that the gravels contain less than 1 percent TiO_2.

Lyon County

EAST WALKER RIVER AREA

Lucky 9 Uranium claims

The Lucky 9 Uranium claims are situated about 1 mile northwest of the Flying W Ranch house and are located near the northwestern part of sec. 19, T. 9 N., R. 27 E. In 1958, the 117 claims were held by Lucky 9 Uranium Incorporated of Reno, Nev.

The area has been extensively prospected for uranium ores by Lucky 9 Uranium Inc. Exploration work included geological mapping, thermal surveys, radiometric surveys, drilling (air and core), trenching, and exploration workings.

The thermal and radiometric surveys results were checked over an aggregate length of more than 3,000 feet by means of 37 drill holes, three short adits, and several trenches. Although carnotite and other uranium minerals occur throughout the area, no substantial concentrations of these minerals have been found.

Most of the exploration work has been centered near or in interbedded tuffs and sandstones. Capping the light-colored tuffaceous sandstones are fragmental andesitic and basaltic rocks. The basic volcanic fragments are strewn over much of the area. Erosion has locally exposed large light-gray patches of tuffaceous sandstones and/or sandy tuffs. For the most part the beds have a northerly strike and dip gently westerly. Figure 3 is a sketch showing the location of faults, workings, and drill doles.

Table 2 gives results of spectrographic analyses of samples from several of the drill holes. In diamond drill hole No. 22, the TiO_2 content for the 760-foot hole averaged less than 1.5 percent. Strata containing varying amounts of titaniferous magnetite, clay, and diatomaceous earth were cut at several horizons in the drill holes.

TABLE 2.

SPECTROGRAPHIC ANALYSES, LUCKY 9 URANIUM CLAIMS *

Description of sample	Rock type	% U_3O_8	% Titanium	% Zirconium
H-16 at 138'	Metavolcanic	0.005 - 0.03	0.3 - 3.0	-
Adit No. 1	-	0.015	0.5 - 5.0	0.03 - 0.3
H-22 at 760'	Green clay	0.005 - 0.03	0.3 - 3.0	0.03 - 0.3
H-22 at 290'	Black sand	0.005 - 0.03	0.5 - 5.0	0.01 - 0.1
H-22 at 270'	Lithic sandstone	0.005 - 0.03	0.3 - 3.0	0.01 - 0.1
H-22 at 185'	Lithic sandstone	0.005 - 0.03	0.3 - 3.0	-
H-16	Sandy clay	0.005 - 0.03	0.3 - 3.0	0.03 - 0.3

* Analyses courtesy of Lucky 9 Uranium, Inc., Reno, Nevada.

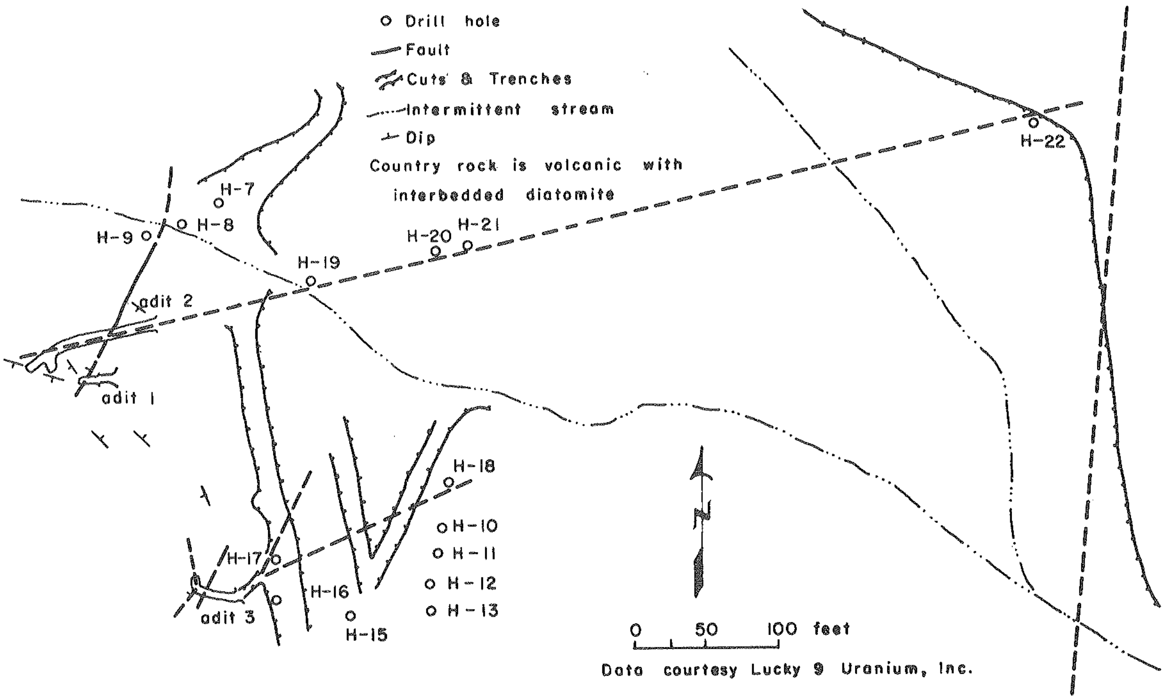

Figure 3. Sketch map showing geology and workings of the Lucky 9 Uranium claims, Lyon County, Nevada.

RVW

Nye County

AMARGOSA DESERT

Big Dune

Big Dune is located in the northeast part of T. 15 S., R. 48 E., an unsurveyed township of the State.

The massive sand dunes have "heavy mineral" concentrations varying from a few percent to nearly 10 percent or more. "Heavy minerals" in the concentrated sands include hornblende, hyperthene, biotite, titaniferous magnetite, magnetite, and minor amounts of rutile, sphene, and zircon. Four samples were collected and assayed, but none contained more than 0.5 percent TiO_2.

BELLEHELEN DISTRICT

The Bellehelen district (T. 3 N., R. 49 E.) encompasses the ghost town, Bellehelen, near the northern end of the Kawich Range; the district is 50 miles east of Tonopah, Nev.

The district was discovered shortly after the turn of the century, and a number of small silver and gold mines operated intermittently until World War II (Kral, 1951, p. 17). Previous geological work was chiefly by company geologists and has not been published.

The northern Kawich Range consists predominantly of rhyolites overlying granite. Mineralization occurs in small fissures of quartz veins which cut the rhyolite. Octahedrite has been reported in these fissure veins, but a reconnaissance investigation of the district failed to reveal any such concentrations.

BELMONT DISTRICT

Flower's ilmenite claims

The titanium group of placer claims owned in 1950 by W. A. Flower and C. C. Boak of Tonopah, Nev. are situated in the Belmont district on the east side of the Toquima Range, Nye County, Nev. The placer, which covers nearly two square miles, lies near the junction of Meadow and Antone Canyons (T. 10 N., R. 45 E.) in an unsurveyed part of the Toiyabe National Forest. The junction of the canyons is approximately 11 miles north of the ghost town of Belmont.

Gold and silver values associated with lead and copper minerals have been reported in metamorphosed shale and limestone one and a half miles west of the junction of Antone and Meadow Canyons (Kral, 1951, p. 24-25). Small quantities of high-grade mercury ore have been shipped from the area.

A reconnaissance investigation of the area revealed complex local geology. In general, the massive brown agglomerates(?) dip gently to the west and cap white to gray tuffaceous rhyolites, tuffaceous agglomerates, and sandstones. Locally, large blocks of quartz-sericite schists, having a maximum size of a foot or more, are present in the tuffaceous rocks. In the lower part of Antone Canyon, black sands are concentrated along small water courses adjacent to weathered tuffaceous rocks and sandstones. The placer debris attains an estimated thickness of 14 feet.

An analysis of black sand concentrates, made available to the Nevada Bureau of Mines by Mr. Flower, is as follows:

Fe_2O_3	67.23%	Al_2O_3	2.8%
CaO	2.6 %	MgO	1.1%

TiO_2	12.3%	V_2O_5	0.3%
Mn	0.5%	Cr_2O_5	0.4%
KO	0.5%	Na_2O	3.7%
Zn	0.2%		

The above data indicate that the concentrate consisted largely of titaniferous magnetite. Grab samples collected along stream beds by the Nevada Bureau of Mines contained less than 1 percent TiO_2.

ROUND MOUNTAIN DISTRICT

The Round Mountain district (T. 10 N., R. 44 E.) is situated near the western slope of the Toquima Range in northern Nye County, Nev. The first important mineral activity in the area occurred in 1906, when gold lode deposits were discovered. Later gold placers were found near the symmetrical rhyolitic hill, known as Round Mountain.

Since 1940 mining has been intermittent except for the placer operations. The Round Mountain Gold Dredging Corporation is currently "dredging" and doing some exploration work in the area.

The Round Mountain Gold Dredging Corporation generously provided two samples of concentrates from their placer gravels. The black sand concentrates from the gold placer dredging operations assayed approximately 15 percent TiO_2. The placer gravels contain less than 2 percent black sands; and the titanium mineral in the gravels is titaniferous magnetite and magnetite.

Placer samples collected from Manhattan Gulch (Manhattan district), approximately 10 miles south of Round Mountain, contained less than 1 percent TiO_2.

SALISBURY WELLS

Salisbury Wash ilmenite claims

Salisbury Wash ilmenite claims (T. 3 N., R. 46 E.) are located 25 miles east of Tonopah, Nev., in Salisbury Wash, between Mud Springs and State Highway 6. According to M. F. Peterson of Tonopah, nearly two hundred titanium claims have been located in the area. Owners of the claims include Lorena Peterson and M. F. Peterson of Tonopah and T. V. Bermen of Hollywood, Calif.

The area is capped by dark-brown, partly vitric, dacitic flow rocks approximately 100 feet in thickness. Beneath the cap rock lies a sequence of altered tuff and/or agglomerate and tuffaceous sandstones, locally overlain by 1 to 10 feet of basalt.

The dacite dips gently to the west. Tuff and tuffaceous sandstones and agglomerates vary in color from light gray to greenish gray. Locally the tuffaceous sandstones are cross-bedded.

Mineralogical and assay data made available to the Nevada Bureau of Mines indicate that the titaniferous placer material contains abundant magnetite, titaniferous magnetite, and ilmenite(?). Qualitative spectrographic analyses indicate that most samples contain from several percent up to nearly 10 percent TiO_2. Although several of the samples collected along Salisbury Wash and its tributaries contained a maximum of 9 percent TiO_2, the samples averaged less than 1 percent TiO_2. The high-grade samples were collected from stream-concentrated black sands. There are only a few tons of the concentrated titaniferous gravels in the area.

Pershing County

RABBIT HOLE SPRINGS DISTRICT

Constant Mineral Separation Co.

This district is located on the western flank of the Kama Mountains about 12 miles south of Sulphur, Nev. It is a placer gold district and although placer mining flourished during the last two decades, the district is currently inactive.

The area consists mainly of pre-Tertiary slates and schists partly covered by valley alluvium and terrace gravels which contain placer deposits. To the east, Tertiary volcanic rocks rest unconformably on metamorphic rocks. In 1958, the Federal Uranium Company had an option on the property of the Constant Mineral Separation Company, and was exploring the area for placer tungsten deposits. Titaniferous magnetite-rich samples of placer concentrates contain up to 5 percent TiO_2.

SCOSSA DISTRICT

Pershing Titanium placer claims

The Pershing Titanium placer claims (T. 33 N., R. 30 E.) are situated adjacent to the western flank of the Antelope Range about a mile southwest of Scossa, Nev. The 16 placer claims are owned by John Prater, Robert Chandler, and associates of Lovelock, Nev.

The unpatented placer claims include low, rolling hills composed of grayish sericite schists and slates. These metamorphic rocks contain small but variable amounts of sphene, rutile, and titaniferous magnetite; placer debris containing up to several percent TiO_2 occurs locally in and along small stream beds in the area.

The Nevada Mining Analytical Laboratory assayed more than 20 samples from the Pershing Titanium claims. Assays of these samples varied from less than 1 percent to 1.6 percent TiO_2.

Wonder Metal claims

The Wonder Metal claims, located approximately 3 miles north of the Pershing Titanium claims, have been reported to contain substantial amounts of titanium. Three samples, collected by the Nevada Bureau of Mines from churn-drill cuttings from several of the claims, contained approximately 1 percent TiO_2.

Figure 4 is a sketch map showing the locations from which samples were taken at the Pershing Titanium and Wonder Metal claims.

OTHER OCCURRENCES

Approximately two miles southwest of the Garrett Ranch (T. 31 N., R. 25 E.), small erratic concentrations of black sands occur in several washes. The black sands, derived from the metamorphic complex to the south, contain minor amounts of titaniferous magnetite and magnetite.

Washoe County

FORTY-NINE RANGE

Forty-nine Range placer

The Forty-nine Range (T. 41-43 N., R. 18-19 E.) is located in the northern part of Washoe County along the California border.

The Range consists of gently easterly dipping interbedded volcanic rocks, including basalt flows, tuffs, and agglomerates. A frontal fault borders the Range on the west. Faults, chiefly east-west trending, dissect the Range into massive blocks which have variable dips to the east.

The stream channels in the valley west of the Range contain magnetite and titaniferous magnetite-bearing gravels. Five placer samples from these streams all contained less than 1 percent TiO_2.

GERLACH DISTRICT

Last Stand claims

The Last Stand claims (T. 34 N., R. 21-22 E.) are located approximately 18 miles northwest of Gerlach, Nev. along the Gerlach-Cedarville road. The claims, staked during March, 1957, include five 160-acre placer claims, and are controlled by members of the Smith and Jeakins families of Gerlach. Workings include several shafts, discovery holes, cuts, and trenches.

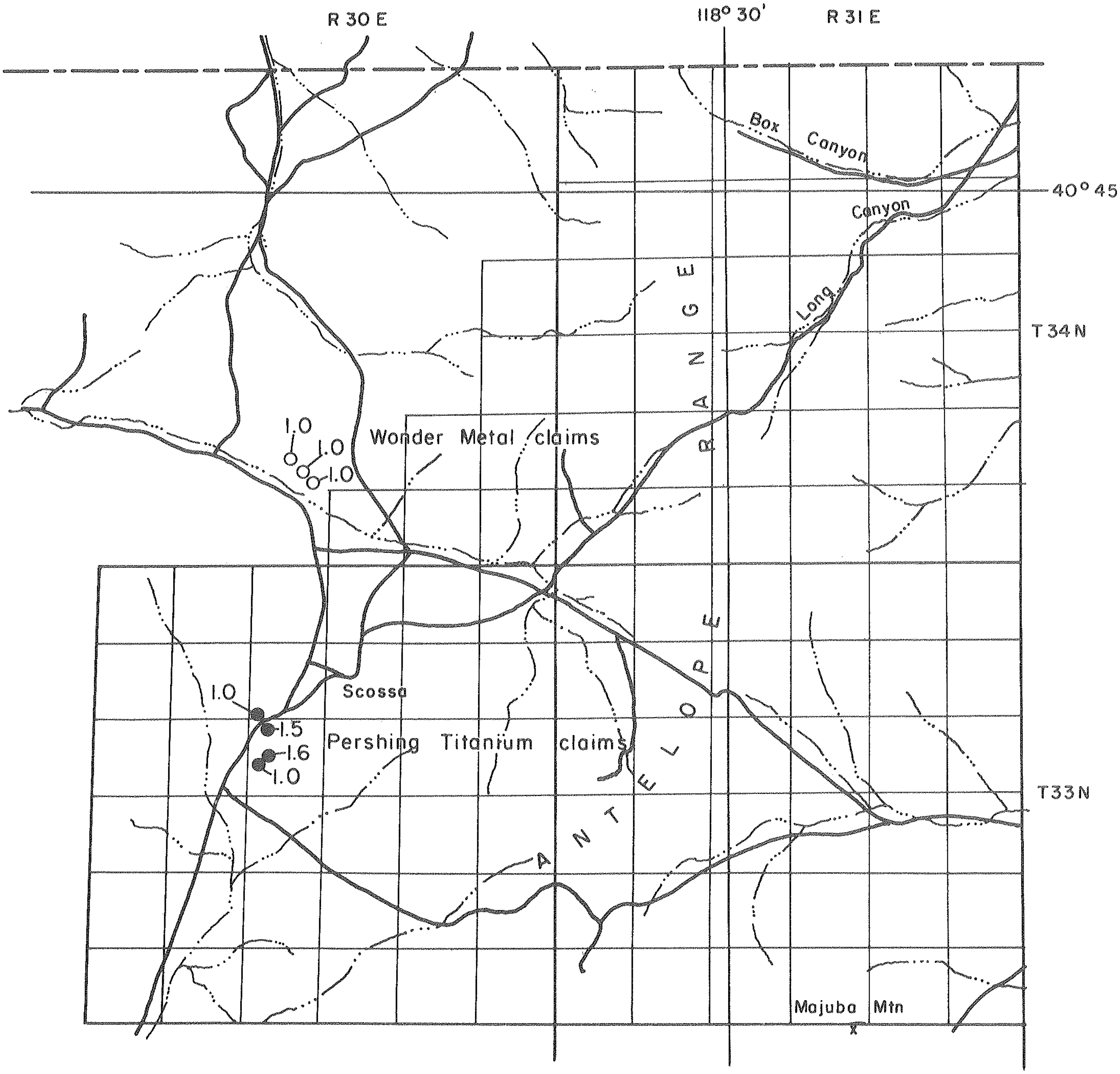

Figure 4. Assay map of the Pershing Titanium claims and Wonder Metal claims, Pershing County, Nevada.

RVW

The altered basement volcanic rocks in the area are capped by gray or brown pitchstone and rhyolites. Recent erosion has exposed large areas of buff, maroon, and red altered volcanic rocks. Gullies and tiny water courses traversing these andesitic rocks exhibit minor placer concentrations of black sands. Locally the altered andesites display small dark lenses which are enriched by titaniferous magnetite and magnetite. Irregular perlitic masses are associated locally with the volcanic rocks.

Random samples collected by the Nevada Bureau of Mines contained from 0.7 to 1.3 percent TiO_2. Samples collected by Mr. C. D. Smith of Gerlach assayed 0.9, 2.5, and 3.8 percent TiO_2; these samples were cut from enriched zones. Black sand concentrates submitted by Smith contained 32.0 percent TiO_2 and traces of scheelite, but to date he has not been able to upgrade the titaniferous magnetite to ore grade.

PEAVINE DISTRICT

Redelius, Miller, and Shipton titanium properties

The Redelius titanium property is located in the northwestern corner of Hungry Valley (secs. 21 and 22, T. 22 N., R. 20 E.). The property owned by Julius Redelius of Reno, Nev., consists of six lode and several placer claims. Workings include two 50-foot shafts and extensive "trenching" along a southeasterly trending fault zone.

Aplite is the country rock in the immediate vicinity of the workings. Minor amounts of rutile occur throughout the aplite, but the tiny rutile blebs or grains appear to be concentrated chiefly in the silicified shear and gouge zones along the fault. Talc and minor amounts of sericite and/or muscovite are generally associated with small rutile lenses. Dark-gray feldspar porphyry dikes which occur in the fault zone contain little or no rutile. Although individual samples have been cut which contained up to 30 percent TiO_2, the average titanium oxide content of samples from areas of "rutile concentrations" assayed less than 1 percent.

There are two other rutile occurrences in the vicinity, the Miller and Shipton properties.

Two miles west of the Redelius property, large aplitic bodies contain an average TiO_2 content of approximately 0.5 percent. Rutile-bearing quartz and feldspar pegmatite bodies associated with these aplitic masses contain up to 3 percent TiO_2, according to Mr. Clyde Miller of Sparks, Nev.

The two Shipton rutile claims (sec. 22, T. 22 N., R. 20 E.) were controlled by Jack Shipton of Sparks, Nev. in 1952. Rutile occurs sparsely near the contact of quartz and feldspar (pegmatitic dikes) in diorite.

OTHER OCCURRENCES

Small rutile-bearing quartz veins, which cut altered volcanics, have been reported just north of the Black Panther mine (3 miles north of Reno, Nev.).

SUMMARY

Titanium-bearing rock deposits in Nevada are limited for the most part to the southern Virgin Mountains, the east flank of the Stillwater Range, and the Hungry Valley area west of the Virginia Range. Although titanium occurrences have been reported elsewhere, these occurrences are very low-grade, averaging 1 percent or less TiO_2.

In the southern Virgin Mountains, titaniferous magnetite and ilmenite(?) occur in small pegmatites. The best estimated grade for limited tonnages is less than 3.5 percent TiO_2. These titanium-bearing pegmatites are widely dispersed. At and near Corral Canyon in the Stillwater Range, irregular albitic dikes or sills contain several thousands of tons of 3.5 percent TiO_2 (chiefly anatase or rutile). The largest titanium-bearing albitic body in this area is approximately 100 by 750 feet, and has an estimated TiO_2 content of 2 percent. In Hungry Valley, Washoe County, aplite, diorite, and "talcose" rocks having a TiO_2 content of over 1 percent are not common. Small concentrations of rutile occur locally in these rocks.

Sedimentary titanium occurrences are widely distributed throughout Nevada. The most important of these is in the Gold Butte district, where there are several million tons of placer material containing chiefly titaniferous magnetite; locally the placer sands contain up to 5 percent TiO_2.

The known titanium occurrences in the State show little economic promise. There are no occurrences of either: (1) large low-grade or small high-grade rock deposits containing more than a few tons of titanium minerals or (2) large low-grade titaniferous placers or beach sands. Certain areas are actually deficient in titanium. In addition, owing to the high ratio of iron to titanium and the homogeneity of the substance, titaniferous magnetite from the numerous rock and placer deposits appears to be unsuited for upgrading to an acceptable TiO_2 content.

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A P P E N D I X

CHEMICAL AND PETROGRAPHIC ANALYSES OF SELECTED SAMPLES FROM NEVADA TITANIUM OCCURRENCES

Location	% TiO_2	Description	Heavy Minerals
CHURCHILL COUNTY			
Sand Springs Area			
<u>Sand Springs Dune</u>			
1. Dune	tr.	Dune sands	
2. Dune	0.8	Dune sands	
3. Dune	0.4	Dune sands	
4. Dune	0.4	Dune sands	
5. Dune	0.4	Dune sands	
6. Dune	0.8	Dune sands	
7. Dune	0.6	Dune sands	Magnetite, titaniferous magnetite, hornblende, garnet, hyperthene, tourmaline, rutile, zircon
8. Dune	3.3	Dune sands	Magnetite, titano-ilmenite, hornblende, hyacinth, hyperthene, limonite
Table Mt. District			
<u>Corral Canyon</u>			
1. 800' S of Corral Canyon	3.5	Albitic dike	Anatase, minor ilmenite, and magnetite
2. 1,850' S of Corral Canyon	2.0	Albitic dike	Anatase, minor ilmenite, and magnetite
3. 500' W of mouth Corral Canyon	1.7	Diabase dike	
4. 700' W of mouth Corral Canyon	0.5	Diabase dike	
5. 800' W of mouth Corral Canyon	0.8	Diabase dike	
<u>Last Chance claims</u>			
1. L. C. no. 4	tr.	Gabbro	

APPENDIX - CONTINUED

CHEMICAL AND PETROGRAPHIC ANALYSES OF SELECTED SAMPLES FROM NEVADA TITANIUM OCCURRENCES

Location	% TiO_2	Description	Heavy Minerals
Last Chance claims - Continued			
2. L. C. no. 4	-	Gabbro	
3. L. C. no. 1	0.9	Diorite	
4. L. C. no. 1	0.4	Aplite	
5. L. C. no. 1	-	Altered metavolcanic	
6. L. C. no. 1	0.4	Gabbro	
7. L. C. placer	0.7	Placer	
8. L. C. placer	1.0	Placer	
9. L. C. placer	1.2	Placer	
CLARK COUNTY			
Bunkerville District			
1. Whitney Ridge	3.5	Pegmatite	
Gold Butte District (southern Virgin Mts.)			
1. SE 1/4 sec. 23, T. 21 S., R. 70 E.	1.5	Placer grab sample, over 200'	Biotite, hornblende, garnet, hyperthene, titaniferous magnetite
2. NE 1/4 sec. 23, T. 21 S., R. 70 E.	1.7	Placer grab sample, over 200'	Hornblende, garnet-spinel, biotite, hyperthene, epidote, zircon, titaniferous magnetite
3. SE 1/4 sec. 9, T. 21 S., R. 70 E.	1.4	Placer grab sample, over 150'	Biotite, garnet-spinel, hornblende, hyperthene, epidote, zircon, titaniferous magnetite
4. NE 1/4 sec. 5, T. 21 S., R. 70 E.	1.8	Placer grab sample, over 200'	Biotite, garnet-spinel, epidote, hornblende, hyperthene, apatite, zircon, titaniferous magnetite

A P P E N D I X - CONTINUED

CHEMICAL AND PETROGRAPHIC ANALYSES OF SELECTED SAMPLES FROM NEVADA TITANIUM OCCURRENCES

Location	% TiO_2	Description	Heavy Minerals
Gold Butte District - Continued (southern Virgin Mts.)			
5. NW 1/4 sec. 14, T. 17 S., R. 69 E.	1.4	Placer grab sample, over 100'	
6. Jumbo Basin	1.0	Grab sample of granitic rock	Biotite, spinel-garnet, hornblende, hyperthene, zircon, titaniferous magnetite
7. Windmill mine area	1.3	Grab sample biotite schist	Biotite, spinel-garnet, enstatite, epidote, titaniferous magnetite, zircon
8. Jumbo Basin	1.2	N part, placer	
9. Gotchell Spring	3.8	Placer	
10. Jumbo Basin	3.8	NW part, placer	
11. Jumbo Basin	0.5	W part, placer	
12. Jumbo Basin	0.8	SW part, placer	
13. Jumbo Basin	4.2	SW part, placer	
14. Jumbo Basin	4.0	S part, placer	
15. Jumbo Basin	tr.	SE part, placer	
16. Scanlon	0.8	Pegmatite	
17. Scanlon	2.5	Placer	
18. Scanlon	tr.	E of stream, placer	
19. Scanlon	2.5	E of stream, placer	
20. Scanlon	0.8	BM 3546, placer	
21. Scanlon	0.3	S of BM 3546, placer	
22. Turkey Springs	3.5	Pegmatite	
23. Ruby Springs	1.0	Placer	
24. Garnet Valley (SW 1/4 sec.25)	4.0	Placer	
25. Garnet Valley (SW 1/4 sec.25)	0.8	Placer	
26. Garnet Valley (NW 1/4 sec.36)	5.0	Placer	

APPENDIX - CONTINUED

CHEMICAL AND PETROGRAPHIC ANALYSES OF SELECTED SAMPLES FROM NEVADA TITANIUM OCCURRENCES

Location	% TiO_2	Description	Heavy Minerals
Gold Butte District - Continued (southern Virgin Mts.)			
27. Garnet Valley (SE 1/4 sec. 36)	4.0	Placer	
28. Jumbo Valley (W side)	5.8	Placer	Titaniferous magnetite, spinel biotite, hornblende, epidote, zircon, tourmaline, garnet
29. Turkey Springs	5.8	Placer	
30. BM 3324	1.7	Placer	
DOUGLAS COUNTY			
Buckskin District			
1. Blue Metal Corundum ore	1.0	Schist	
ELKO COUNTY			
Gonce Creek			
Black Beauty claims			
1. Canyon	-	Slate	Clay, sericite, quartz, minor sphene
2. Canyon	-	Sandstone	Magnetite, ilmenite, hornblende, pyrite, epidote, hyperthene
Railroad District			
1.	0.3	Placer grab sample	
2.	0.2	Placer grab sample	

A P P E N D I X - CONTINUED

CHEMICAL AND PETROGRAPHIC ANALYSES OF SELECTED SAMPLES FROM NEVADA TITANIUM OCCURRENCES

Location	% TiO_2	Description	Heavy Minerals
EUREKA COUNTY			
Eureka District			
Hunter Ranch ilmenite claims			
1. Hunter Creek	0.8	Tuffaceous sandstone	Magnetite, ilmenite, hornblende, biotite, enstatite, limonite, actinolite
2. Hunter Creek	0.7	Tuffaceous sandstone	
3. Hunter Creek	tr.	Tuffaceous sandstone	
4. Hunter Creek	3.0	Stream concentrates	
5. Hunter Creek	0.5	Tuffaceous sandstone	
HUMBOLDT COUNTY			
Pine Forest Range			
Gridley Lake ilmenite placer			
1. 1 mile E of Lake	2.8	Stream concentrates	
2. 1 mile E of Lake	1.0	Placer sample	
Other Occurrences			
1. Vicksburg district	0.1	Schist	
2. Vicksburg district	0.6	Schist	
3. Ashtown district	tr.	Gneiss	
4. Ashtown district	0.1	Schist	
5. Ashtown district	tr.	Schist	

CHEMICAL AND PETROGRAPHIC ANALYSES OF SELECTED SAMPLES FROM NEVADA TITANIUM OCCURRENCES

Location	% TiO_2	Description	Heavy Minerals
Other Occurrences - Continued			
6. Bartlett Butte area	0.3	Schist	
7. Bartlett Butte area	0.3	Schist	
8. Bartlett Butte area	0.5	Schist	
9. Bartlett Butte area	0.8	Schist	
Sand Creek Occurrence			
1. SE of Creek	6.8	Skarn	
2. SE of Creek	tr.	Hybrid rock	
3. SE of Creek	0.5	Hornfels	
LINCOLN COUNTY			
Panaca Ilmenite Placers			
1.	0.8	Stream placer	
2.	0.5	Stream placer	
LYON COUNTY			
East Walker River Area			
Lucky 9 Uranium claims			
1. H-22 (515')	4.2	Sandstone	Titaniferous magnetite, magnetite, hornblende, hyperthene, biotite

A P P E N D I X - CONTINUED

CHEMICAL AND PETROGRAPHIC ANALYSES OF SELECTED SAMPLES FROM NEVADA TITANIUM OCCURRENCES

Location	% TiO_2	Description	Heavy Minerals
Lucky 9 Uranium claims - Continued			
2. Adit no. 1	1.2	Sandstone	Magnetite, titaniferous magnetite, hornblende, biotite, epidote
3. H-22 (0-20')	1.3	Tuffaceous sandstone	
4. H-22 (25-80')	1.2	Tuffaceous sandstone	
5. H-22 (80-100')	1.5	Tuffaceous sandstone	
6. H-22 (100-120')	1.2	Tuffaceous sandstone	
7. H-22 (120-130')	1.5	Tuffaceous sandstone	
8. H-22 (145-150')	1.7	Tuffaceous sandstone	
9. H-22 (180-185')	1.5	Sandstone	
10. H-22 (200-215')	1.3	Sandstone	
11. H-22 (265-295')	1.2	Sandstones, basalt	
12. H-22 (295-335')	1.2	Sandy tuffs	
13. H-22 (335-375')	1.0	Basalt (interbedded sandstone)	
14. H-22 (380-400')	1.2	Clay	
15. H-22 (405-420')	1.3	Clay	
16. H-22 (420-460')	1.2	Clay	
17. H-22 (460-480')	0.8	Tuffaceous sandstone	
18. H-22 (480-545')	1.0	Sandstone	
19. H-22 (685-700')	0.8	Tuffaceous sandstone	
20. H-22 (700-720')	1.0	Tuffaceous sandstone	
21. H-22 (720-740')	1.3	Tuffaceous sandstone	

A P P E N D I X - CONTINUED

CHEMICAL AND PETROGRAPHIC ANALYSES OF SELECTED SAMPLES FROM NEVADA TITANIUM OCCURRENCES

Location	% TiO_2	Description	Heavy Minerals
NYE COUNTY			
Amargosa Desert			
Big Dune			
1. Dune	0.4	Dune sand	Hornblende, magnetite, ilmenite, rutile, zircon
2. Dune	0.3	Dune sand	Hornblende, hyperthene, biotite, titaniferous magnetite, sphene
3. Dune	0.1	Dune sand	Hornblende, titaniferous magnetite, biotite, sphene, zircon
4. Dune	0.4	Dune sand	Hornblende, titaniferous magnetite, hyperthene, sphene, biotite.
Belmont District			
Flower's ilmenite claims			
1. Antone Canyon	0.8	Stream concentrates	
2. Antone Canyon	1.0	Stream concentrates	
Round Mountain District			
1. Placer	15.0	Concentrates from dredge	Chiefly ilmenite
2. Placer	13.5	Concentrates from dredge	Chiefly ilmenite

A P P E N D I X - CONTINUED

CHEMICAL AND PETROGRAPHIC ANALYSES OF SELECTED SAMPLES FROM NEVADA TITANIUM OCCURRENCES

Location	% TiO_2	Description	Heavy Minerals
Manhattan District			
1.	tr.	Placer gravels	
2.	0.5	Placer gravels	
Salisbury Wells			
Salisbury Wash ilmenite claims			
1. Salisbury Wash	9.1	Black sand concentrates	Titaniferous magnetite, hornblende, biotite, zircon
2. Salisbury Wash	tr.	Placer gravels	
3. Salisbury Wash	0.3	Placer gravels	
4. Salisbury Wash	0.3	Placer gravels	
5. Salisbury Wash	tr.	Placer gravels	
PERSHING COUNTY			
Rabbit Hole Springs District			
Constant Mineral placer			
1.	5.0	Stream concentrates	
2.	4.5	Stream concentrates	
Scossa District			
Pershing Titanium claims			
1. Stream bed	0.5	Minor schist	

A P P E N D I X - CONTINUED

CHEMICAL AND PETROGRAPHIC ANALYSES OF SELECTED SAMPLES FROM NEVADA TITANIUM OCCURRENCES

Location	% TiO_2	Description	Heavy Minerals
<u>Pershing Titanium claims - Continued</u>			
2. Stream bed	0.5	Minor schist	
3. Stream bed	0.7	Minor schist	
4. L.M.P.T. no. 1	0.6	Minor schist	
5. SW cor. PT no. 2	1.0	Minor schist	
6. SW cor. PT no. 2	1.6	Minor schist	
7. Stream bed	1.5	Schist	
8. Stream bed	1.0	Schist	
9. Stream bed	0.4	Phyllite	Sphene, pyrite, limonite
<u>Wonder Metal claims</u>			
1. L.M.W.M. no. 1	1.0	Churn drill cuttings	
2. 1,200' W L.M.W.M. no. 1	1.0	Churn drill cuttings	
3. 400' W L.M.W.M. no. 2	1.0	Churn drill cuttings	
Other Occurrences			
<u>Garrett Ranch</u>			
1. 1/2 mile SW	0.5	Stream concentrates	
2. 1/2 mile SW	1.0	Stream concentrates	
WASHOE COUNTY			
Forty-nine Range			

APPENDIX - CONTINUED

CHEMICAL AND PETROGRAPHIC ANALYSES OF SELECTED SAMPLES FROM NEVADA TITANIUM OCCURRENCES

Location	% TiO_2	Description	Heavy Minerals
Forty-nine Range placer			
1. W flank of Range	0.2	Stream concentrates	
2. W flank of Range	0.8	Stream concentrates	
3. W flank of Range	0.9	Stream concentrates	
4. W flank of Range	0.3	Placer gravels	
5. W flank of Range	0.7	Stream concentrates	
6. W flank of Range	0.2	Stream concentrates	
Gerlach District			
Last Stand claims			
1. L. S. no. 1	0.7	Altered volcanic tuff	
2. L. S. no. 1	tr.	Altered volcanic tuff	
3. L. S. no. 1	0.8	Altered volcanic tuff	
4. L. S. no. 2	0.9	Altered volcanic tuff	
5. L. S. no. 2	1.3	Altered volcanic tuff	
6. L. S. no. 2	0.9	Altered volcanic	
7.	23.3	Concentrate of ilmenite tuff	
8.	2.5	Ilmenite-rich tuff lenses	
9.	3.8	Ilmenite-rich tuff lenses	
10. L. S. no. 3	0.9	Altered volcanic tuff	
Peavine District			
Miller titanium property			
1.	0.7	Aplite	Hornblende, biotite, epidote, apatite, magnetite, rutile

CHEMICAL AND PETROGRAPHIC ANALYSES OF SELECTED SAMPLES FROM NEVADA TITANIUM OCCURRENCES

Location	% TiO_2	Description	Heavy Minerals
Miller titanium property - Continued			
2.	0.5	Aplite	
3.	1.0	Aplite	
Redelius titanium claims			
1. Workings	0.5	Fault zone in talc schist	
2. Workings	tr.	Fault zone in talc schist	
3. Workings	0.4	Fault zone in talc schist	
4. Workings	0.4	Fault zone in talc schis'	
5. 1/2 mile E of workings	0.6	Aplite	
6. 1/2 mile E of workings	0.5	Aplite	
7. 1/2 mile E of workings	0.3	Aplite	

INDEX

TITANIUM OCCURRENCES

● Rock

■ Sedimentary

▣ Combined and Sedimentary

ROCK

1 Black Beauty claims, Elko Co.
2 Sand Creek, Humboldt Co.
3 Last Stand claims, Washoe Co.
4 Wonder Metals claims, Pershing Co.
5 Pershing Titanium claims, Pershing Co.
6 Last Chance claims, Churchill Co.
7 Corral Canyon, Churchill Co.
8 Redelius Titanium claims, Washoe Co.
9 Miller Titanium claims, Washoe Co.
10 Black Panther mine, Washoe Co.
11 Blue Metals Corundum, Douglas Co.
12 Bellehelen district, Nye Co.
13 Whitney Ridge, Clark Co.
14 South Virgin Mountains, Clark Co.
15 Boss mine, Clark Co.

SEDIMENTARY

1 Gridley Lake Ilmenite, Humboldt Co.
2 Forty-Nine Range, Washoe Co.
3 Last Stand claims, Washoe Co.
4 Constant Mineral Separation Co., Pershing Co.
5 Dixie Creek, Elko Co.
6 Last Chance claims, Churchill Co.
7 Hunter Ranch Ilmenite, Eureka Co.
8 Sand Springs, Churchill Co.
9 Lucky 9 Uranium, Lyon Co.
10 Round Mountain, Nye Co.
11 Flower Ilmenite, Nye Co.
12 Salisbury Wash, Nye Co.
13 Panaca Wash, Lincoln Co.
14 South Virgin Mountains, Clark
15 Big Dune, Nye Co.

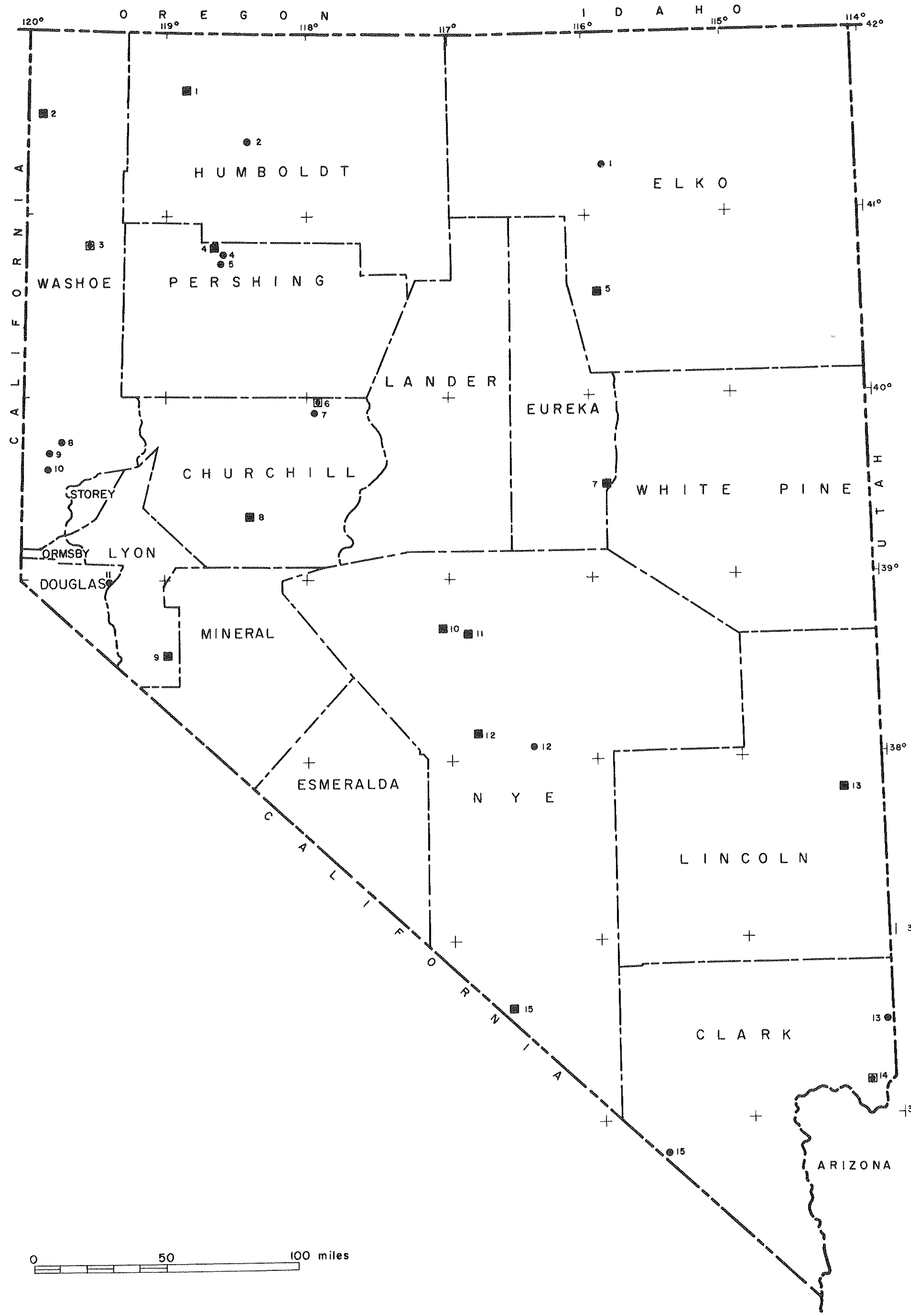

Plate I. Map showing location of titanium occurrences in Nevada.

RVW

The Mackay School of Mines is one of the several colleges of the University of Nevada. The School consists of three divisions: the academic Departments of Instruction, the Nevada Bureau of Mines, and the Nevada Mining Analytical Laboratory. The Mackay School of Mines is thus the State of Nevada's educational research and public service center for the mineral industry.

The Nevada Bureau of Mines and the Nevada Mining Analytical Laboratory serve the public as State agencies to assist in developing Nevada's mineral resources. They identify, analyze, and evaluate minerals, rocks, and ores found in Nevada. They conduct field studies on Nevada geology and mineral deposits, including metallic and industrial minerals as well as oil and gas. They pursue laboratory and library research in mineral beneficiation, extractive metallurgy, and economic problems connected with the mineral industry of Nevada.

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