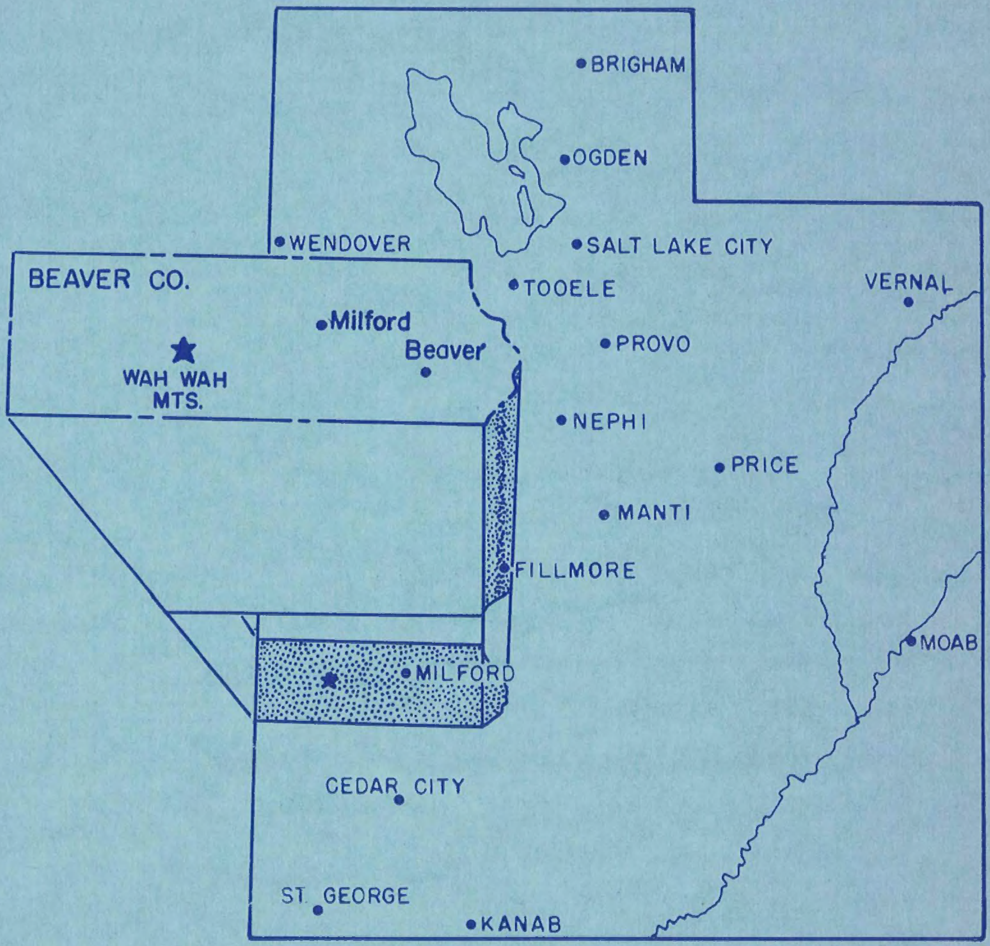
HYDROTHERMAL ALTERATION AND MINERALIZATION STAATS MINE AND BLAWN MOUNTAIN AREAS, CENTRAL WAH WAH RANGE, BEAVER COUNTY, UTAH



Utah Geological and Mineralogical Survey

Special Studies 12

UTAH GEOLOGICAL AND MINERALOGICAL SURVEY

103 Civil Engineering Building
University of Utah
Salt Lake City, Utah 84112

THE UTAH GEOLOGICAL AND MINERALOGICAL SURVEY since 1949 has been affiliated with the College of Mines and Mineral Industries at the University of Utah. It operates under a director with the advice and counsel of an Advisory Board appointed by the Board of Regents of the University of Utah from organizations and categories specified by law.

The survey is enjoined to cooperate with all existing agencies to the end that the geological and mineralogical resources of the state may be most advantageously investigated and publicized for the good of the state. The *Utah Code, Annotated, 1953 Replacement Volume 5, Chapter 36, 53-36-2,* describes the Survey's functions.

Official maps, bulletins, and circulars about Utah's resources are published. (Write to the Utah Geological and Mineralogical Survey for the latest list of publications available).

THE LIBRARY OF SAMPLES FOR GEOLOGIC RESEARCH. A modern library for stratigraphic sections, drill cores, well cuttings, and miscellaneous samples of geologic significance has been established by the Survey at the University of Utah. It was initiated by the Utah Geological and Mineralogical Survey in cooperation with the Departments of Geology of the universities in the state, the Utah Geological Society, and the Intermountain Association of Petroleum Geologists. This library was made possible in 1951 by a grant from the University of Utah Research Fund and by the donation of collections from various oil companies operating in Utah.

The objective is to collect, catalog, and systematically file geologically significant specimens for library reference, comparison, and research, particularly cuttings from all important wells driven in Utah, and from strategic wells in adjacent states, the formations, faunas, and structures of which have a direct bearing on the possibility of finding oil, gas, salines or other economically or geologically significant deposits in this state. For catalogs, facilities, hours, and service fees, contact the office of the Utah Geological and Mineralogical Survey.

THE SURVEY'S BASIC PHILOSOPHY is that of the U. S. Geological Survey, i.e., our employees shall have no interest in Utah lands. For permanent employees this restriction is lifted after a 2-year absence; for consultants employed on special problems, there is a similar time period which can be modified only after publication of the data or after the data have been acted upon. For consultants, there are no restrictions beyond the field of the problem, except where they are working on a broad area of the state and, here, as for all employees, we rely on their inherent integrity.

DIRECTORS:

William P. Hewitt, 1961-
Arthur L. Crawford, 1949-1961

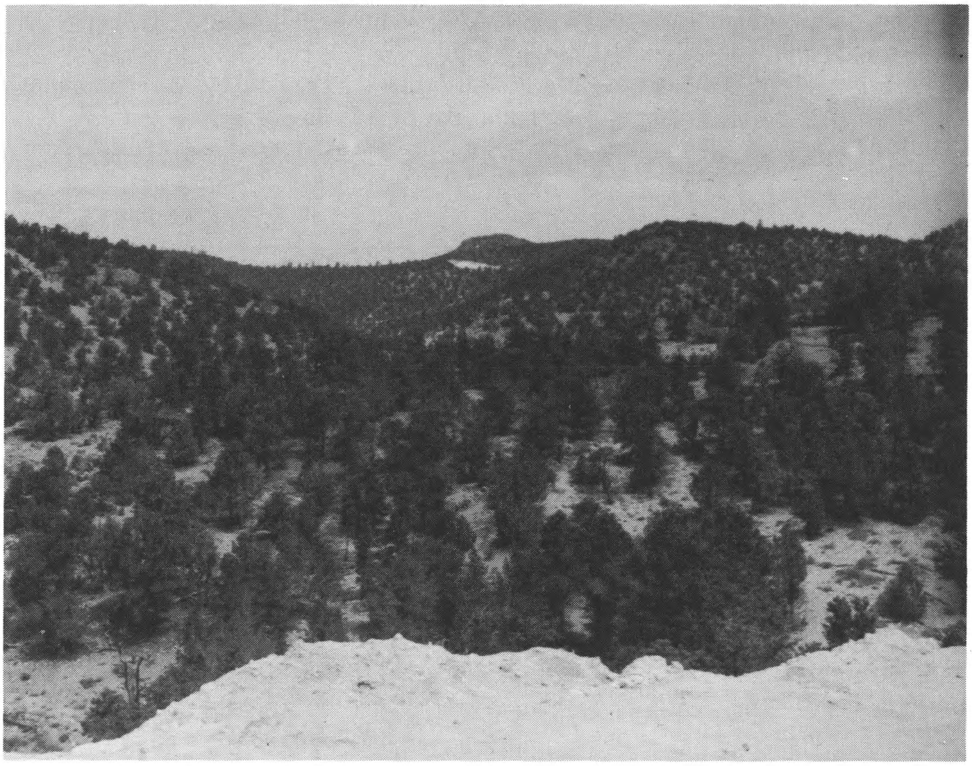
HYDROTHERMAL ALTERATION AND MINERALIZATION

STAATS MINE AND BLAWN MOUNTAIN AREAS,

CENTRAL WAH WAH RANGE,

BEAVER COUNTY, UTAH

by James A. Whelan
Department of Mineralogy
University of Utah



Blawn Mountain from the southwest, showing exploration cuts.

Utah Geological and Mineralogical Survey
affiliated with
The College of Mines and Mineral Industries
University of Utah, Salt Lake City, Utah

Publication of and field work for this Study supported by the Uniform School Fund of the University of Utah.

SPECIAL STUDIES NO. 12. • PRICE $1.50 • JUNE, 1965

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

HYDROTHERMAL ALTERATION AND MINERALIZATION IN THE STAATS MINE AND BLAWN MOUNTAIN AREAS, CENTRAL WAH WAH RANGE, BEAVER COUNTY, UTAH

by James A. Whelan[1]

ABSTRACT

Two adjacent areas of hydrothermal alteration and mineralization, designated the Staats Mine and Blawn Mountain areas, were mapped in the central part of the Wah Wah Mountain Range, about 45 miles southwest of Milford, Beaver County, Utah.

In the Staats Mine area (named for the Staats fluorite-uranium mine) a rhyolite-porphyry complex, intruded by igneous breccia, has intruded Paleozoic dolomites. On the west side of the intrusion, a mylonized breccia has been developed in which both fluorite and uranium mineralization occur: the fluorite in small lenticular shoots; the uranium as impregnations and incrustations of urannite, autunite, uranophane, metatorbernite, and an unidentified yellow uranium mineral. There has been commercial production of both fluorite and uranium from the area.

Blawn Mountain, also a rhyolite porphyry intrusive, intrudes Paleozoic dolomites on the south, quartzite to the west, and possibly Tertiary volcanic flow to the north. Along the south and west sides of the mountain, kaolinitic, alunitic, uranium, and iron mineralization occurs. Significant tonnages of kaolinite and a pure, high potash variety of alunite are exposed in outcrop and in exploration cuts. In addition, areas of kaolinitic float have been mapped. The Blawn Mountain kaolinite, much of it lightly iron stained, is relatively pure. If the iron staining is superficial, as it appears, the kaolinite would be suitable for ceramic or filler purposes.

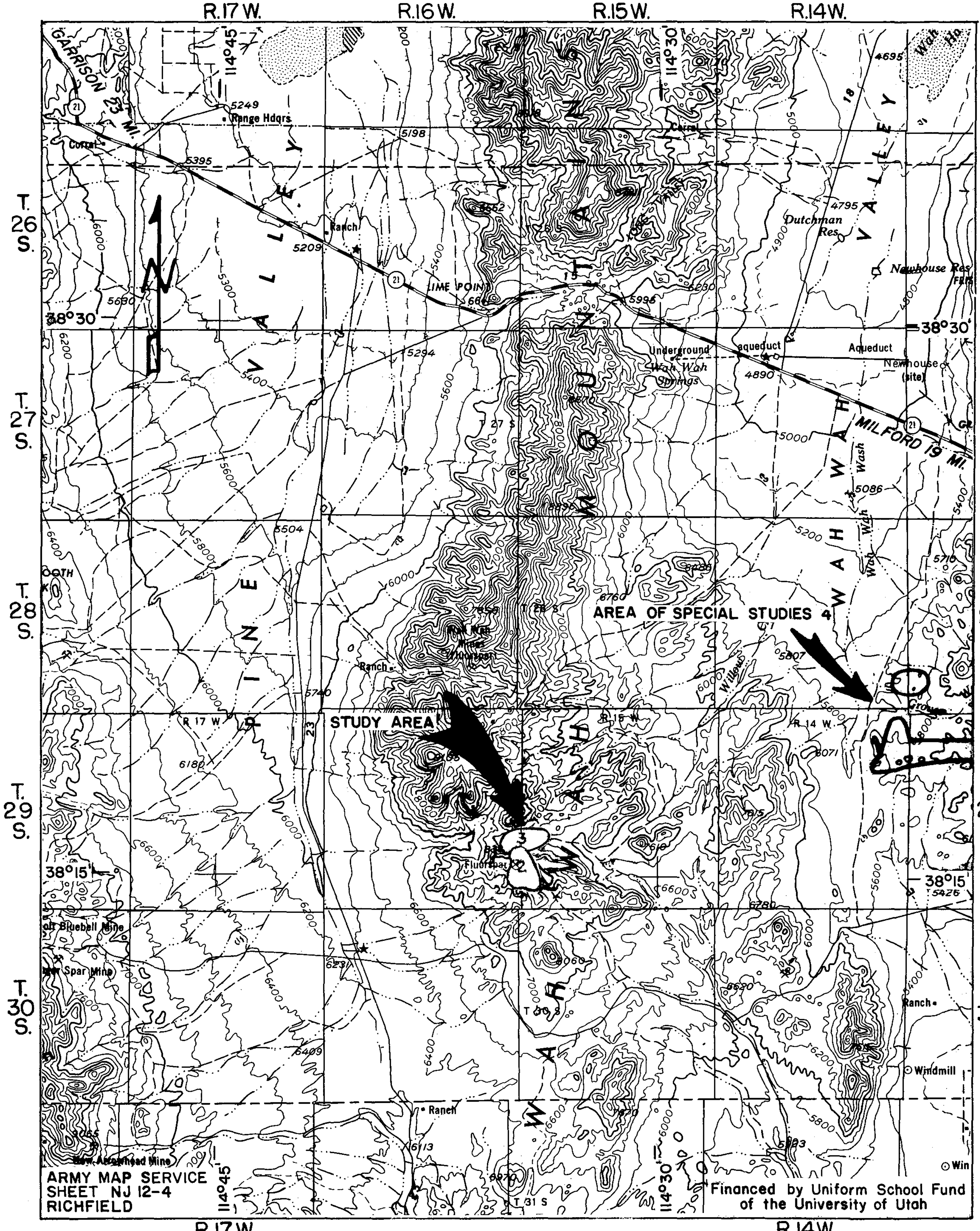
Also occurring in the Blawn Mountain area are radioactive iron-stained clays, together with reported radioactive material in drill holes. Neither the grade of uranium mineralization nor the specific minerals has been determined. Small occurrences of iron mineralization, chiefly magnetite-hematite mixtures exist, and the rhyolite porphyry, severely silicified, is almost a pure silica rock.

The report lists recommendations for prospecting and exploration.

---

1. Department of Mineralogy, University of Utah.

PLATE 1



LOCAL INDEX TO STUDY AREAS

INTRODUCTION

This report summarizes the results of one of a continuing series of studies of hydrothermal alteration zones of possible economic significance financed by the Uniform School Fund of the University of Utah. The area described, located in the south central portion of the Wah Wah Range, Beaver County, Utah, contains several rhyolite porphyry intrusions with associated hydrothermal alteration and mineralized breccia zones.

Geography

Because of differences in mineralization and alteration, the study area (Plate I) was divided into the Staats Mine area and the Blawn[1] Mountain area, even though the areas adjoin each other.

Access to the area is by gravel and dirt roads from Milford, a distance of 45 miles. The region may be reached more easily by taking Utah Highway 21 to the west side of the Wah Wah Range, a distance of 35 miles, and then taking gravel and dirt roads south into the area for a distance of 30 miles.

The climate is arid, but sudden summer thunder storms may be severe enough to wash out roads. In winter, access into the higher parts of the area is presently limited because of snow.

No permanent surface water is available, but water is obtained from several windmill-pumped wells in the southern Wah Wah Mountains. No power is available in the area.

Blawn Mountain has a maximum elevation of 8,390 feet. The hills representing the intrusions in the Staats Mine area have maximum elevations of about 7,800 feet. The valleys surrounding these intrusions have elevations down to 7,200 feet.

The mapped areas are forrested with piñon and ponderosa pine at higher elevations. At lower elevations the predominant vegetation is juniper.

The southern Wah Wah Mountains are on public domain. Much of the area mapped, however, has been claimed as mineral lands under the mining law of 1872.

---

1. Various maps denote this ridge and the associated wash as Blawn or Blonde Mountain and Wash respectively. The earliest records available to the writer were 1938 land plats which record Blawn Wash. Blawn will be used throughout this report.

The current status of the various claims is unknown. The Bureau of Land Management, Salt Lake City, has plats showing the Monarch claims One through Four and the Eureka Number One claim as patented.

Past Production

The first ore shipments from the areas mapped were small shipments of iron ore from the Blawn Mountain area to the Frisco smelters between 1880 and 1900.

About 1935 fluorspar was first discovered in the area and between 1935 and 1946, 3,500 tons of 80-91 per cent CaF_2 ore were shipped from the Staats Mine[1] (Monarch and Eureka claims) (Thurston et al., 1954, p. 16-19). The same mine has produced about 1,900 tons of uranium ore (Nackowski and Levy, 1959).

In the summer of 1963 the only activity in the area was the shipment of minor tonnages of kaolinite and alunite from Blawn Mountain to Rocky Mountain Refractories, Salt Lake City.

Previous Studies

The earliest summary of geology in the Wah Wah Range is given in Butler et al. (1920). Crawford and Buranek (1943, p. 13-14) briefly describe the iron deposits on Blawn Mountain. A U.S. Geological Survey map by Taylor and Powers (1953) is on open file.

The Staats fluorite mine is briefly described by Thurston, et al. (1954, p. 16-19). Arthur Richards and John C. Brooke (1961) have assembled a map of the southern Wah Wah Range (but north of the area of this report) from data of the Southern Methodist University field camp. The most complete study of the area described in this report is the University of Washington doctoral thesis by G. M. Miller (1959). Nackowski and Levy (1959) give statistical data on the production of fluorite and uranium from the area and mention the Blawn Mountain iron occurrences. Some sketch maps of Blawn Mountain have been prepared by the Atomic Energy Commission and various mining companies.

All available data were used in the field study and preparation of this report.

---

1. The Staats Mine has also been called the Monarch Mine, the Skougard Mine, the Roberts and Skougard Mine, and the Roberts and Staats Mine (Thurston et al., 1954).

Field and Laboratory Methods

No quadrangle maps were available of the area. Topography is shown on the U.S. Geological Survey A.M.S. map Richfield NJ -214 at a scale of 1:250,000. Sheet 2 of the General Highway Map of Beaver County, at a scale of one inch to a mile, was used to locate certain physical features. Where possible, mapping was done on vertical aerial photographs with scale of approximately 400 feet to the inch. Five section and quarter section monuments were found and used for control. Because of heavy timber cover and because many roads and cuts have been made since the aerial photographs were taken (1949), much of the area was mapped by tape and compass traverse. The maximum closure found during plotting was 80 feet.

Over one hundred samples were studied at the Department of Mineralogy, University of Utah, utilizing optical methods, thin sections, infrared absorption spectra, differential thermal analysis, x-ray diffraction and fluorescence, and chemical techniques.

Field work was completed during the summer of 1963 and laboratory work was completed during the 1963-64 school year.

Acknowledgments

Allen O. Taylor and John F. Powers of the Cerro Verde Company, Salt Lake City, contributed their knowledge of the area through helpful discussions.

Mr. Mickey Robis, Milford, Utah, and the Rocky Mountain Refractories Company, Salt Lake City, furnished geologic sketch maps of the Blawn Mountain area.

Gustav Baetcke was field assistant on the project.

Professor Lehi Hintze, Head, Department of Geology, Brigham Young University, discussed various aspects of the problems and gave much assistance by furnishing maps and publications on the area.

Financial assistance for the field work and publication of this study was received from the Uniform School Fund, University of Utah.

GENERAL GEOLOGY OF THE WAH WAH RANGE

The Wah Wah Mountains, basically a syncline plunging towards the northeast, are a typical Basin and Range feature. North of the area mapped (the main portion of the range), Cambrian Prospect Mountain Quartzite generally constitutes the west edge of the range, and the section rises from west to east into Cambrian limestones and dolomites. On the east side of the range, Tertiary volcanics are prominent.

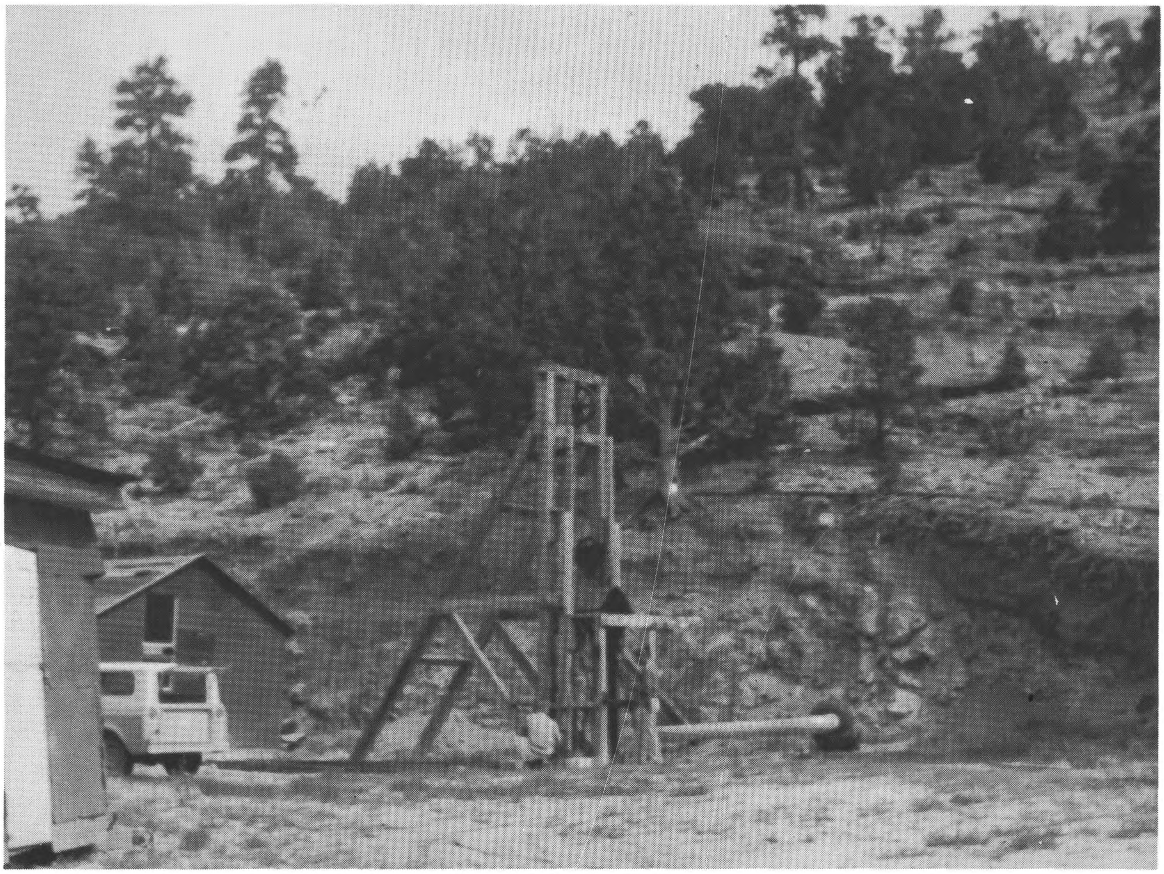


Figure 1. Headframe and hoisthouse, Staats Mine.

Figure 2. Main intrusion, Staats Mine area.

In the study area, faulting, including thrust faulting, and intrusion by rhyolite porphyry are important. Rock types include the Ordovician Eureka Quartzite, Paleozoic dolomites and limestone, probably ranging in age from Ordovician through Mississippian, intrusive rhyolite porphyry, and Tertiary volcanics.

For the geology surrounding the areas described herein the reader is referred to Miller (1959).

STAATS MINE AREA

The area which, for convenience, will be called the Staats mine area (Plate II) is about $1\frac{1}{4}$ miles long and $\frac{1}{2}$ mile wide. It lies along and just east of the eastern boundary of Sec. 35, T. 29 S., R. 16 W. This area is named for the Staats Mine which has workings on the west and south edges of the main intrusion. Access from the south is by gravel road up Sawmill Canyon or from the northeast from Blawn Mountain by dirt road. A series of rhyolitic intrusions and associated breccias intrudes Paleozoic dolomites. These intrusions are topographically expressed as low hills.

The main workings of the Staats Mine are along the northwest edge of the map area. The plant consists of a shaft, headframe, hoisthouse, and compressor house (Figure 1). Workings, besides those off the main shaft, consist of an open cut, an adit, and an inclined shaft in poor condition.

In the center of the map area, on the road across the intrusions, is an adit and winze operation. The mine plant consists of an ore bin.

On the southern part of the west side of the intrusions are two adits, one above the other. There is one shed and an ore bin in this locality.

On the very south end of the intrusion complex is a large open rut. A shaft, filled with water in the summer of 1963, is located at the end of the open cut.

Sedimentary Rocks

The intruded dolomites have been designated Cambrian by Thurston _et al._ (1954); Devonian-Silurian, with possibly some Ordovician by Taylor and Powers (1953); and in part Ordovician to Devonian and in part Devonian Sevy Dolomite by Miller (1959). The writer did not attempt to differentiate the dolomites. The undifferentiated dolomites-Sevy Dolomite contacts on Plate II were adapted from Miller's (1959) map.

The dolomites are massive. When taking dip measurements, it is hard to distinguish bedding from jointing. They are generally gray but locally buff. Buff dolomites are present near the Staats shaft area and around the adit of the Staats mine, located on the east-west road across the intrusion. The buff dolomites may represent a hydrothermal bleaching of the gray dolomites related to fluorite mineralization. Vugs up to one-quarter inch are common in some outcrops, and fractures up to an eighth of an inch wide are common throughout the dolomites. The fractures and vugs are usually filled with white calcite which weathers to iron-stained tan-colored surfaces. No fossils were found.

Petrographically the dolomites are a mosaic of anhedral dolomite crystals which average about 0.04 mm. in size. Some samples contain less than one per cent quartz in isolated angular grains up to 0.08 mm. in size.

The contact between the dolomites and the mineralized igneous breccia is sharp.

Near the monument for Sec. 36, T. 29 S., R. 16 S., Sec. 1, T. 30 S., R. 16 W., Sec. 31, T. 29 S., R. 15 W. and Sec. 6, T. 30 S., R. 15 W., a breccia consisting of 60 per cent angular dolomite fragments up to two inches across in a cement of coarse white calcite, locally stained red, was found. The grain size in the dolomite fragments is about 0.03 mm. Calcite grains are up to 1 mm. The red coloration of some of the calcite is due to irregular blebs of hematite with individual grains up to 0.03 mm. in size.

Intrusive Rocks

Two, or possibly three, intrusions occur in the Staats mine area. All are rhyolite porphyry.

The northernmost intrusion is topographically a small knob on the north end of the map area. Since it is separated from the main intrusion by only a narrow band of breccia, it is probably connected with the main intrusion at relatively shallow depth.

The main intrusion is topographically expressed as a hill elongated in the north-south direction and cut by a narrow valley just north of the township line between T. 29 S. and T. 30 S. The rhyolite porphyry to the north of this valley has a purplish cast; whereas the porphyry to the south, also in the form of a hill, is tan due to the oxidation of accessory pyrite.

Miller (1959, p. 120-121) speculates that the intrusion north of the valley may represent a sill associated with a stock south of the valley. He bases this theory on the apparent concentric shells on the intrusion south of this valley as seen on aerial photographs and on columnar jointing in the rhyolite north of the valley.

In general, the writer agrees with Miller's speculation. The northern intrusion may be a sill or may crosscut the sediments at a low angle. Where possible, strikes and dips were measured in the dolomites, and the orientation of flow lines were measured in the rhyolites. Both types of measurements were difficult because of the massiveness of the rocks and, in both cases, the attitude of the joints may have been determined occasionally rather than the desired parameter.

The dips of the sediments around the intrusions do not indicate doming.

Flow lines on the southernmost, or tannish, intrusion do indicate concentric shells. Flow lines in the northern intrusion are inconclusive as to the presence or absence of concentric shells.

The rhyolite in the most southwest portion of the southern intrusion must have formed from a viscous magma, because flow lines occur as schlerin of quartz crystals. The rhyolite in this portion of the stock contains accessory fluorite.

Average modal analyses of the northern and southern main intrusions are given in Table 1.

TABLE 1
AVERAGE MODAL ANALYSES OF THE
NORTHERN AND SOUTHERN MAIN INTRUSIONS,
STAATS MINE AREA, WAH WAH MOUNTAINS

Mineral	Per cent	
	Northern Intrusion	Southern Intrusion
Groundmass		
Quartz	39	45
K-feldspar	47	45
Phenocrysts		
Quartz	6	2
Sanidine	8	7
Biotite	1	1
Plagioclase	1	1
Accessory		
Pyrite	<< 1	< 1
Zircon	<< 1	
Alteration		
Hematite	<< 1	<< 1
Sericite	< 1	< 1

In both intrusions, the groundmass is a mosaic of quartz and K-feldspar. In various thin sections, the minerals in the groundmass vary in size between 0.01 mm. and 0.1 mm; the average crystal size in the groundmass is about 0.03 mm.

Quartz phenocrysts are generally anhedral and range in size up to about 4 mm. Sanidine phenocrysts are euhedral to subhedral and range in size up to about 2 mm. Biotite phenocrysts are normally euhedral, and the long dimension of laths varies in size up to about 0.5 mm.

Accessory pyrite is more common in the southern intrusion than in the northern intrusion. The tan coloration of the southern intrusion is due to the superficial alteration of accessory pyrite, probably due to weathering.

Both intrusions are bleached and exhibit some indications of hydrothermal alteration, chiefly slight sericitization of the sanidine phenocrysts and K-feldspar in the groundmass. In thin sections exhibiting relatively more severe alteration, biotite has reaction rims of a green chlorite. Chloritic alteration of the biotite is not common, however.

Mylonized Breccia

Fluorite and uranium mineralization in significant amounts are confined to a mylonized breccia zone which occurs on the north, west, and southeast sides of the Staats intrusions. The breccia zone, where found, was up to 300 feet wide. It was not found on the east side of the stock, but may be present and covered with talus. The writer believes the breccia zone to be absent or very narrow on the east side of the stock, however.

Grey in fresh exposures, the breccia consists of quartz and feldspar crystals, with occasional rock fragments up to six inches across, in a fine-grained matrix. Stringers and patches of fine-grained green minerals also occur.

The composition of the breccia is extremely variable. Quartz is ubiquitous. Other minerals include montmorillonite (including an iron-rich variety), probably nontronite, chlorite, K-feldspars, plagioclase, sericite, fluorite, kaolinite, calcite, dolomite, pyrite, hematite, uraninite, autunite (?), uranophane (?), and meta-torbenite.

The rock fragments, including dolomite, rhyolite, and altered fragments of older volcanic rocks, varied from well rounded to angular. Usually they were rounded, although dolomite fragments near the dolomite-breccia contact were often angular.

The breccia is hydrothermally altered. Unaltered potash feldspars were found in only two out of ten thin sections. Quartz feldspars, calcite, and dolomite probably represent remnants of the country rock and intrusion, although there may have been remobilization of the carbonates by hydrothermal solutions. Montmorillonite, nontronite, chlorite, sericite, and kaolinite are alteration minerals. Fluorite, pyrite, and uraninite were introduced. Hematite, autunite (?), uranophane (?), and metatorbenite probably formed by weathering.

On the southwest side of the intrusion, where the two adits have been driven for uranium production, balls of clay up to several inches across were found. X-ray diffraction analysis showed these to consist of about 53 per cent calcite, 47 per cent kaolin, and a trace of montmorillonite. These balls are thought to represent altered limestone or dolomite fragments.

In the cuts on the north side of the east-west road across the intrusions, the breccia is cut by veinlets of a very fine-grained quartz-calcite mixture.

The contact of the breccia with both the dolomites and intrusions is sharp. Along their respective contacts dolomite and rhyolite fragments become more common.

The presence of volcanic rock fragments in the breccia indicates that the intrusions are younger than the volcanic rocks of the range. It is possible that the Staats mine intrusives are correlative with the Thomas Range rhyolites, which are about 20 million years old (Jaffe *et al.*, 1959).

Igneous Breccia

n breccia occurs in the center and along the south edge of the southern intrusion. Rather than friable, it is consolidated; its matrix is a mosaic (0.01 mm.) of quartz and K-feldspar; and it has been mapped as a separate intrusive facies.

Mottled gray to tan and vesicular in hand specimen, this breccia contains anhedral crystals of quartz and sanidine up to about 2 mm. and angular chert fragments up to $\frac{1}{2}$-inch in size. Biotite is present and often altered to serpentine. Irregular patches of fine-grained calcite and dolomite were present in some of the thin sections studied. Accessory minerals include anhedral pyrite and black opaques.

Alteration is mild. There is some sericite on the sanidine and K-feldspar grains. About half of the biotite is altered to serpentine. Some of the black opaques and/or pyrite is altered to hematite.

The igneous breccia could be an equivalent to the mylonized breccia which had magma present during consolidation; it could represent an equivalent breccia which has not undergone hydrothermal alteration; or it may represent a late separate intrusion accompanied by brecciation. The writer favors the last hypothesis, as the contact with rhyolite on the north side of the igneous breccia mass in the southern intrusion is brown and has a baked appearance over a zone several feet wide.

Fluorite Mineralization

The fluorite deposits of the Staats mine area have been adequately described by Thurston (1954) in Bulletin 1005 of the U.S. Geological Survey. Pertinent portions of his descriptions are given below:

> The fluorspar deposits occur along the faulted contact of a Tertiary rhyolite porphyry and a Cambrian limestone[1/]. The wall rocks were altered only slightly, but irregular boundaries of some fragments of country rock enclosed in massive fluorspar suggest partial replacement[2/]. The silica content of the ore is low and is probably derived from inclusions of rhyolite porphyry; quartz veins are not present in the ore. Some $CaCO_3$ is present, owing to included limestone fragments. The SiO_2 and $CaCO_3$ content did not exceed 5 percent, respectively, and averaged about 2 percent of each. Autunite and uranophane were found by Wyant (1947), see Cited References section of this report) as local coatings on the fluorite. Two grab samples from some of the pits northeast of the main shaft contained 50 and 68 percent CaF_2. Assays of carload shipments of fluorspar that had been selectively mined and sorted ranged from 80 to 91 percent CaF_2 and averaged in excess of 85 percent CaF_2.
>
> The fluorspar occurs in lenticular shoots within larger pod-like ore zones. The waste between shoots is composed of brecciated limestone and rhyolite porphyry. Apparently the depth of each shoot is greater than the length: the shoots range from 2 to 6 feet wide and from 5 to 10 feet long, but are reported to extend more than 25 feet in depth. The shoots are oriented roughly parallel to the irregular contact zone of the limestone and rhyolite porphyry. The contact zone is intricately faulted, with many variations in strike and dip and sharp undulations in the trace.

---

1. See the preceding section on sedimentary rocks pages 11-12.

2. In addition to the alteration of the breccia described on page 14 of this report, some rhodocrosite float was found in the vicinity of the main Staats workings.

> Two separate areas of fluorspar mineralization on the Staats property have been explored. Most of the prospecting centers around the main deposit at the head of the valley...but a small deposit has been opened about half a mile southeast...
>
> The principal workings at the main deposit (the Staats mine) are an 85-foot shaft, an opencut, and an adit. This deposit was first explored by an opencut; then a shaft was sunk about the middle of the opencut, and stopes were driven at various levels from the shaft. At the 85-foot level a drift extends 65 feet southward. About 400 feet southeast of the shaft an adit exposed several pockets of fluorspar along a faulted segment of the contact between the rhyolite porphyry and limestone...Because of caving ground, only a small part of the shaft workings was accessible for examination. Apparently enough fluorspar remains in the vicinity of the shaft to be worth recovering. Within 600 feet to the north, northeast, and southeast, several pits and trenches show fluorspar in the contact zone.
>
> An adit about half a mile to the southeast leads to a winze operation from which 200 tons of ore was mined in 1944... The ore in the winze formed a shoot 10 feet long, 6 feet wide, and about 55 feet deep.

Uranium Mineralization

The Staats Mine area has produced 1,900 tons of uranium ore (Nackowski and Levy, 1959). The writer has not been able to obtain data on the grade of this material.

The primary uranium mineral is uraninite, which occurs as impregnations in the mylonized breccia. Hearsay indicates that uranium and fluorite mineralization are associated.

Wyant (1947, reported in Thurston 1954) reported autunite and uranophane as local coatings on the fluorite. The writer found incrustations of metatorbernite ($Cu(UO_2)_2(PO_4)_2 \cdot 8H_2O$) (*x*-ray identification) on mylonized tuff samples from the dump of the open cut at the south end of the map area. On the dump of the two adits on the southwest side of the map area, a yellow secondary uranium mineral was found as incrustations on the mylonized breccia. The writer was not able to identify the *x*-ray diffraction pattern of this mineral, or to identify it by optical properties.

Only the geologic history related to the mineralization is given here. Field relationships and laboratory studies suggest the following sequence of events:

1. Intrusion of the Paleozoic dolomites by Tertiary rhyolite porphyry. This occurred after the Tertiary volcanics were extruded, inasmuch as fragments of older volcanic rocks are found in the breccias related to the intrusions. The northern mass of rhyolite porphyry was probably intruded as a sill or as a dike cutting the bedding at a low angle; the southern intrusion as a stock. The intrusion was accompanied by faulting on the western side of both intrusive masses and on the southern and southeastern sides of the southern mass.

2. Hydrothermal alteration of the mylonized portions of, and feldspar crystals in, the mylonized breccia.

3. Fluorite mineralization of the mylonized breccia. This event occurred close in time to the intrusion of the rhyolite porphyry, as shown by the fact that the rhyolite in the southwest portion of the southern stock contains fluorite as an accessory mineral.

4. Uranium mineralization of the mylonized breccia. This stage was probably contemporaneous with the fluorite mineralization.

5. Intrusion of the igneous breccia. This event may have occurred any time after the emplacement of the rhyolite porphyry. The fact that the igneous breccia shows little alteration could indicate that it is post mineralization.

6. Weathering and oxidation of the uraninite forming secondary uranium minerals.

BLAWN MOUNTAIN AREA

Blawn Mountain is an east-west trending ridge of silicified rhyolite just north of the center of the southern edge of Sec. 30, T. 29 S., R. 15 W. The white color of the intrusion is the reason the ridge is often designated Blonde Mountain. North of Blawn Mountain are Tertiary volcanics. Elsewhere it is surrounded by Paleozoic sedimentary rocks. A geologic map of what has been designated as the Blawn Mountain area is shown as Plate III. The area mapped is approximately one and a half miles long in the east-west direction and up to one-half mile across in the north-south direction.

Kaolinite, alunite, uranium and iron mineralization occur in the area. Several exploration cuts have been made in the kaolinitic and alunitic mineralization along the Blawn Mountain ridge (Figure 3). Nineteen holes have been drilled in the general area of the ridge (E. M. Garrick, 1958). South of Blawn Mountain, 160 feet below the ridge, an adit has been driven 495 feet N 45 E in an attempt to intersect the mineralization at depth. The Iron Queen workings, on the Blawn Mountain ridge, consist of a short adit, a small stope and a small glory hole. Detailed geologic relationships are given in later sections of this report.

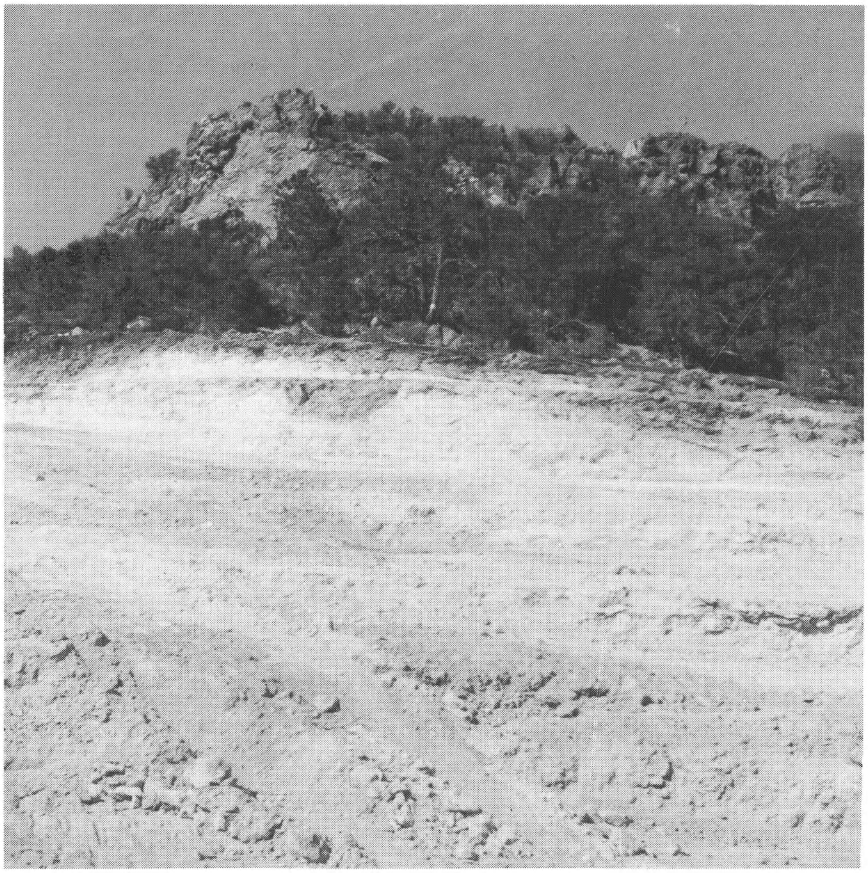


Figure 3. Cut in alunite at Blawn Mountain. The ridge in the background is silicified rhyolite porphyry.

Access is generally from the southeast by dirt road up Blawn Wash which connects with the graveled county road across the Wah Wah Range or by dirt road from the Staats Mine area to the southwest. A dirt road, passable to four-wheel drive vehicles, connects with State Highway 21 to the north.

Sedimentary Rocks

EUREKA QUARTZITE

On the northwest side of the Blawn Mountain map area, the mineralization is in contact with the Ordovician Eureka Quartzite. In this locality the Eureka Quartzite is a white fine-grained orthoquartzite. In places, float of this rock is jet black due to staining by manganese oxides.

DOLOMITES

The Blawn Mountain intrusive is bounded on the south by gray and buff dolomites which were mapped by Miller (1959) as Ordovician-Devonian dolomites, in part Devonian Sevy, and by Taylor and Powers (1953) as undifferentiated Silurian-Devonian dolomites.

Fine-grained and massive, the dolomites are bluish gray on the west side of the map area and buff to the east. Whether this is a facies change or an alteration effect is not known. As shown in thin section, they are clean dolomites, recrystallized to a mosaic texture, with grain sizes of 0.1 to 0.2 mm. Fossils are rare.

Volcanic Rocks

The crest of Blawn Mountain is composed of silicified rhyolite. This rock is described in the section on hydrothermal alteration and mineralization.

West of the silicified rhyolite on Blawn Mountain is a small area of rhyolite. Whether this outcrop represents a flow or a stock cutting the sediments at an angle is not known. A cross section on an unpublished map of the Kincsem Mining Company (E. M. Garrick, 1958) shows drill holes penetrating "volcanic agglomerate and tuff" (mapped by this writer as rhyolite on the basis of outcrop and thin section studies) to depths of 160 feet. A hole 260 feet deep enters "Paleozoic limestone" at a depth of about 200 feet.

To the north of the silicified rhyolite of Blawn Mountain, unsilicified rhyolites are found. Because of timber and soil cover, the writer's investigation did not indicate the exact contact between silicified and unsilicified rhyolite. Miller (1959) mapped the entire Blawn Mountain area as flows, whereas Taylor and Powers (1953) mapped the Blawn Mountain silicified rhyolite as intrusive; and the writer favors the interpretation of Powers and Taylor.

All of the outcrops of igneous rock examined by the writer were rhyolite, rhyolite porphyry, or silicified rhyolite porphyry.

Breccia

Near the southwest corner of the map area is an outcrop of breccia consisting of angular quartzite, chert, and dolomite fragments, all up to several inches across in a rhyolite matrix. This has been interpreted as a small breccia pipe.

Mineralization and Hydrothermal Alteration

KAOLINITE

At Blawn Mountain the mineralization which has the greatest economic potential and is present in the greatest quantity is kaolinite ($Al_4Si_4O_{10}(OH)_8$). It is exposed in cuts, in outcrop and as float (see Plate III).

In cuts and in outcrop, the kaolinite is massive and often tan, occasionally white. The tan color is due to a light iron staining. When clods or fragments of the tan kaolinite are broken, however, their centers are white. For this reason, the staining is thought to be superficial.

The clay float generally consists of white angular fragments up to several inches in size.

The kaolinite samples collected by the writer were remarkably pure. Mineralogic analysis, consisting of a combination of optical and petrographic examination, *x*-ray diffraction studies, differential thermal analysis, and infrared absorption studies gave the results presented in Table 2.

Mineralogic examination by various methods indicated that the kaolinite is crystalline.

Considering sample 221, it should be noted that dickite (see below) is a polymorph of kaolinite with essentially the same physical properties and uses.

If adequate tonnages could be developed and if the iron staining is superficial, the kaolinite might be suitable for exploitation as filler for paper or rubber, or as raw material for high quality ceramics.

Some indications of the firing characteristics of the kaolinite are given by the differential thermal analysis of sample 151 the pattern of which consisted of two reactions: a strong endothermic reaction, representing the breakdown of hydroxyl to water and oxygen at 625° C.; and a strong exothermic reaction, essentially representing the formation of crystalline ceramic phases, at 944° C. Bronson Stringham, Department of Mineralogy, University of Utah, reports (personal communication) a sample of kaolinite from this deposit fired at cone 33.

TABLE 2

MINERALOGIC ANALYSES OF KAOLINITE SAMPLES

SAMPLE (1)	LOCATION (1)	COLOR	ANALYTICAL RESULTS
151	Vein, Iron Queen Ore Body	White	100% Kaolinite
219	S.W. End of Map Area	White	100% Kaolinite
220	S.W. End of Map Area	White	100% Kaolinite, Trace Dolomite (2)
221	S.W. End of Map Area	White	50% Kaolinite, 50% Dickite
235	Just W. of Sil. Rhy. Porphyry	Tan (3)	100% Kaolinite
242	Veinlets in Iron Queen Ore Body	White	100% Kaolinite
243	N.W. Edge of Map Area	White	100% Kaolinite
244	N.W. Edge of Map Area	Tan (3)	100% Kaolinite
246	Float, N.W. Edge of Map Area	White	100% Kaolinite
249	Float, S. Central Portion Map Area	Brown	95% Kaolinite, 5% Hematite
255	Float, E. Most End of Map Area	White	100% Kaolinite Tr. Qtz. & Alunite (4)
257	W. End of Silicified Rhy.	White	100% Kaolinite

(1) Location of samples shown on Plate III.
(2) Probably less than 0.5%.
(3) No iron minerals detected.
(4) Less than 0.5% quartz. Unmeasured, but trace amount of alunite.

DICKITE

One sample, numbered 221, from the southwest end of the map area, consisted of about 50 per cent kaolinite and 50 per cent dickite. Since dickite is a polymorph of kaolinite with a slightly different crystal strucutre but the same composition and essentially the same physical properties, the presence of dickite in some of the kaolinite should not hinder its exploitation.

The presence of dickite is considered as an indication of hydrothermal origin of the deposits (Deer, Howie, and Zussman, 1962, p. 209).

MONTMORILLONITE

Montmorillonite was found in only one locality in the deposit. For uranium exploration, an adit was driven south and slightly to the west of the Iron Queen adit. The portal is 160 feet below the clay outcrops. The adit is about 485 feet long and bears about N 45 E. It is entirely in buff limestone. The limestone is cut by clay veins up to about an inch across. One of these veinlets was found to consist of 90 per cent montmorillonite and 10 per cent kaolinite. The montmorillonite may represent an outer zone peripheral to the main kaolinite-alunite mineralization.

ALUNITE

Considerable alunitic mineralization occurs in the Blawn Mountain area.

The alunite is tan to very white, but is easily distinguished from the kaolinite because it is powdery, whereas the kaolinite is consolidated and massive.

Data on alunite samples are given in Table 3.

Samples 227, 229, and 230 are from a small area of alunite mineralization which cuts the igneous outcrop on the west side of the map area. This area is close to the Eureka quartzite outcrops, and the quartz in alunite may come from that rock. Even if a market for alunite were found, the iron staining and silica in the alunite of this area would hinder its exploitation.

Sample 239 and an unnumbered sample are from exploratory cuts just south and southwest of the silicified rhyolite intrusion. In the exposure and southwest of the silicified rhyolite, several exploratory benches have been cut. The alunite exposed is uniformly white and powdery. X-ray diffraction, infrared absorption, optical, and differential thermal analysis studies indicate alunite is the only mineral present. A chemical analysis is given in Table 4.

TABLE 3

BULK ANALYSIS OF ALUNITE-BEARING SAMPLES

NUMBER	LOCATION (1)	COLOR	COMPOSITION
227	Near Igneous Outcrop W. Side of Map Area	Tan	Alunite 42% Quartz 58%
229	Near Igneous Outcrop W. Side of Map Area	Tan	Alunite 48% Quartz 45% Goethite 4% Clays 3%
230	Near Igneous Outcrop W. Side of Map Area	Tan	Alunite 70% Quartz 28% Dolomite 2%
239	Just S. W. of Silc. Rhy.	White	100% Alunite
Un-num.	South of Silc. Rhy.	White	100% Alunite

1. Locations are shown on Plate III.

TABLE 4

CHEMICAL ANALYSIS[1] OF BLAWN MOUNTAIN ALUNITE AND THEORETICAL ALUNITES

	Blawn Mountain	Alunite $KAl_3(SO_4)_2(OH)_6$	Natro-Alunite $NaAl_3(SO_4)_2(OH)_6$	Hydronium Alunite $(H_3O)Al_3(SO_4)(OH)$
Al_2O_3	35.2	36.96	38.44	38.83
K_2O	7.15	11.35	-----	-----
Na_2O	1.0	-----	7.79	-----
SO_3	38.2	38.65	40.21	40.61
H_2O+	20.5(1)	13.04	13.56	20.56
H_2O-	0.5			
Fe	0.36			
SiO_2	0.6			
TOTAL	103.01	100.00	100.00	100.00

1. Analysts: Na_2O, K_2O-- Kenneth Farley Other oxides--Lester Bucher.
2. Determined as loss on ignition at 650°.

The analytical results indicate a K:Na ratio of 82.5:17.5. The high water content may indicate some hydronium ion (H_3O+) substitution in the potash positions.

X-ray diffraction data are in good agreement with published data. Based on x-ray diffraction data (R.L. Parker, 1962), the K:Na ratio is 80:20, which is considered in good agreement with the analytical data.

The differential thermal analysis of the clean alunite gives a very strong endothermic reaction, representing breakdown of hydroxyl to water and oxygen at 5778° C.; a medium exothermic reaction, at 740° C.; and a very strong endothermic reaction, representing decomposition to potassium sulfate, gamma-alumina, and sulfur trioxide at 844° C.

The infrared absorption spectrum consists of two strong O-H stretch bands at 3500 cm^{-1} and 3480 cm^{-1}, strong S-O bands at 1220 cm^{-1}, 1075 cm^{-1}, 1040 cm^{-1}; additional strong, but unassigned bands occur at 675 cm^{-1}, 620 cm^{-1}, and 590° cm^{-1}.

The Blawn Mountain alunite is a very clean high potash alunite. If sufficient tonnages can be developed in the Blawn Mountain area and adjacent areas, it should have potential as a raw material for aluminum production. Thoenen (1941) states that an aluminum oxide content of 30 per cent is necessary for potential aluminum production. The Blawn Mountain alunite deposit could produce ore well above this aluminum content.

SILICIFIED RHYOLITE PORPHYRY

The crest of Blawn Mountain is silicified rhyolite porphyry. White, hard porcelain-like rhyolite porphyry, the rock contains about 15 per cent anhedral, gray, vitreous quartz phenocrysts up to 2.5 mm. in size. The groundmass is a mosaic of quartz, presumably about half representing replaced K-feldspar, with a dirty appearance under the microscope. A trace of biotite, in laths up to 0.2 mm. long, is present. Less than one per cent zircon in euhedral to anhedral crystals up to 0.5 mm. in size is present.

The silicification of this rock is essentially complete as shown by the analysis given in Table 5.

The silicified rhyolite porphyry would not be an economical source of silica for glass or as a silica abrasive because of crushing costs. Also, the iron content is probably slightly high for use in glass making. If not too fractured in place, it could be used as a substitute for ganister for siliceous firebrick. It is an attractive, durable, resistant rock; and a market as a building stone for such uses as fireplace facings might be developed for it.

TABLE 5
CHEMICAL ANALYSIS[1] — SILICIFIED RHYOLITE PORPHYRY

SiO_2		99.20
Al_2O_3		0.04
Fe		0.48
CaO		0.10
MgO		0.10
P_2O_5		0.01
	TOTAL	99.93

1. Analyst - Lester Bucher.

TABLE 6
MINERALOGIC ANALYSES, IRON OCCURRENCES

SAMPLE	LOCATION (1)	MINERALS
152	Iron Queen Claims	Magnetite with minor hematite
241	Iron Queen Claims	Magnetite with minor hematite
253	Center of Map Area	Hematite, minor fluorite
254	Center of Map Area	Hematite
256	Western Portion of Map Area	Magnetite, minor hematite

1. Locations are shown on Plate III.

IRON MINERALIZATION

Several small occurrences of iron mineralization are present in the Blawn Mountain area. The occurrences have been briefly described by Crawford and Buranek (1943, p. 13-14). About the turn of the century, some iron from the Iron Queen Claims, for use as a smelter flux, was probably shipped to Frisco. The writer concurs with Crawford and Buranek that the deposits are lenticular replacements in dolomite. They report the chief minerals to be hematite and limonite with "possibly a small amount of magnetite." This writer found the most prominent minerals to be magnetite and hematite with minor amounts of goethite. Mineralogic analysis of iron smaples are given in Table 6.

Crawford and Buranek (1943) give the following analysis of Iron Queen Mineralization:

	Crismon and Nichols, Salt Lake City, Utah Analyst
Fe	64.8
Insoluble	2.9
S	0.11
P	0.009
Mn	0.45
Au	0.01 (oz./T.)
Ag	Trace

The mineralization at the Iron Queen Claims is cut by small veinlets of kaolinite. Traces of disseminated purple fluorite were found at the Iron Queen Prospect and at a hematite occurrence in the central portion of the map area.

There are no indications that sufficient iron mineralization occurs to warrant development or exploitation as iron ore. However, the Iron Queen mineralization is located adjacent to the clean alunitic and kaolinitic mineralization described above. Several occurrences of iron mineralization are adjacent to areas of kaolinitic float. Therefore, those areas with iron mineralization are considered favorable for prospecting for kaolinite and alunite.

FLUORITE

As noted above, some disseminated purple fluorite crystals occur in the iron mineralization at Blawn Mountain. Fluorite does not occur in quantities suitable for exploitation, however.

URANIUM MINERALIZATION

Radioactivity, determined with a portable Geiger-Mueller counter, was noted in the large cut at the southwest end of the map area, and seemed to be associated with heavily iron stained clays.

On the basis of seven drill holes, E. M. Garrick (1958) has plotted an indicated and inferred uranium ore body approximately 400 feet long by 75 feet wide, at depths of 49 to 90 feet below the surface. This mineralized zone is about 15 feet thick. At a depth of about 130 feet, a second 10 foot thick zone, 200 feet long, is plotted. The width of this zone is not known. Both radioactive zones run northwest from the large cut at the southwest end of the map area.

No assay data are available. It is believed that the holes were qualitatively logged with a portable radiation counter.

The radioactive minerals were not identified either in the field or in the laboratory studies.

An ore purchase agreement for the area is in effect with the Atomic Energy Commission (M. Robis, R.E. Cohenour, and Joseph R. Anderson, oral communications), but to date no ore has been shipped from the map area.

Structure and Geologic Relationships

In general the alunite, kaolinite, and iron mineralization lie on the south side of the Blawn Mountain intrusive, which is in part a silicified rhyolite trending generally east-west.

Miller (1959) and Taylor and Powers (1953) both map the contact between the intrusion and the Paleozoic dolomites on the south side of Blawn Mountain as a fault contact.

The intrusion and the alunite-kaolinite mineralization must dip to the north. An adit 160 feet below the ridge along Blawn Mountain, driven 485 feet approximately N 45 E, is still in dolomite. Additional drilling was necessary before the clay zones were encountered (M. Robis, personal communication). If projected vertically to the surface, the face of this drift would be almost directly under the silicified rhyolite porphyry.

Whether the Blawn Mountain intrusive is intrusive into the flow to the north was not definitely determined.

The small isolated area of igneous rock on the west end of the map area bottoms in Paleozoic rocks at a depth of 200 feet (E. M. Garrick, 1958). This igneous rock might be either an intrusion cutting the sediments with a low northerly dip or an erosional scab of the volcanics from the flows north of Blawn Mountain.

Geologic History

The details of geologic history of the Blawn Mountain map area are not as straightforward as those of the Staats Mine area. The following suggestions are made:

1. Intrusion of the Paleozoic sediments and Tertiary volcanic flows by the Blawn Mountain intrusive. Because of their proximity and similar appearance and composition (prior to the silicification of the Blawn Mountain intrusive), the Blawn Mountain intrusion and Staats Mine intrusions are considered to be equivalent in time and from the same magma source. Because of this correlation and the fact that the Staats Mine breccias contain fragments of earlier volcanics, the Blawn Mountain intrusive is tenatively considered younger than the volcanics to the north.

2. Hydrothermal alteration and mineralization followed the intrusion. The kaolinite and alunite both indicate acid conditions during mineralization, which is concordant with the volcanic nature of the rhyolite porphyry intrusions. The alunite is a lower temperature mineral than the kaolinite and is, therefore, probably slightly later. The relative ages of the silicification of the rhyolite porphyry and of the iron mineralization are not known. The silicification of the rhyolite may be contemporaneous with the deposition of alunite. The introduced silica in the rhyolite porphyry may represent the silica of the hydrothermal solutions which during the kaolinitic stage of mineralization formed the kaolinite. The silicification of the K-feldspar of the rhyolite porphyry may have released the potash now contained in the alunite. A possible source of the iron mineralization is from the replaced dolomites, since a small amount of iron is always found in the magnesium positions of dolomite.

3. Intrusion of the breccia pipe. No field evidence which could indicate the relative time of this intrusion was obtained. It is considered late, however, since the igneous breccia of the Staats Mine area appears to be late in the sequence of events in that area.

CONCLUSIONS, POTENTIAL, AND SUGGESTIONS FOR FUTURE WORK

The Staats Mine area and Blawn Mountain Ridge area of the Central Wah Wah Mountains contain significant fluorite, uranium, kaolinite, alunitic, and iron mineralization, as well as a silicified rhyolite porphyry which has a potential commercial value.

The fluorite deposits of the Staats Mine area are small, but of good grade. Additional exploration could possibly locate additional ore bodies.

Trenching and/or drilling could be utilized to determine whether the fluorite-uranium-bearing mylonized breccia occurs on the east side of the Staats Mine intrusives.

Additional data are needed on the Blawn Mountain uranium occurrences. Specifically the grade of the uranium mineralization should be determined. Additional data are also needed as to the tonnage available. The uranium-bearing minerals should be determined.

Drilling would be necessary to determine whether the iron staining on the Blawn Mountain kaolinite is a superficial feature or persists at depth. If the iron-staining is superficial, paper or ceramic markets might be developed.

Trenching in the areas of clay float would determine whether these areas represent an additional reserve of kaolinite (or alunite) in the immediate area. Areas around, but particularly north of, areas of iron mineralization are considered favorable areas for prospecting for clay.

The alunite at Blawn Mountain is a high potash variety and very pure. It represents a future potential source of alumina and potash.

While significant reserves of iron mineralization were not noted in mapping, a magnetometer survey east and west along the Blawn Mountain Ridge could indicate whether additional iron mineralization occurs at depth.

The writer believes that the Blawn Mountain mineralization may represent a portion of a longer east-west lineation or belt of mineralization which could contain discontinuous areas of clay mineralization. Hearsay indicates clay deposits exist both east and west of the area mapped. Time did not allow checking this in the field. Blawn Mountain may represent a western portion of the Grover Wash, West White Mountain, and East White Mountain alteration zones mapped by Stringham and Brooke in 1962 (Stringham, 1963). In general the areas east and west of the Blawn Mountain map area should be prospected for clay, alunite, and mixtures of the two.

CITED REFERENCES

Butler, B. S., Laughlin, G. F., Heikes, V. C. and others, 1920, Ore Deposits of Utah: U.S. Geol. Survey Prof. Paper 111, p. 527-529.

Crawford, A. L., and Buranek, A. M.,1943, Utah Iron Deposits other than those of Iron and Washington Counties, Utah: Utah Geol. and Mineralog. Survey Circ. 24, p. 13-14.

Deer, W. A., Howie, R. A., and Zussman, J., 1962, Rock-Forming Minerals: Sheet Silicates, Longmans, Green, and Co., Ltd., London, v. 3, p. 209.

Garrick, E. M., 1958, Unpublished Map and Section, Kincsem Mining Company, Bogdanich Development Co.

Jaffe, H. W., Gottfried, D., Waring, C., and Worthing, H. W., 1959, Lead-Alpha Age Determinations of Accessory Minerals of Igneous Rocks (1953-1957): U.S. Geol. Survey Bull. 1097 - B, p. 15.

Miller, G. M., 1959, The Pre-Tertiary Structure and Stratigraphy of the Southern Portion of the Wah Wah Mountains, Southwest Utah: Univ. of Washington Ph.D. Thesis, 170 p.

Nackowski, M. P., and Levy, E., 1959, Mineral Resources of the Delta-Milford Area: Univ. of Utah Engineering Experiment Station Bull 101, 112 p.

Parker, R. L., 1962, Isomorphous Substitution in Natural and Synthetic Alunite: Am. Mineral., v. 47, p. 127-136.

Richards, A., and Brooke, J.E., 1961, Geology of the Southern Wah Wah Mountains, Utah: Unpublished map, Geology Dept., Southern Methodist University.

Stringham, B., 1963, Hydrothermal Alteration in the Southeast Part of the Frisco Quadrangle, Beaver County, Utah: Utah Geol. and Mineralog. Survey Special Studies 4, 24 p.

Taylor, A. O., and Powers, J. F., 1953, Reconnaissance Geologic Map Wah Wah Range, Beaver County, Utah: U.S. Geol. Survey Trace Elements Memorandum Report (Map on Open File).

Thoenen, J. R., 1941, Alunite Resources of the United States: U.S. Bureau of Mines Rept. of Investigation 3561, 40 p.

Thurston, W. R., Staatz, M. H., and Cox, D. C., 1954, Fluorspar Deposits of Utah: U.S. Geol. Suvery Bull. 1005, 16-19.

Wyant, D. G., 1947, Staats Fluorspar Mine, Beaver County, Utah: U.S. Geol. Survey Unpublished Report, 11 p.

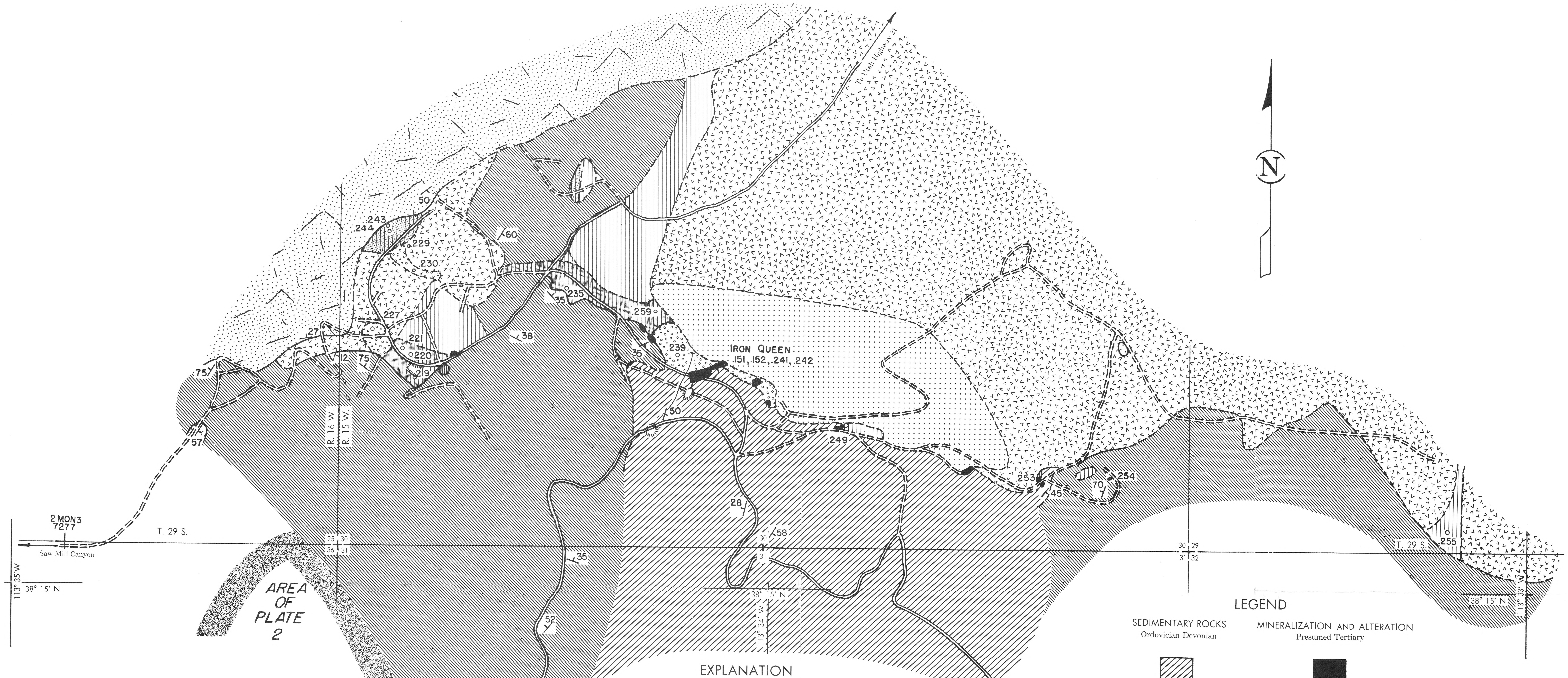
GEOLOGY OF THE STAATS MINE AREA, WAH WAH MOUNTAINS, BEAVER COUNTY, UTAH

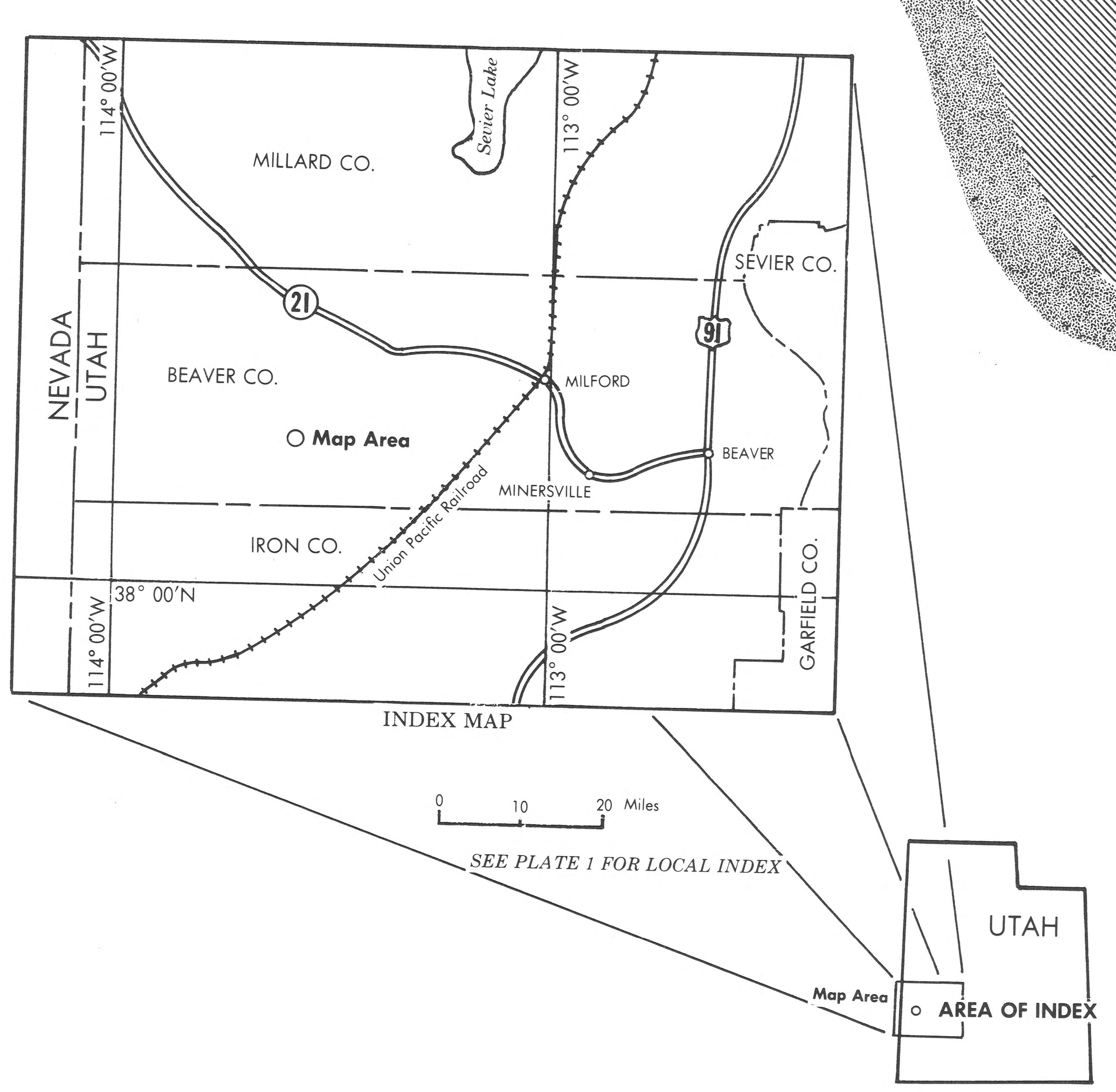
Mapped by J. A. Whelan and G. Baetcke in 1963

Financed by the Uniform School Fund of the University of Utah

0 500 1000
SCALE IN FEET

PLATE 2





GEOLOGY OF BLAWN MOUNTAIN, CENTRAL WAH WAH MOUNTAINS, BEAVER COUNTY, UTAH

Mapped by J. A. Whelan and G. Baetcke in 1963

Financed by the Uniform School Fund of the University of Utah.

0 500 1000
SCALE IN FEET

PUBLISHED AND SOLD BY THE
UTAH GEOLOGICAL AND MINERALOGICAL SURVEY
W. P. HEWITT, DIRECTOR
103 CIVIL ENGINEERING BUILDING
UNIVERSITY OF UTAH
SALT LAKE CITY 12, UTAH

PLATE 3