



# UTAH GEOLOGICAL AND MINERALOGICAL SURVEY

The Utah Geological and Mineralogical Survey, authorized by act of the Utah State Legislature in 1931, became a reality in 1941 and functioned for eight years within the Department of Publicity and Industrial Development. By law it was transferred from the Department of Publicity and Industrial Development, and since July 1, 1949, it has functioned under the aegis of the College of Mines and Mineral Industries, University of Utah.

*The Utah code, Annotated, 1953 Replacement Volume 5, Chapter 36, 53-36-2, provides that the Utah Geological and Mineralogical Survey "shall have for its objects":*

1. "The collection and distribution of reliable information regarding the mineral resources of the State.

2. "The survey of the geological formations of the State with special reference to their economic contents, values and uses, such as: the ores of the various metals, coal, oil-shale, hydro-carbons, oil, gas, industrial clays, cement materials, mineral waters and other surface and underground water supplies, mineral fertilizers, asphalt, bitumen, structural materials, road-making materials, their kind and availability; and the promotion of the marketing of the mineral products of the State.

3. "The investigation of the kind, amount, and availability of the various mineral substances contained in State lands, with a view of the most effective and profitable administration of such lands for the State.

4. "The consideration of such other scientific and economic problems as, in the judgment of the Board of Regents, should come within the field of the Survey.

5. "Cooperation with Utah state bureaus dealing with related subjects, with the United States Geological Survey and with the United States Bureau of Mines, in their respective functions including field investigations, and the preparation, publication, and distribution of reports and bulletins embodying the results of the work of the Survey.

6. "The preparation, publication, distribution and sale of maps, reports and bulletins embodying the results of the work of the Survey. The collection and establishment of exhibits of the mineral resources of Utah.

7. "Any income from the sale of maps and reports or from gifts or from other sources for the Survey shall be turned over to the State Treasurer and credited by him to a fund to be known as the Survey Fund to be used under the direction of the Director of the Survey for publication of maps, bulletins or other reports of investigation of the Geological and Mineralogical Survey."

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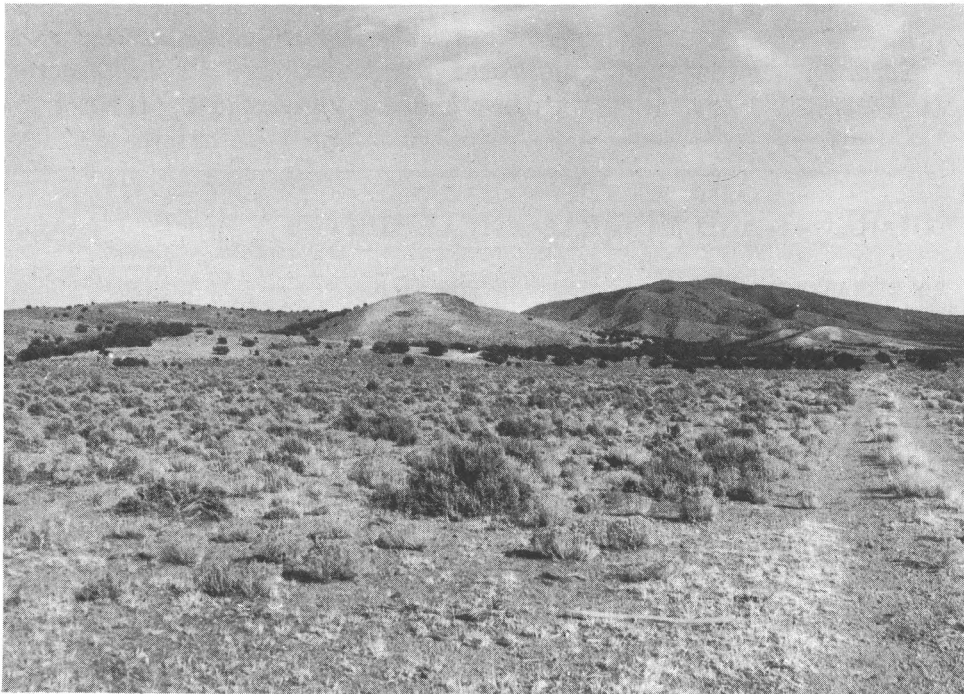
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# HYDROTHERMAL ALTERATION IN THE SOUTHEAST PART OF THE FRISCO QUADRANGLE, BEAVER COUNTY, UTAH

*by Bronson Stringham  
Department of Mineralogy  
University of Utah*



Utah Geological and Mineralogical Survey  
affiliated with  
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University of Utah, Salt Lake City, Utah

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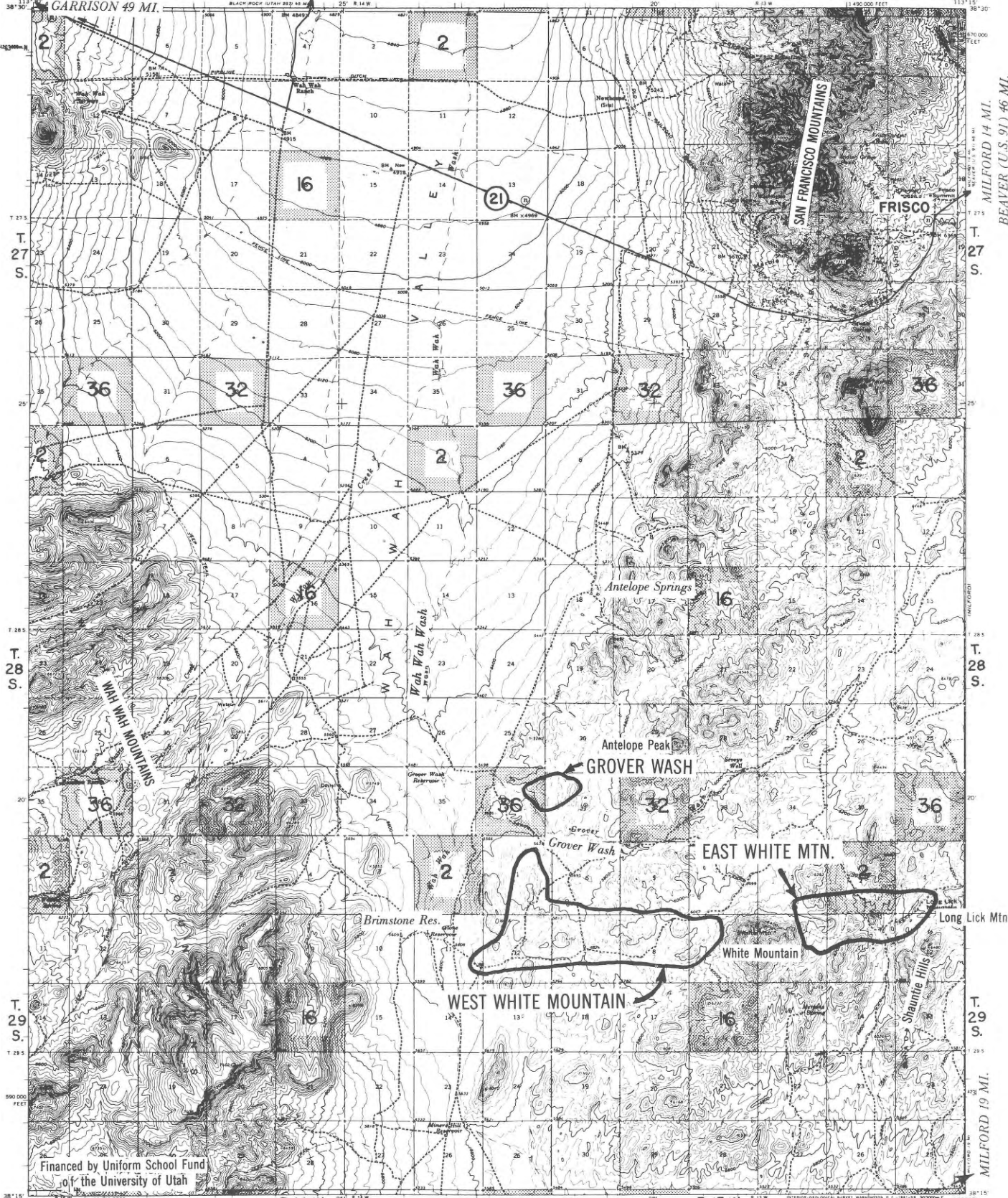
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**HYDROTHERMAL ALTERATION  
IN THE SOUTHEAST PART OF THE FRISCO QUADRANGLE  
BEAVER COUNTY, UTAH**

**ABSTRACT**

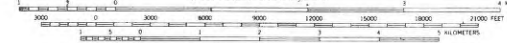
Fourteen miles south of the Horn Silver Mine in Beaver County, Utah, is an extensive east-west trending hydrothermal alteration area involving ignimbrites. The area is 5 1/2 miles long and 1/2 to 1 1/2 miles wide. The extrusive rocks have been correlated with the Needles Range, Isom and Quichapa ignimbrites which lie upon a strong relief surface of folded Paleozoic rocks. The alteration consists of weak to very strong development of fine-grained, massive, white alunite often intimately mixed with kaolinite followed by silicification. Later weak to strong hematite mineralization has been accomplished in altered and fresh rock alike.

A very small amount of pyrite, pyrolusite, and autunite are also found. Late hot spring activity deposited siliceous sinter and native sulphur. Except for perhaps the hematite stage, it is believed that the solutions which affected the alteration and mineralization were strongly acid in nature.



Financed by Uniform School Fund  
of the University of Utah

R. 14 W. SCALE: 1:120,000 R. 13 W.



CONTOUR INTERVAL 40 FEET  
DATUM IS MEAN SEA LEVEL

### Local Index to Study Areas

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS  
FOR SALE BY U.S. GEOLOGICAL SURVEY, DENVER 25, COLORADO OR WASHINGTON 25, D.C. STATE LAND  
A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

ROAD CLASSIFICATION

	Medium-duty		Light-duty
	Unimproved dirt		State Route

QUADRANGLE LOCATION

FRISCO, UTAH  
N3815-W13235-15  
1959

APPROXIMATE MEAN  
DECLINATION, 1959

# **HYDROTHERMAL ALTERATION IN THE SOUTHEAST PART OF THE FRISCO QUADRANGLE BEAVER COUNTY, UTAH**

**by Bronson Stringham**

## **LOCATION**

The Frisco Quadrangle (size 15 minutes) is located about 15 miles west of Milford, Utah in Beaver County. Included within the northeast part of the quadrangle is the well known Horn Silver Mine and the ghost town of Frisco. The alteration areas under study are in the southeast portion of the quadrangle about 10 miles directly south of the town of Frisco (Plate I). The areas are conveniently approached from Milford along the main Milford-Baker paved highway where a good graded road at a point 22 miles from Milford extends southward for 12 miles. It was in excellent condition during the summer of 1962 and had had little rain wash damage. At the terminus of this road, which reaches practically to the main alteration area, are several secondary roads which make the entire alteration area under study readily accessible to ordinary travel except for low passenger cars. Vegetation consists principally of scattered to dense piñon pine and juniper with large broad areas covered with sagebrush and bunchgrass. Water for drinking is essentially absent. Water in Antelope Springs, which is passed on the road from the north, is drinkable only in emergency. No inhabitants were found in the entire area and during the complete summer's work only two vehicles were seen. Several corrals and stock loading chutes occur. There are essentially no fences to impede cross country jeep travel. Elevations within the area vary from about 5,700 feet to as much as 6,200 feet, except for White Mountain and Antelope Peak, both of which attain altitudes near 6,800 feet. The entire area is somewhat of a hodgepodge of irregularly distributed low hills and shallow valleys.

## **REASON FOR STUDY**

Alteration areas south of Frisco in the Frisco Quadrangle have been known for a long time. They are extensive and have created considerable exploration interest over the past years. It is believed there may be private reports concerning the alteration, none of which are public information. Further, it is believed that no extensive detailed work has been done here by any geologic agency. Three areas were selected because of their limited size, allowing the possibility of completing a reasonably thorough job in one summer. This was accomplished in 1962. Mr. John Brooks assisted with the study.

From a long range point of view the entire area is being studied geologically by Dwight Lemmon of the U.S. Geological Survey at the present time. His work, however, probably will not encompass the detail of the alteration features that has been attained during this study.

The economic deposits of the area, in addition to the non-commercial types exposed at the surface, might include ore bodies at depth beneath the alteration, as at Frisco, at Tintic, and various other mining districts throughout the West.

The three separate areas studied are listed as (1) West White Mountain, an area consisting of about four square miles; (2) East White Mountain, consisting of about 1.5 square miles; and (3) an area called Grover Wash, consisting of about 1/3 square mile, where some previously unknown Paleozoic rocks and heavily silicified limestones are present.

## **FIELD AND LABORATORY TECHNIQUES**

Paired low level air photos were used and enlargements to an approximate scale of 400 feet to the inch were secured where detailed field mapping was required. The quality of these enlargements was extremely good, allowing very close control on the ground. Thirteen section corners and quarter corners were found in the field and plotted accurately on the enlarged photos. Upon plotting these section markers and through checking with township plats, it was found that the photo distortion in the West White Mountain area, involving a length of about three miles, was less than 25 feet. Hence, in drawing the final maps which accompany this report, no corrections for distortion have been attempted. Errors of this magnitude, therefore, may be expected.

Several trips were made to the University of Utah during the summer field season. Specimens were checked in the laboratory optically, with the x-ray, infra red, and differential thermal analysis instruments. Such mineral determinations are believed necessary for meaningful field work in the altered areas.

## **CURRENT WORK AND LIMITATIONS**

Mr. Dwight Lemmon of the U.S. Geological Survey has been mapping the Frisco Quadrangle for several years, but he is restricted from furnishing any geologic information at this time. Since such a study is being made, it was believed that the present work should not involve detailed geologic observations beyond the alteration areas. However, a brief account of the unaltered rocks is in order. Each of the three areas has distinctive features and will be discussed separately in the following report.

## **WEST WHITE MOUNTAIN AREA**

The West White Mountain area extends from the western slopes of White Mountain westward a distance of nearly four miles to the Wah Wah Wash flat near Brimstone reservoir. The width averages about 3/4 mile. Near the western end is a northward-extending prong encompassing about another mile. The area can be described topographically as a low east-west ridge running west of White Mountain with occasional branching ridges. The northward prong is on another northward-extending ridge. Throughout the entire alteration area can be seen white and red colored hills and ridges which are distinctly different from the color of unaltered rocks to either side. Two secondary roads cross the area and one extends throughout the length. Thus, the entire West White Mountain alteration area can be traversed readily by jeep or pickup.

### **Paleozoic (Callville) Limestone**

The oldest rock in the West White Mountain area is Paleozoic limestone which crops out at the eastern end of the alteration zone near the base of White Mountain. The entire area of White Mountain is composed of the Callville Formation of Pennsylvanian age as determined by L. Hintze of Brigham Young University. The rocks here are more or less flat-lying with gentle dips both to the east and west. The formation consists mainly of blue sandy limestones, somewhat thin-bedded in places and as far as could be determined entirely unaltered even in the most eastern portion of the alteration area where altered volcanic rocks are directly in contact with the limestone. The outline of the contact of the younger rocks with the limestone is so irregular it is believed that an interpretation of a fault contact at this point is untenable.

### **Tertiary Ignimbrite**

The next younger rocks, labeled Tv on Plate II, consist of four early Tertiary ignimbrite units. These are the only rocks involved in the alteration in question. At the base of this series, lying directly upon limestone, is an unidentified ignimbrite. Not yet named it is distinctive enough to be recognized readily in the field. It consists of an undetermined thickness of bluish, grayish, and reddish ignimbritic rock which breaks down readily upon weathering into very small pieces. The porphyritic, fragmental, and glassy nature of this ignimbrite is readily discernable in these pieces. It lies conformably beneath the Needles Range Ignimbrite (Mackin, 1960) and is referred to as the pre-Needles unit.

Lying conformably upon the pre-Needles unit is the Needles Range ignimbrite. Only a few unaltered outcrops of this ignimbrite were discovered. Hence, no real determination as to its extent or thickness has been attempted. The Needles Range ignimbrite consists of a red to purple, glassy to aphanitic rock containing crushed spheroids,

crystals, and lithic fragments. It shows a well-bedded character, and attitudes can be determined readily which show that there has been gentle crystal warping since its origin.

Lying upon the Needles Range volcanic unit is the Isom ignimbrite (Mackin, 1960). This constitutes most of the unaltered rock within the area studied. The Isom Formation has an extremely varied lithologic character. Much of the Isom is a rather dense, glassy to aphanitic, reddish to purplish rock having phenocrysts up to 5 mm in length. However, within this lithology are lenses of vitrophyre and scattered dark latitic or basaltic rocks which distinctly resemble flows.

Lying upon the Isom and exposed widely in many places throughout the area is the easily identified Quichapa ignimbrite (Mackin, 1960). This consists principally of lighter-colored tuffaceous-appearing material which contains many angular lithic fragments, mostly of Isom derivation. Where unaltered it weathers to rounded forms and can be confidently identified and correlated throughout the area.

White Mountain, whose height is nearly 6,800 feet from its base around 6,200 feet, shows that considerable relief existed before the ignimbrites were extruded upon the older rocks.

### **Tertiary Andesite**

Lying upon the Quichapa is an undetermined thickness of Middle to Late Tertiary lava flows which are largely grayish to black latite, and some basalt. All these may be slightly porphyritic. Vesicles here are very rare. The rock weathers readily to more or less rounded and gentle slopes. The ignimbrites below the andesite type rocks have been gently folded and eroded so that the andesites lie upon the ignimbrites unconformably. These rocks have not been affected by hydrothermal alteration.

### **Tertiary (?) Basalts**

Lying also unconformably upon the andesites and the ignimbrites are Late Tertiary dark to black, dense aphanitic basalts which in part are strongly vesicular and amygdaloidal. These are underlain for the most part by a thin bed of white to gray, loose, poorly exposed, vitric crystal and lithic tuffs.

### **Quaternary**

The youngest deposits of the area consist of unconsolidated mixtures of gravel, sand, silt, and clay cemented with caliche of Quaternary age. Also mapped as Quaternary alluvium are lake beds, stream wash or deep soil cover where bed rock cannot be determined.

## Mineralization

The main purpose of this study was to determine the nature and extent of the secondary mineralization in the area. Only the ignimbrites have undergone alteration, establishing the age of the alteration as probably early middle Tertiary. The secondary minerals found, listed not in their order of abundance, are: alunite, kaolinite, quartz, hematite, limonite, pyrite, and sulphur. Probably the most abundant of these minerals are alunite and kaolinite. The recognition of these two minerals proved to be very difficult in the field. Hence, an effort to differentiate specific areas containing abundant kaolinite or abundant alunite was not made. Some rocks are slightly altered and some rocks are entirely altered, thus making possible a field classification based upon the degree of alteration. The recognition of the original ignimbrite which was altered was not attempted since alteration invariably obliterated most of the primary features which would allow this identification. An exception was made, however, for what is believed to be the Quichapa Formation, where in one large altered area most of the rocks show an extremely brecciated character which when weathered exhibit an extremely cellular-type surface, readily recognized in the field. No attempt was made to correlate this area with known unaltered Quichapa of the district. The altered Quichapa (?) rocks have been distinguished in the mapping from altered rocks whose original identity could not be made. These latter are grouped under one symbol on the accompanying map (Plate II).

The development of alunite and kaolinite invariably yields white to grayish rocks, whereas the silicified rocks are predominantly grayish. The hematitized rocks, of course, are reddish, whereas those containing limonite are brownish. In the mapping of these several types, careful attention was paid to the various field criteria that could be established, and outlines of the different alteration types drawn as carefully as possible from point to point. It is believed that the mapping, having been done on a scale of 400 feet to the inch, has been accomplished with first order accuracy in most places. However, in some areas where the tree cover is thick, the position of the contacts may be slightly in error.

The development of the secondary minerals could be divided as follows: true alteration, true replacement, and introduction along cracks and fractures. All the minerals found show all three types of replacement. The different alteration types which were mapped are discussed in detail below.

Intensive Alunite and Kaolinite. The field appearance of intensive alunite and kaolinite alteration is probably the most varied of all the types which were mapped. In general, the rocks are white to slightly purplish with only a few remnant structures or phenocrysts observable.

The rock generally is earthy in appearance. Many samples of this rock were thin-sectioned to determine the extent of development of kaolinite and alunite. It was found to be extremely varied, and no one area seemed to show a real predominance of one mineral over the other. However, there is a suggestion in the over all examination that throughout the area alunite is more abundant in the eastern section, whereas kaolinite seems to be more abundant in the western section. Not only are the primary minerals and ground mass completely or partially altered to kaolinite and alunite, but in a few places alunite and kaolinite veins are found that vary from a fraction of an inch to an inch in width. When these veinlets are seen, the differences between alunite and kaolinite become readily apparent. Because individual crystals are so small, both minerals are porcelain-like to earthy in hand specimen appearance. The alunite generally shows a slight pinkish tint and, of course, is scratched with some difficulty. Kaolinite veins are generally milk white or slightly grayish white and the soft nature of the mineral is readily apparent. Some rocks were included in this type where small hematite spheroids as much as 1/2 mm in diameter are present. Upon thin section examination is found a development of very fine quartz, in many cases appearing somewhat like chalcedony. However, this alteration is generally rather minor. When silicification becomes intense, the rock was mapped as silicified. In thin section kaolinite and alunite can be distinguished readily. Kaolinite is generally in rosettes, worm-like structures or fine aggregates. This, together with its rather low birefringence and length-slow character, make it easily distinguished from alunite under the microscope. Recognizable crystal units of kaolinite vary in size from  $10\mu$  to 0.05 mm in diameter.

Under the microscope the alunite can appear in two forms. It may be either flaky with moderate birefringence, or euhedral, square to lozenge shaped crystals with low birefringence. Sizes of crystal units range from around  $20\mu$  to 1.0 mm. The index of refraction of the alunite of course is considerably higher than that of the kaolinite. The length-fast nature of alunite serves as an immediate positive optical check. The microscopic determinations were verified with both x-ray and infra-red analysis. The infra-red curve for alunite is distinctively different from the curve for kaolinite. Approximately 25 infra red curves were run, and it is believed that an accurate determination of these materials has been made. Both alunite and kaolinite may be separated into individual clumps or intimately mixed with one another. So far, no halloysite or allophane has been discovered, nor has any mineral of the montmorillonite group or the illite groups been shown to be present. It may be stated here that a few prospect pits were found on extremely white material of this type, evidently on the speculation that the material was clay and could be used for ceramic purposes. However, the invariable presence of alunite mixed with kaolinite makes the material entirely unsuited for any ceramic use.

Moderate Alunite and Kaolinite An alteration type was mapped where only a moderate amount of alunite and kaolinite was developed. These rocks are invariably white or grayish white with a rather dense appearance and generally with the preservation of some original structures such as lithic fragments or phenocrysts. Thin-section examination of this type shows invariably that the kaolinite and alunite are present along with much glass, and quartz of the extremely fine variety may be slightly more abundant than in the (AK) intensive alteration type. Generally, within these areas no veinlets of alunite or kaolinite were discovered. The chief criteria used for mapping this unit was its rather dense porcelain-like appearance with vuggy nature where the development of coarser quartz has occurred.

Silicification. The silicified rock is readily apparent and easily identified in the field. Its superior hardness, grayish color and resistance to erosion make it stand up generally in bold outcrops. Here the quartz has been introduced into the rock in profuse amounts and upon microscopic examination found to be much more coarse grained than that found in the alunitized and kaolinitized rocks. Microscopic examination shows that most of the silicified specimens contain a little alunite and a small amount of kaolinite. Often relic structures are to be found here, some of the original rock features, such as lamination, flow banding, preservation of phenocrysts, are still to be seen. Vugs with coarse, recognizable quartz crystals are very rare.

Chalcedony. Field recognition made the mapping of one silicified type possible, where the development of chalcedony and opal has taken place. Some original structures are preserved as relics, but in general these have been obliterated. This rock contains no alunite or kaolinite. The chalcedony and opal vary from gray to yellow, and in the extreme western part of the area may be a deep red. This material could be of high value to the lapidarist, except that no pieces larger than six inches in dimension are to be found without flaws of one kind or another. Most of this material probably would have to be used as a smaller gem rather than in the ornamental field. At least one mining claim has been established on a chalcedonic area, evidently for the purpose of mining the material for polishing purposes.

Altered Breccia (Quichapa ?) Along the main east-west alteration zone in sections 7 and 8 is to be found about 3,000 feet of highly brecciated altered rock. This rock could be altered Quichapa Formation which it resembles greatly. Two alteration types are mapped within this area in addition to the hematite-bearing rock. These are: (1) A strong development of silica where the entire rock has been replaced by fine-grained quartz. The original breccia features, however, are usually well preserved. (2) A strong development of alunite and kaolinite. Here also the original breccia features are well preserved and upon weathering the breccia fragments have been etched out,

giving the rock very often a distinct cellular-like appearance. The breccia fragments are often found to be altered to pure alunite and sometimes kaolinite in various places.

Hematite. Distributed in various intensities throughout the area is red to purplish hematite which has developed late in the mineralization sequence. It may be found disseminated in the rock or along fractures. Often only a dusty facing can be seen on fractures, but occasionally solid red earthy hematite can be seen. Three degrees of alteration of this type have been mapped.

(1) Where the extrusive rock is more or less fresh or unaltered but with hematite developed to a moderate degree on fracture surfaces, this type has been mapped as Fhm.

(2) Where the extrusives are moderately or strongly altered and hematite is present to a moderate degree, mainly along fractures, the rock has been mapped as Ahm. Thin sections show that the alteration preceding the development of hematite in this type is generally what would be expected--kaolinite, alunite, and fine quartz. Sometimes hematite here is present in small clumps or clots within the rock, not necessarily connected with fractures.

(3) The strongest and the most definite type of hematite alteration was mapped as Hm where hematite has developed strongly in fresh and/or altered extrusive rocks. Red to purple hematite pervades this rock not only along the fractures but is abundantly present within the body of the rock as clots and clumps. Because of the strong red color, this type of alteration was found to be most readily recognizable of all the types mapped.

Limonitized Rock. Several small areas and a fairly large one were found where altered rock has had limonite deposited chiefly along fractures in the rock. An effort was made to find the source of the limonite such as the former presence of pyrite. However, no trace of pyrite or pyrite casts of any sort were found in this alteration type.

Siliceous Sinter. At the extreme western edge of the mapped area are found several veins from which have been mined native sulphur. Encasing the native sulphur is a porous cellular-type siliceous sinter, believed to be the result of hot spring deposition--in this case probably not on the surface but at some depth.

Sulphur Deposits (Nackowski, 1959). Two areas where sulphur has been mined are found at the western end of the area mapped. On the ridge near the east-central part of section 12 is found a small amount of native

sulphur in cavities within the slightly altered rock, but no distinct veins of sulphur were found at this particular point. At the extreme western end of the area on what is known as Sulphur Knoll, native sulphur is found in two east-west trending veins, the western one slightly north of the eastern one. Both veins appear to be a little more than a foot in width and perhaps in either case not more than 50 to 60 feet in length. The sulphur has been opened for a depth of possibly 20 feet, and one adit at the south base of the hill had apparently been opened trying to cut the sulphur vein at depth; but from the nature of the material on the dump, either the objective was not achieved or sulphur was not encountered. The origin of the sulphur has been attributed to hot spring activity, following the development of the siliceous sinter which encases the sulphur veins.

Pyrite and Manganese. One small area where pyrite was present in altered rock was found on the east side of a ridge in section 1. This pyrite is very difficult to observe because of the extremely small size of the crystals, and it was only by accident that this occurrence was discovered. No oxidation has been developed on the pyrite. One must hunt rather diligently in this area to find uncontroversial pyrite in a rock. It is disseminated in rather widely spaced small crystals and could be a primary constituent in the extrusive. No channeling of any sort was noticed accompanying the pyrite. Slightly to the north of the pyrite occurrence is an area of strong hematite development where on some fracture surfaces black manganese oxide has been deposited in small amounts.

## **EAST WHITE MOUNTAIN AREA**

The East White Mountain area was selected for alteration study even though it is isolated from the West White Mountain alteration area. Drawing an east-west line through White Mountain encompasses the main West White Mountain area and the East White Mountain area, thus suggesting that some structural alignment is probable between the two areas. However, upon detailed study it was found that the two areas show some differences, not only in the general geologic setting, but also in the alteration. Also exposed in the East White Mountain area is more encouraging economic mineralization, as evidenced by the innumerable prospect pits, adits, and mining claims which are to be found there. Thus, a separate report is considered proper to present the material in a more clear and detailed fashion. The general geology of the area has been mapped somewhat differently from the West White Mountain area. The western terminus was set at White Mountain. The eastern terminus was made near Long Lick Mountain, a large hill of Paleozoic rocks rising up through the extrusives. The intensity of alteration seems to be drying out at the point where the map terminates.

This area may be more conveniently approached from Milford from the south. The road here, however, is dirt, some of it graded and some of it not. A dirt road skirts the northern part of the White Mountain; thus the area is readily approached from the West White Mountain area, and travel time may be shorter over this route, even though the distance is greater. Over most of the East White Mountain mapped area is a thick growth of piñon pine and juniper with occasional areas of sagebrush and bunchgrass. The slopes are steep although the relief is not too great. Water can be found about a mile north of the area, but is drinkable only in an emergency. Though there are evidences of many claims having been staked here, none of them has yet been checked for ownership or validity.

### **Geologic Setting**

The oldest rocks in the area are folded Paleozoic limestones. A steep topography was eroded upon these limestones and early Tertiary ignimbrites extruded upon it with little subsequent crustal warping. Mineralization and alteration was then followed by flows of andesite extruded in presumably Middle or Late Tertiary time. Quaternary deposits are exemplified principally by deep soil, slope and stream wash.

### **Paleozoic**

The Paleozoic rock of the area is exposed in two places. The eastern base of White Mountain is shown upon the map and consists of presumably Callville Limestone of Pennsylvanian age. Bedding on the east side of White Mountain is readily apparent in the limestone. Some of the beds seem to be fairly thick and massive; however, most of the series is rather medium to thin bedded. In the east-central portion of the mapped area are two hills of limestone which apparently have been very strongly sheared and folded as dips are extremely difficult to obtain. In one place, however, it was believed that evidence was present to show that at least on the eastern portion of the area the rocks dip to the northeast. The age of these limestones is not known, since no fossils were found anywhere within them.

### **Tertiary**

Lying upon the rough limestone topography is a tuffaceous material believed to be similar and correlatable to the Early Tertiary pre-Needles unit west of White Mountain. Here, however, the pre-Needles unit is quite thick, up to approximately 200 feet. Colors vary from bluish to purple through rather light gray and white in its upper parts. These features have enabled mapping of the upper contact with some degree of accuracy. This contact was not observed in detail throughout its entire length, but from the enlarged photographs it is believed that a fair approximation of the upper contact of the pre-Needles was discerned. It is within this formation that a great deal of the hydrothermal alteration has been accomplished.

Lying above the pre-Needles is a thin unit of extrusive rock, probably not more than 50 to 100 feet thick, that appears very much like Needles Range ignimbrite (Mackin, 1960). It has all the previously described characteristics of that formation, being more or less purplish to red in its over all color with lithic fragments, phenocrysts, flattened spheroids, and prominent lamination. No attempt was made to differentiate on the map the Needles from the Isom ignimbrite (Mackin, 1960) which lies above.

The Isom ignimbrite here is identical to that exposed west of White Mountain, being more or less reddish to purplish in color and much more dense and massive than the Needles Range below. Considerable alteration has been accomplished also within the Isom and possibly the Needles Range Formations.

### **Tertiary Andesite**

Lying unconformably upon the Needles Range is a series of andesites latites which are very similar to those found west of White Mountain and are thought here to be of the same age, that is, Middle to Late Tertiary. These rocks are not involved in the alteration and are hence believed to be younger than the alteration activity.

### **Quaternary**

The youngest material in the area is alluvium, consisting of gravels, sand, clays, slope wash, deep soil, and stream wash. This formation covers most of the lower stream courses as well as occasionally a broad flat.

### **Mineralization**

The alteration units which have been mapped east of White Mountain vary only in one major respect from the alteration west of White Mountain. Alunite and kaolinite are fairly well developed in large areas of the rocks. The Isom and Needles Range have been extensively altered near White Mountain and two intensities have been mapped here, that is, where alunite and kaolinite are strong (AK) and where kaolinite and alunite are rather moderately developed (ak). These rocks appear identical with those of the West White Mountain area, being largely white to sometimes grayish. An indication of the intense type of alteration is that most of the relic structures are obliterated; whereas with a moderate alteration relic structures often are preserved, such as phenocrysts, lithic fragments, etc.

Chlorite. One type of alteration seen east of White Mountain which is not present west of White Mountain is a chloritic (Chl) type found principally where the upper parts of the pre-Needles tuffaceous material is present. Several pits and cuts have been dug on this alteration, but apparently no economic mineralization has been found.

Silicification. Silicified rock (S) is represented in two places within the area. Directly east of the limestone of White Mountain are two small streaks of silicification in the alunited and kaolinitized ignimbrite. Most of the silicification, however, may be observed in the Paleozoic limestones near the central portion of the map. Here four or five large areas of silicified limestone are to be found together with one small stringer. This silicification has been imposed upon generally brecciated limestone material. No pits or prospects were found in this silicified rock, hence, it is believed that no economic mineralization accompanied the silicification.

Hematite. Hematite occurs extensively east of White Mountain, and two types involving the intensity of its development have been mapped. Where the ignimbrites have been altered to alunite and kaolinite, with a moderate amount of hematite along cracks and fractures and moderately disseminated throughout the rock, it has been mapped as moderately altered hematitic rock (Ahm). Some large patches of heavily developed hematite have been mapped. In one place near the section corner of 1, 2, 11, and 12, hematite was so strongly developed that prospect pits have been dug. Close examination shows that in one place at least a third of the rock has been altered to hematite. This was the heaviest development of hematite seen throughout the area. One small patch of pre-Needles unit was discovered near the north-central portion of the map where limonite has been deposited upon the fracture surfaces of the rock.

Siliceous Sinter. One small area of siliceous sinter was discovered directly east of the Paleozoic rocks of White Mountain. The siliceous sinter here is identical with that found west of White Mountain, being white to grayish in color, extremely porous, and cellular in appearance. A small pit was dug on the south margin of this sinter area, no doubt searching for a deposit of sulphur similar to that which was found in the West White Mountain area near the siliceous sinter at the extreme western edge of the map. No sulphur is evident, however.

### **Economic Mineralization**

Near the east-central portion of the map area (Plate III) where pre-Needles unit has been faulted in contact with silicified limestone, there is a pit with a minor amount of small autunite crystals and some yellow carnotite crystals. This pit has been dug recently in pre-Needles material; and though the uranium minerals are not present in sufficient amount to be mined, it shows that some uranium mineralization has been accomplished. Several other prospect pits have been dug immediately to the west and north, no doubt with encouragement offered by the uranium mineralization at the place above described. However, within these pits no further mineralization was found. As above mentioned, there is one prospect on a strong hematite mass near the section corner

of 1, 2, 11, and 12. The hematite, of course, was not present in sufficient concentration or amounts to warrant more than a shallow pit. Alteration has been intense throughout the area at various points. It is believed that the same economic possibilities are present here as were proposed in the West White Mountain area. The alunite, which invariably accompanies the clay materials, makes the use of the latter impossible for ceramic purposes. The strong development of silicification in the limestone and the presence of uranium mineralization offer encouragement that the rocks below the ignimbrites may at some points contain economic minerals.

## GROVER WASH AREA

The smallest of the three areas has been termed the Grover Wash Area (Plate IV). Not originally included in the program, this area was mapped because previously unrecorded limestones and quartzites were found, and it was considered proper that they be studied. Their position off the northern extension of the main area further suggested some interest, especially since the limestones are intensely silicified and some small intrusives are present in this area.

A good dirt road extends through the area. It is a branch from the main north-south road used during the mapping of the West White Mountain area. There is no water. The topography is low, with maximum elevations about 100 to 150 feet above the flat. A few scattered piñon pines and junipers are present with sagebrush and bunchgrass. Field mapping was done on enlarged aerial photos with a scale of approximately 400 feet to the inch.

Two hills of Paleozoic rock exposures are present. The west hill, which is divided almost in two by the range line between R 14 W and R 13 W, is composed of eastward-dipping limestones with one shale bed. This shale yielded abundant fossils consisting of recognizable Derbyon crassus together with many as yet unidentified bryozoan and one spirifer. The age of these rocks is set by Professor Stokes of the University of Utah at possibly late Mississippian.

All the rocks here are well exposed. One small fault cuts across the area at the south end. Three small intrusive rhyolitic type rocks intrude the west area. The extent of the eastern-most intrusive is not known because of gravel and stream wash cover towards the east. Alteration consisting principally of silicification has been rather intense in the limestones, with large areas showing relic brecciated character being exposed. One adit was dug on the most brownish colored of the silicified outcrops. There must have been some prospecting encouragement here, for the work is more extensive than would have been warranted had there been no value in the original

outcrop. Close examination of this outcrop showed casts of what possibly could have been former pyrite crystals. Other silicified areas appear to be rather barren of mineralization other than silica, except for an occasional brown patch.

On the hill to the east are two types of rock separated by a fault. Limestone occurs dipping to the eastward near the main road, and here one small dike-like intrusive was discovered. One horn coral was found, however, it was so poorly preserved no further identification could be made of it. Hence, the ages of these rocks are not known. The lithology here appears to be somewhat similar to those rocks of presumably Mississippian or Pennsylvanian age in the west hill. Near the small dike the limestone is rather black and filled with small dolomite veinlets. It is believed hydrothermal dolomite has developed here to a slight extent. The rocks north of the main southeastward-trending fault are a series of thin limestone beds within massive to coarse-bedded hard quartzite. These rocks are dipping to the west in a reverse manner to that of the limestones both of the east and west hill. No age determinations were possible on the quartzite since no fossils of any sort were found within either the limestones or the quartzites. It has been suggested that this may be the Ely Limestone. The extrusives of the area consist principally of pre-Needles ignimbrite and possibly Isom lying directly above. In one place near the southwestern part of the west hill was found some small pre-Needles fragments with malachite stains on them. These were assayed and found to run 0.18 per cent copper. A sample of the silicified limestone at the prospect on the west hill was also assayed and found to run a trace in gold and none in silver.

## **ORIGIN OF THE ALTERATION**

The presence of kaolinite and alunite in profuse amounts throughout the whole area makes it unquestioned that the solutions which accomplished the alteration were distinctly acid in character; and further, with abundant sulphate and native sulphur present, the acids were probably sulfuric in nature. In many places the alteration is pervasive and only occasionally follows channels. Hematite which has been introduced in large amounts over the area has come in later than the main alunite-kaolinite alteration.

It is rather unusual, and in this case, disappointing, aside from the hematite, to find such a thorough lack of economic minerals or useful metals in such a large alteration area. Either there originally were no economic metals in the solutions which caused the alteration or else the economic minerals were deposited at some depth and only the solutions which were lean in economic minerals progressed into the area which has been altered.

## **PROPOSALS FOR FURTHER STUDY**

The presence of large amounts of hematite within the altered area would seem to indicate that a magnetic survey would be justified here. Iron could be deposited at depth in the form of magnetite, and it is believed if such is the case it could be readily detected by a magnetic survey.

An intensive, systematic sampling of the area from a geochemical point of view may show some distribution patterns or high content of useful metals within the area.

---

## **CITED REFERENCES**

Mackin, J. H., 1960, Structural significance of Tertiary volcanic rocks in southwestern Utah: *Am. Jour. Sci.*, v. 258, p. 81-131.

Nackowski, M. P., and Levi, Enrique, 1959, Mineral resources of the Delta-Milford area: *Utah Eng. Experiment Station Bulletin* 101.

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Maps 2, 10, and 11 are out-of-print.

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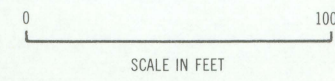
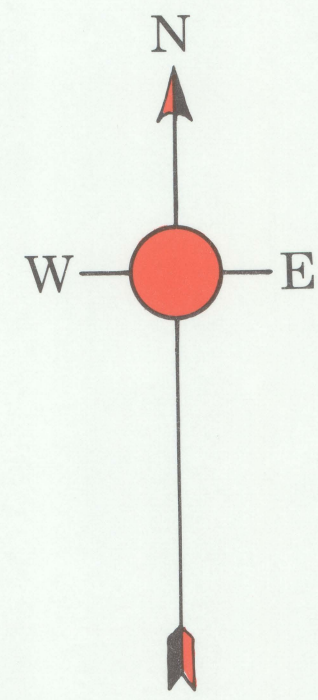
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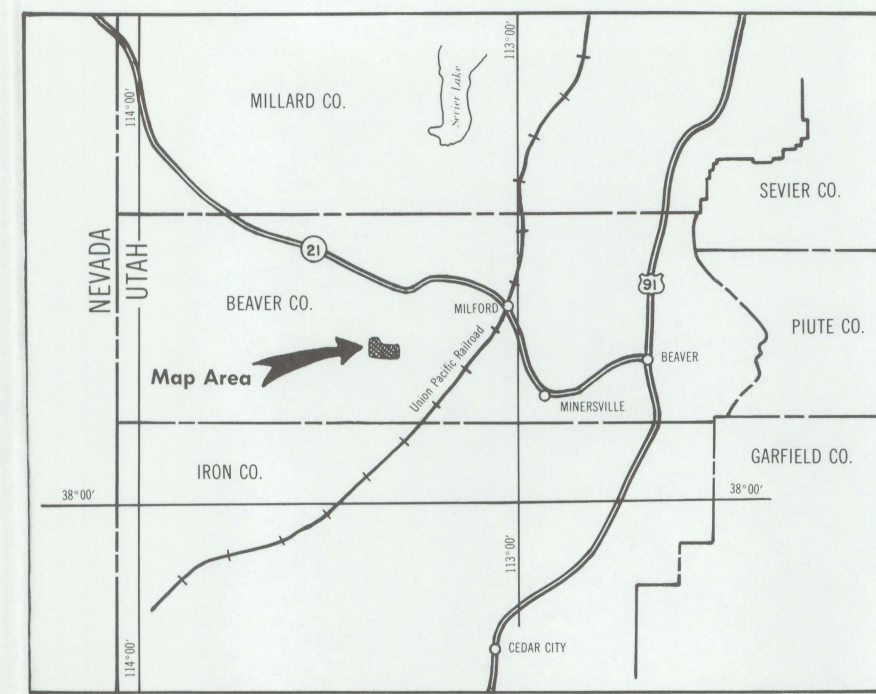
# ALTERATION MAP OF THE WEST WHITE MOUNTAIN AREA, FRISCO QUADRANGLE, BEAVER CO., UTAH

Mapped by Bronson Stringham and John Brooke in 1962

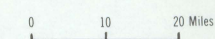


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INDEX MAP



SEE PLATE 1 FOR LOCAL INDEX

### LEGEND

- Qal** Quaternary  
*Unconsolidated mixtures of gravel, sand, silt, clay mixed with considerable caliche. Lake beds, stream wash or deep soil cover is included.*
- Tb** Late? Tertiary  
*Basalt: Dark to black dense aphanitic basalts, occasionally strongly vesicular and amygdaloidal. Often underlain by white to gray loose, poorly exposed vitric, crystal and lithic tuff.*
- Tv** Middle to Late Tertiary  
*Andesite, latite and some basalt: Largely grayish to black, often porphyritic; vesicles rare, weathers to rounded shapes.*
- Te** Early to Middle Tertiary  
*Ignimbrites, flows and tuffs: Fresh and unaltered, believed to be equivalent to (1) pre-Needles, (2) Needles Range, (3) Isom, (4) Quichapa granibrites and tuffs (see text for description).*
- Pc** Paleozoic  
*Callville? Limestone: Thick to thin-bedded sandy limestone of White Mountain.*

### EXPLANATION

- Unimproved road
- 1/4 section in place
- Prospect pit

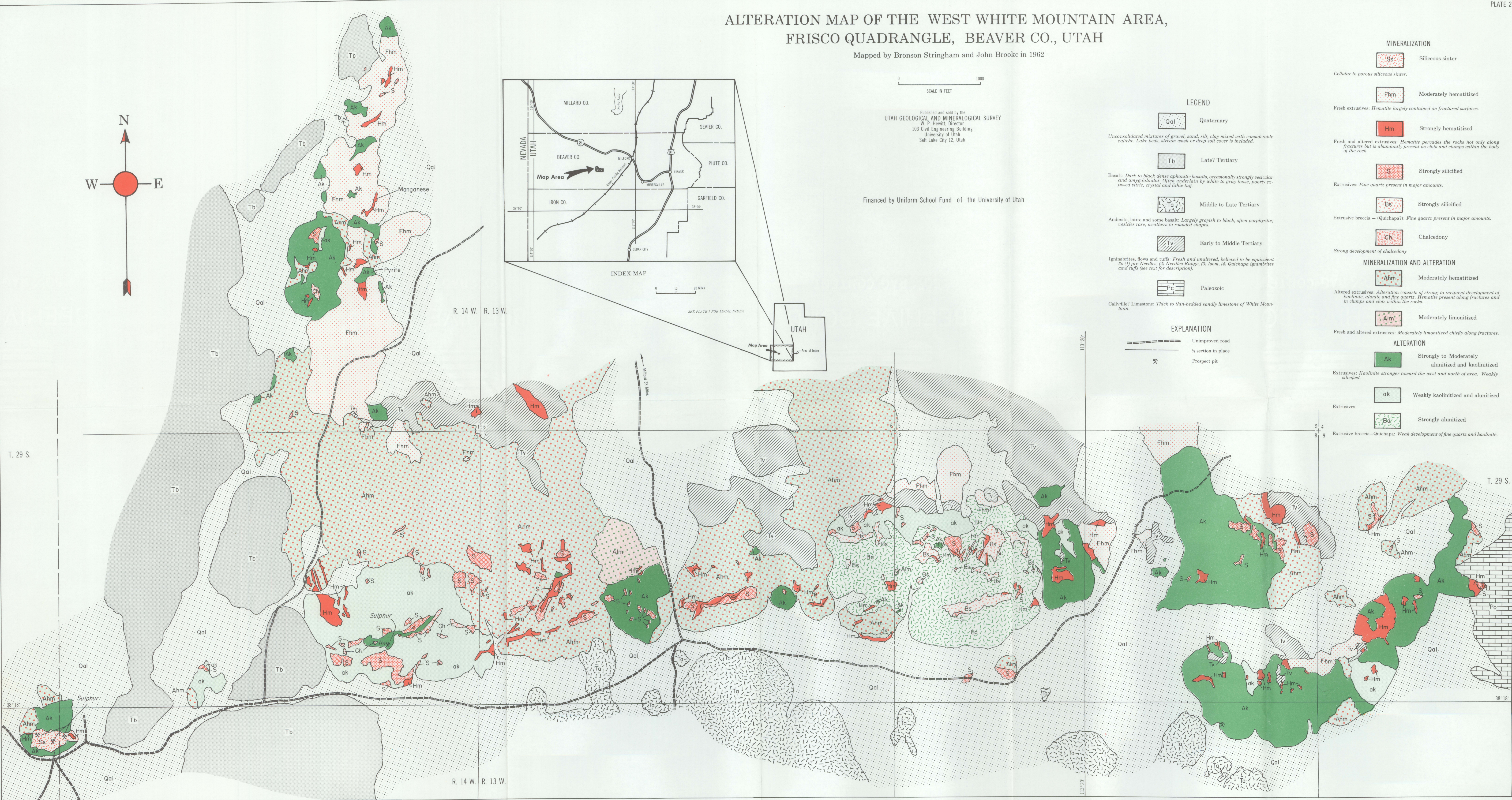
### MINERALIZATION

- Ss** Siliceous sinter  
*Cellular to porous siliceous sinter.*
- Fhm** Moderately hematitized  
*Fresh extrusives: Hematite largely contained on fractured surfaces.*
- Hm** Strongly hematitized  
*Fresh and altered extrusives: Hematite pervades the rocks not only along fractures but is abundantly present as clots and clumps within the body of the rock.*
- S** Strongly silicified  
*Extrusives: Fine quartz present in major amounts.*
- Bs** Strongly silicified  
*Extrusive breccia - (Quichapa?): Fine quartz present in major amounts.*
- Ch** Chalcedony  
*Strong development of chalcedony.*

### MINERALIZATION AND ALTERATION

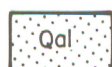
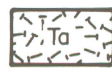


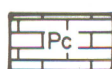
- Ahm** Moderately hematitized
- Alm** Moderately limonitized  
*Fresh and altered extrusives: Moderately limonitized chiefly along fractures.*
- Ak** Strongly to Moderately alunitized and kaolinized  
*Extrusives: Kaolinite stronger toward the west and north of area. Weakly silicified.*
- ak** Weakly kaolinized and alunitized
- Ba** Strongly alunitized  
*Extrusive breccia - Quichapa: Weak development of fine quartz and kaolinite.*

### ALTERATION





EXPLANATION



LEGEND

-  Quaternary  
*Unconsolidated mixtures of gravel, sand, silt, clay mixed with considerable caliche. Lake beds, stream wash or deep soil cover is included.*
-  Late? Tertiary  
*Andesite, latite and some basalt: Largely grayish to black, often porphyritic; vesicles rare, weathers to rounded shapes.*
-  Early Tertiary  
*Ignimbrites, flows and tuffs: Fresh and unaltered, believed to be equivalent to Needles Range, and Isom (see text for description).*
-  Early pre-Needles  
*Ignimbrites, flows and tuffs*
-  Pennsylvanian  
*Callville? Limestone: Thick to thin-bedded sandy limestone of White Mountain.*




MINERALIZATION

-  Strongly hematitized  
*Fresh and altered extrusives: Hematite pervades the rocks not only along fractures but is abundantly present as clots and clumps within the body of the rock.*
-  Strongly silicified  
*Extrusives: Fine quartz present in major amounts.*

MINERALIZATION AND ALTERATION

-  Moderately hematitized  
*Altered extrusives: Alteration consists of strong to incipient development of kaolinite, alunite and fine quartz. Hematite present along fractures and in clumps and clots within the rocks.*
-  Moderately limonitized  
*Fresh and altered extrusives: Moderately limonitized chiefly along fractures.*

ALTERATION

-  Strongly to Moderately alunitized and kaolinitized  
*Extrusives: Weakly silicified.*
-  Weakly kaolinitized and alunitized.  
*Extrusives*
-  Moderately altered to chlorite  
*Pre-Needles: Moderately altered to chlorite.*

ALTERATION MAP OF THE EAST WHITE MOUNTAIN AREA,  
FRISCO QUADRANGLE,  
BEAVER CO., UTAH

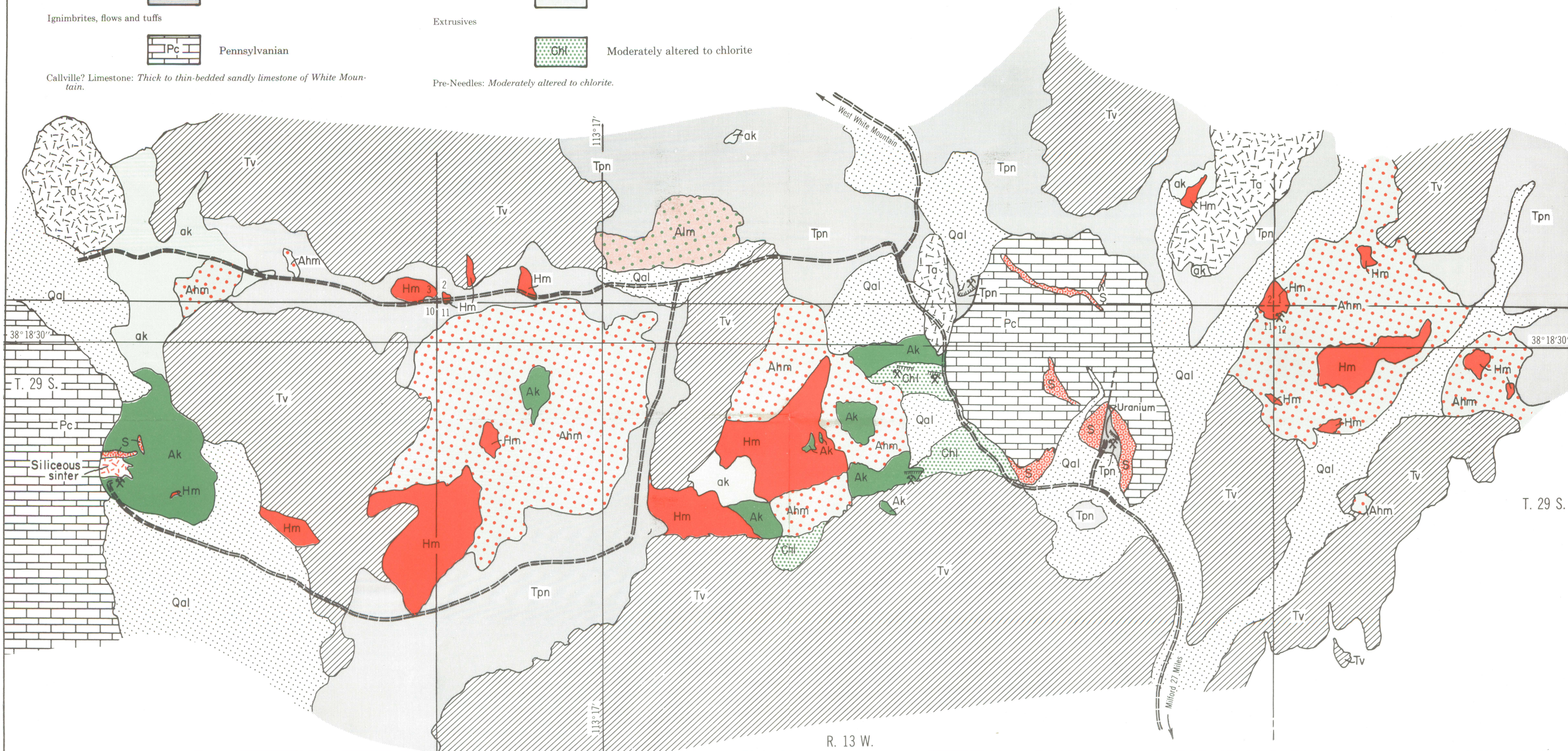
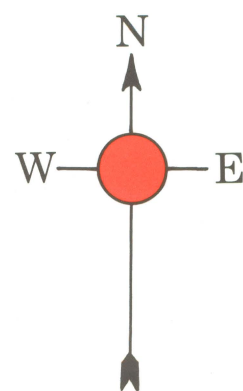
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Location and Index Information on Plates 1 and 2

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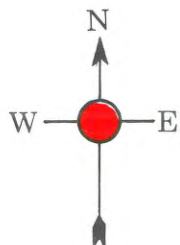


# GEOLOGIC MAP OF THE GROVER WASH AREA, FRISCO QUADRANGLE, BEAVER CO., UTAH







Geology by Bronson Stringham and John Brooke in 1962






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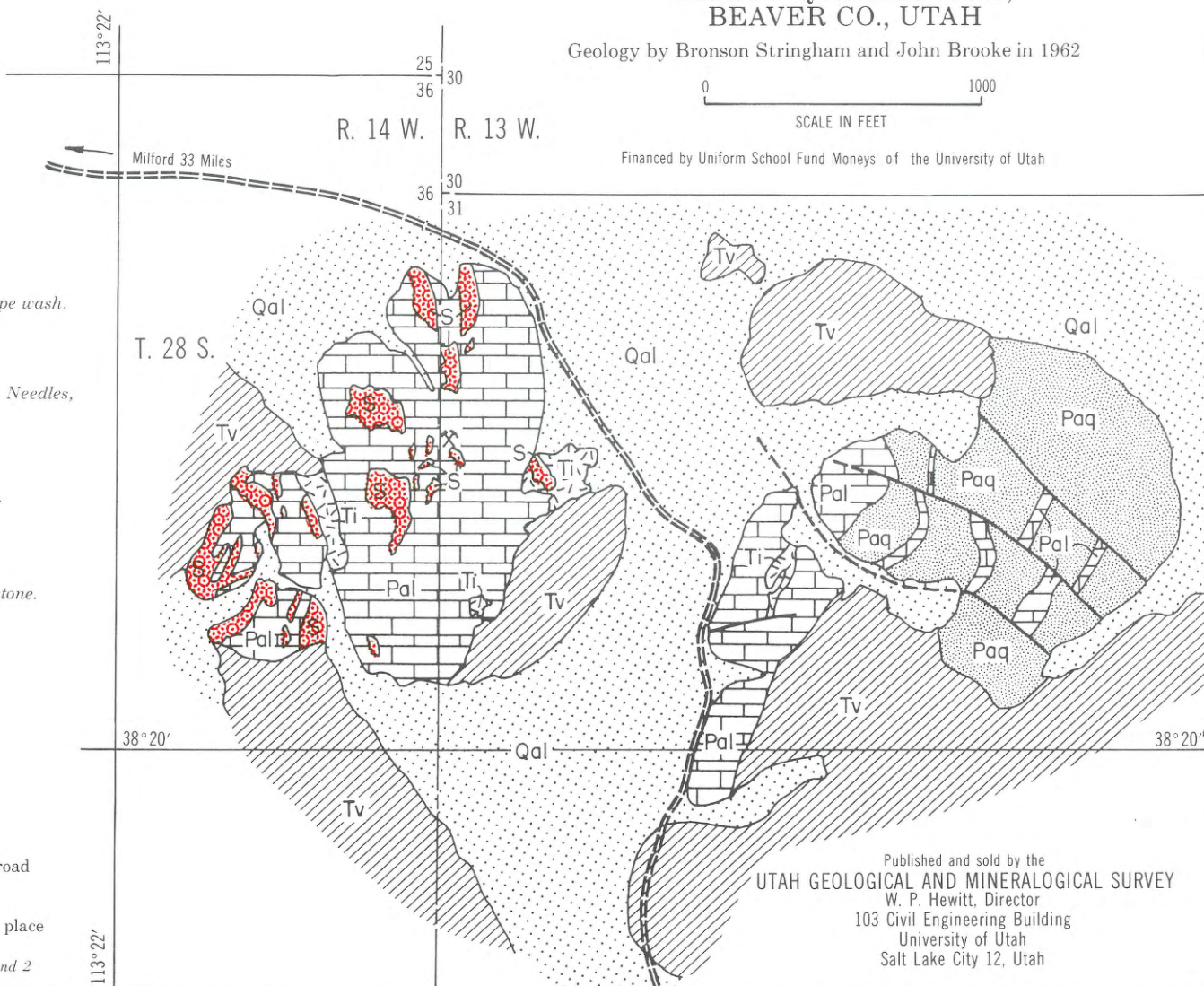
## LEGEND

-  Qal  
Quaternary alluvium, stream and slope wash.
-  Tv  
Tertiary ignimbrites, pre-Needles, Needles, and Isom.
-  Ti  
Tertiary intrusive rhyolite.
-  Pal  
Paleozoic Pennsylvanian? limestone.
-  Paq  
Paleozoic quartzite
-  Silicification

## EXPLANATION

-  Unimproved road
-  Prospect pit
-  1/4 section in place

Location and Index Information on Plates 1 and 2



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