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GEOLOGY OF THE TWINRIDGE PLUTON AREA, NEVADA TEST SITE, NEVADA

By

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ABSTRACT

As a part of the U.S. Department of Energy's Nevada Nuclear Waste Storage Investigations program, the Twinridge pluton is evaluated as a potential site for nuclear waste storage in crystalline rocks. The Twinridge pluton is quartz monzonite that crops out over an area of approximately 76 m^2 in the Halfpint Range, northeastern Nevada Test Site. It intrudes the Johnnie Formation and Stirling Quartzite of Precambrian age, and is overlain by Tertiary volcanic rocks. The area is structurally characterized by Basin and Range faults, folds, and thrust faults.

Geologic and aeromagnetic data suggest that the Twinridge pluton and the Climax stock, a much larger exposure of granitic rocks to the northwest, may be genetically related and possibly coalesce at depth to form a continuous crystalline body as suggested by: (1) approximate coincidence of the Halfpint anticline with exposures of the Twinridge pluton and the Climax stock; (2) similar mineral composition of the two exposures; (3) possible gravity sliding of Precambrian rocks from the axial trace of the anticline; (4) elongation of aeromagnetic contours and occurrence of highs parallel to the axial trace of the anticline; and (5) distribution of alteration and mineralization parallel to the axial trace of the anticline.

The Twinridge pluton area should not be considered for further study as a potential nuclear waste repository for the following reasons: (1) it lies within one of the most highly faulted zones at the Nevada Test Site; (2) numerous Quaternary faults displace alluvium, a few of which can be traced into bedrock immediately northeast of the Twinridge pluton exposures; and (3) characterization of the Twinridge pluton would be difficult without extensive drilling and additional geophysical surveys.

INTRODUCTION

This report is the result of library research and a brief field examination of the Twinridge pluton area, as part of a study to characterize crystalline bodies for possible nuclear waste repository sites at the Nevada Test Site (NTS). Work was performed on behalf of the U.S. Department of Energy's Nevada Nuclear Waste Storage Investigation program. The Twinridge pluton is located at Twinridge Hill, in the Halfpint Range, in the extreme northeastern part of the NTS (fig. 1). Elevations range from about 1,494 m to approximately 1,615 m, and the area is accessible via several jeep trails. This part of the NTS is approximately 113 km northwest of Las Vegas, Nev., in the southern part of Nye County.

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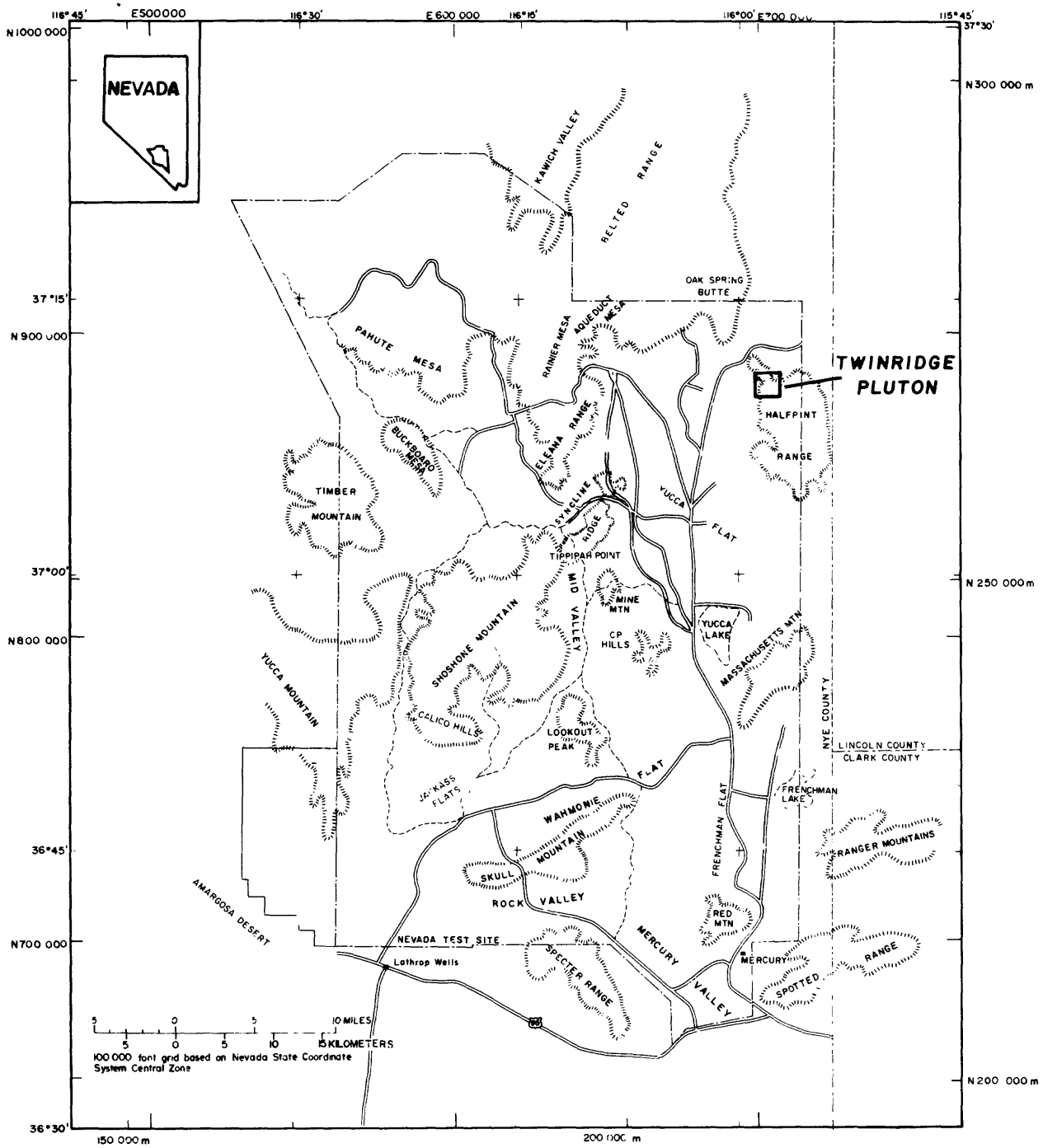


Figure 1.--Index map showing location of Twinridge pluton, Nevada Test Site, Nevada.

GEOLOGY

Stratigraphy

The oldest exposed rocks are those of the Precambrian Johnnie Formation, which is divided into two members: a lower quartzite and siltstone member, and an upper Rainstorm Member (Barnes and others, 1965). The quartzite and siltstone member is approximately 600 m thick, predominantly light-gray to pale-red micaceous quartzite with interbedded light-olive-gray to pale-red micaceous siltstone (Barnes and others, 1965). The overlying Rainstorm Member is approximately 300 m thick, composed of light-brown to light-red and dark-gray siltstone and silty limestone (Barnes and others, 1965).

The Johnnie Formation is overlain by the Stirling Quartzite, also of Precambrian age. The formation is approximately 900 m thick, predominantly quartzite and dusky red-purple to grayish-pink siltstone (Barnes and others, 1965).

The Precambrian rocks are overlain unconformably by volcanic rocks, mostly zeolitized tuffs of Tertiary age, that include the Tub Spring and Grouse Canyon Members of the Belted Range Tuff.

The Tub Spring Member, as much as 76 m thick, consists of welded ash-flow tuff, greenish- to yellowish-gray with local light-gray vitric nonwelded tuff at the base (Barnes and others, 1965).

The tuffs of the Grouse Canyon Member range in thickness from 70 to 76 m and include massive nonwelded ash-flow tuff and zeolitized bedded ash-fall tuff. The tuffs are light gray, white, and pale pink (Barnes and others, 1965; F. M. Byers, Jr., written commun., 1980).

Twinridge Pluton

The Twinridge pluton is exposed in two small outcrops (fig. 2) that occur on the east side of Twinridge Hill, with total surface exposure of approximately 76 m^2. The pluton is a quartz monzonite porphyry similar in composition to the Climax stock (Houser and Poole, 1961; Maldonado, 1977), a composite stock of Cretaceous age (101±3.2 m.y., Naeser and Maldonado, 1978). Although no ages have been determined for the Twinridge pluton, it is probably the same age as the Climax stock.

In thin section, rocks of the exposed Twinridge pluton have a medium-grained granular matrix, composed essentially of quartz, potassium feldspar, and plagioclase, with trace amounts of zircon, apatite, iron oxide (hematite), and opaques. Phenocrysts consist of quartz (as much as 10 mm across), potassium feldspar (45 mm), plagioclase (10 mm), biotite (5 mm), and muscovite (5 mm).

Alteration of the quartz monzonite porphyry has resulted in formation of sericite, clay, quartz, and calcite. Argillic alteration has completely destroyed some of the plagioclase phenocrysts and has also affected the potassium feldspars but to a lesser degree. Other alteration includes conversion of biotite to chlorite and muscovite with mineral grains commonly rimmed with limonite and hematite.

The pluton has intruded the quartzite and siltstone of the Johnnie Formation, altering them to spotted schist and hornfels, as shown on figures 2 and 3. Other alteration of the country

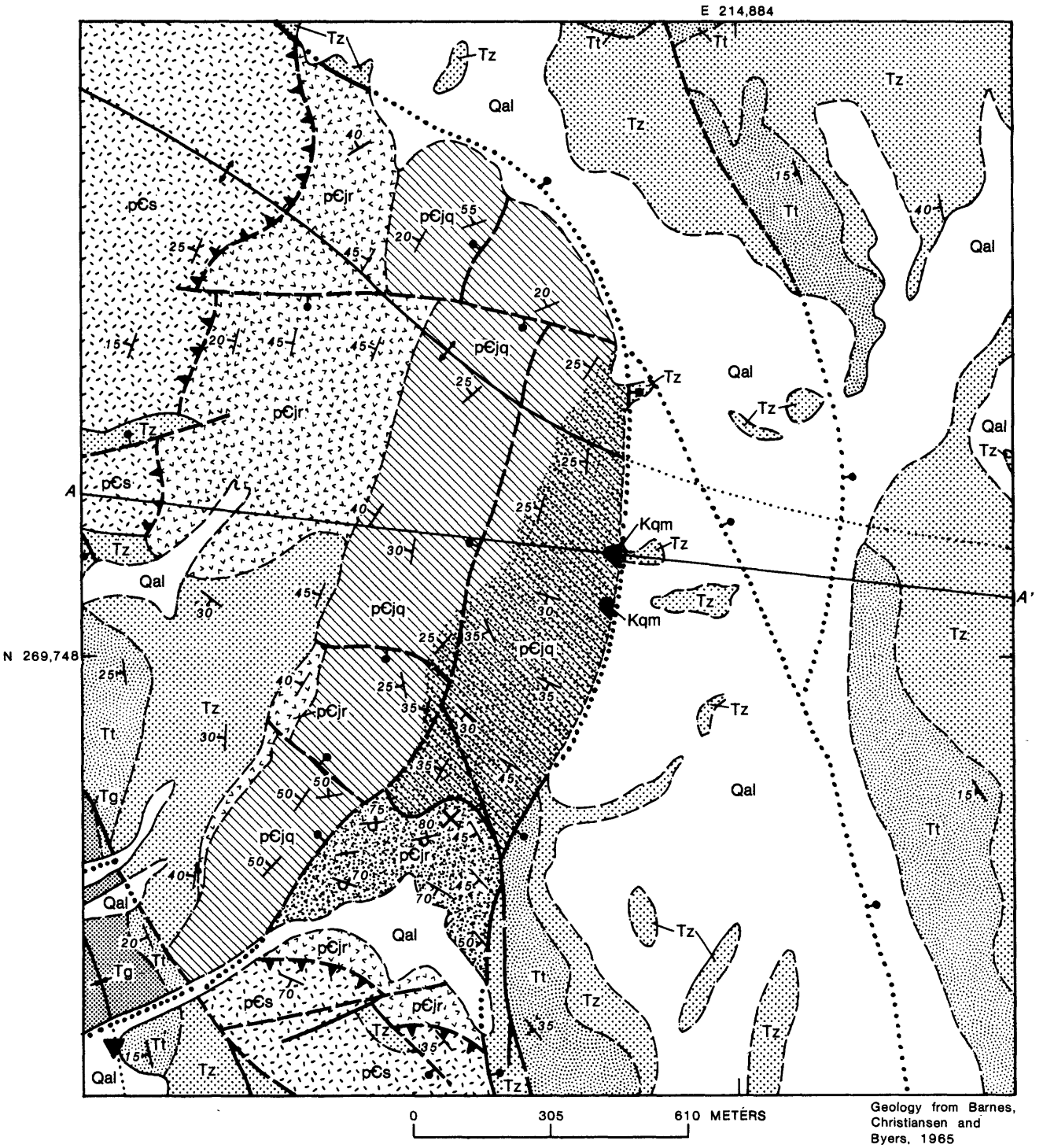


Figure 2.--Generalized geologic map of the Twinridge pluton area, Nevada Test Site, Nevada.

EXPLANATION

ALLUVIUM (Quaternary)

BELTED RANGE TUFF (Tertiary):
Grouse Canyon Member

Tub Spring Member

Zeolitized tuff

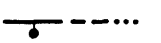
QUARTZ MONZONITE OUTCROP OF THE TWINRIDGE PLUTON (Cretaceous)

STIRLING QUARTZITE (Precambrian)

JOHNNIE FORMATION (Precambrian)
Rainstorm Member, stippling indicates contact metamorphosed area

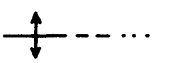
Quartzite and siltstone member, stippling indicates contact metamorphosed area

Contact, dashed where approximately located

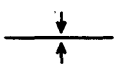


Fault, dashed where approximately located, dotted where concealed, bar and ball on downthrown side

Low-angle fault, dashed where approximately located, sawteeth on upper plate



Anticline, trace of axial plane, dashed where approximately located, dotted where concealed



Syncline showing trace of axial plane

Strike and dip of beds

Strike and dip of overturned beds

Strike of vertical beds

Strike and dip of foliation

Prospect Pit

Recrystallized fault breccia, shown on cross section only, figure 3

Figure 2.--Continued.

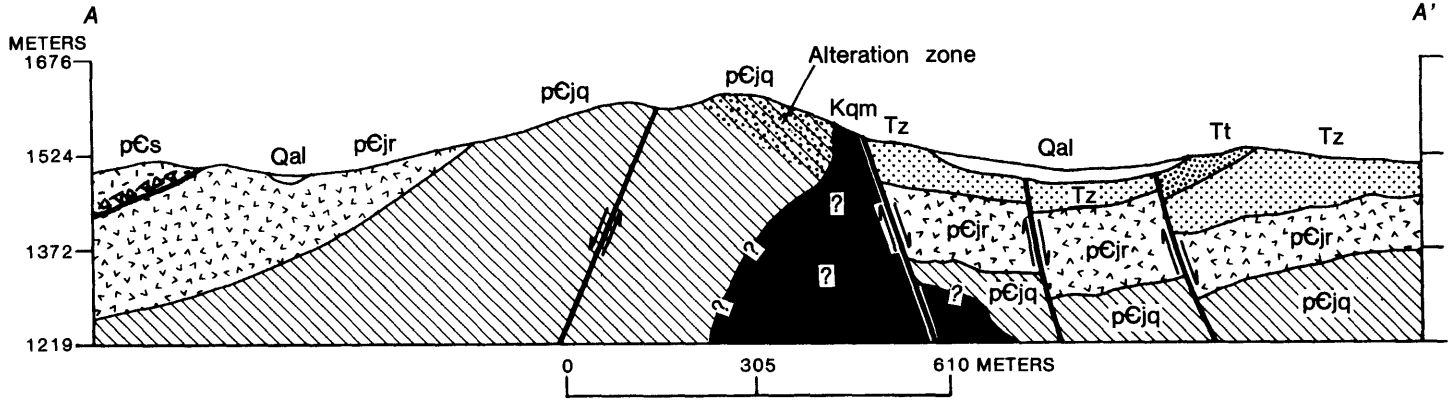


Figure 3.--Generalized geologic section, along line A-A' of figure 2. (See figure 2 for explanation of symbols.)

rock occurs in the southern part of the Twinridge Hill area, where the silty limestones of the Rainstorm Member have been metamorphosed to tactite. No intrusive is exposed in this area, but the presence of tactite suggests an intrusive in the subsurface.

Structure

The Twinridge Hill area lies in one of the most highly faulted zones at the NTS (W. J. Carr, written commun., 1980). The major structures present in the area are as follows: (1) bedding-plane faults; (2) Halfpint anticline; and (3) north-, northeast-, and northwest-trending high-angle Basin and Range normal faults.

The bedding plane faults occur along the Johnnie Formation-Stirling Quartzite contact, where brecciated zones are common. No omission of strata has been observed along the thrust plane (Barnes and Christiansen, 1967), suggesting the possibility that the faults formed as detachments along bedding planes. The detachment could have resulted from gravity sliding of the Stirling Quartzite off the Halfpint anticline. The brecciated base of the Stirling Quartzite is present along both sides of the axial trace of the anticline, parallels the axial traces of the anticline, and generally dips away from the axis of the anticline (fig. 4).

The Halfpint anticline is located in the north half of the Twinridge area, where the axial trace of the anticline crosses the northern part of the Halfpint Range (Carr, 1974) and extends as far northwest as the Climax stock (pl. 1, in pocket). Both the Twinridge pluton and the Climax stock are exposed along the crest of the Halfpint anticline (Hinrichs, 1968) and are probably genetically related to a larger crystalline body at depth (G. D. Bath and C. E. Jahren, written commun., 1980). The emplacement of a crystalline body at depth could be responsible for the doming of the area, which formed the Halfpint anticline. An aeromagnetic survey flown 2.45 km above sea level shows contours that encircle the Climax stock and then bulge east-southeastward around the Twinridge pluton (Hinrichs, 1968) (fig. 5). The elongation of the magnetic anomaly in a southeasterly direction essentially parallels the axial trace of the Halfpint anticline. Another aeromagnetic survey (fig. 6) measured about 150 m above ground surface shows magnetic highs that occur along or parallel to the axial trace of the anticline. Another possible explanation for the formation of the anticline is regional compression; however, the strike of the axis of the anticline is not compatible with the proposed southeastward direction of thrust movement (Barnes and Poole, 1968) in the area.

The most important structural feature in the area is the system of high-angle normal faults spaced approximately 300 m apart. Three major sets of these faults displace the Precambrian and Tertiary rocks, and strike north, northwest, and northeast. The northwest-trending faults are the most prominent, followed by the northeast- and north-trending sets (pl. 1). The northeast-trending faults have uplifted the Twinridge Hill area approximately 300 m forming a structural block (horst).

Numerous northeast- and north-trending faults have also been mapped in alluvium in Emigrant Valley, an area immediately north of Twinridge Hill (pl. 1). One of these faults can be traced into the bedrock east of The Hump (pl. 1; W. J. Carr, written commun., 1980).

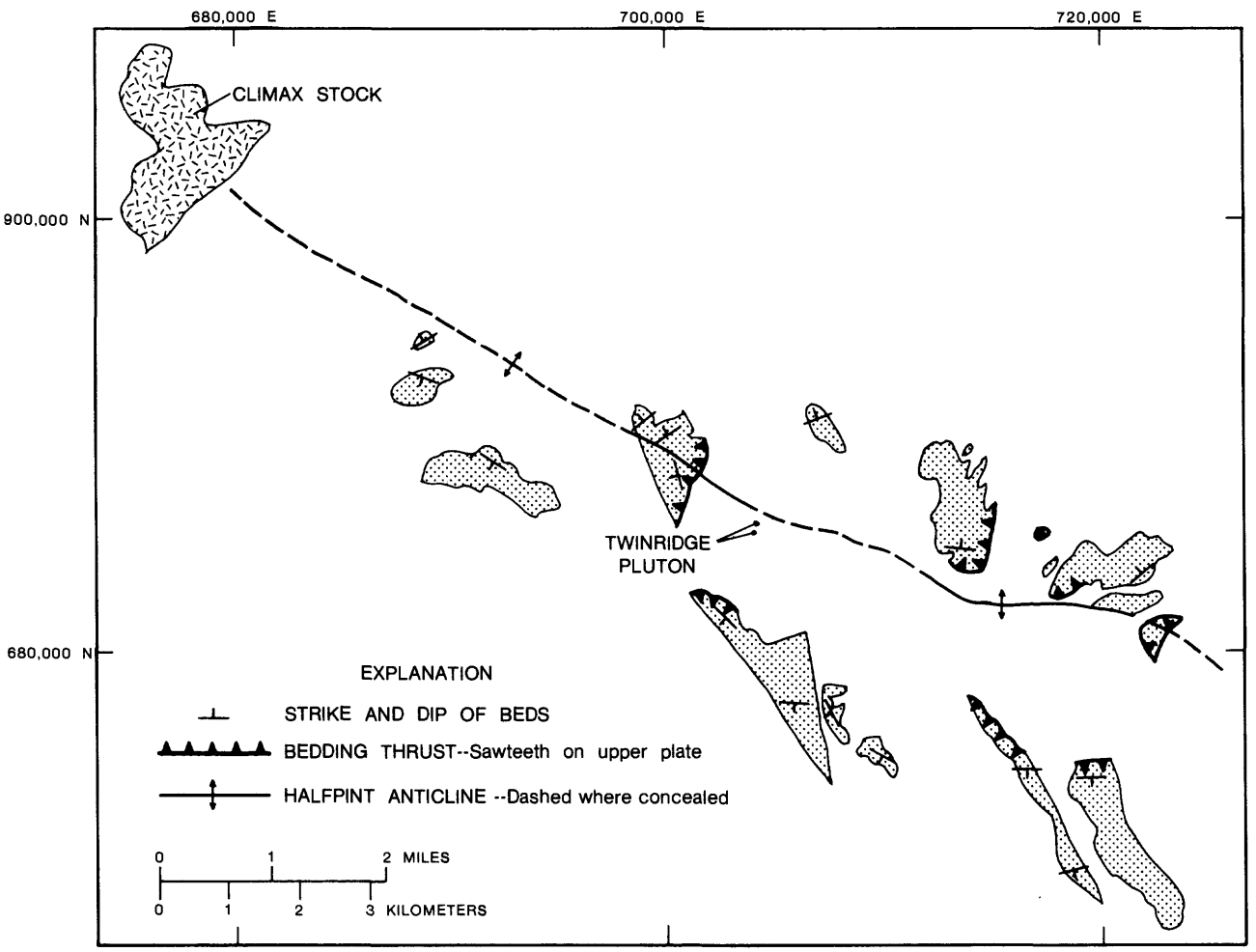


Figure 4.--Relationship between Climax stock, Twinridge pluton, Halfpint anticline, and Stirling Quartzite.

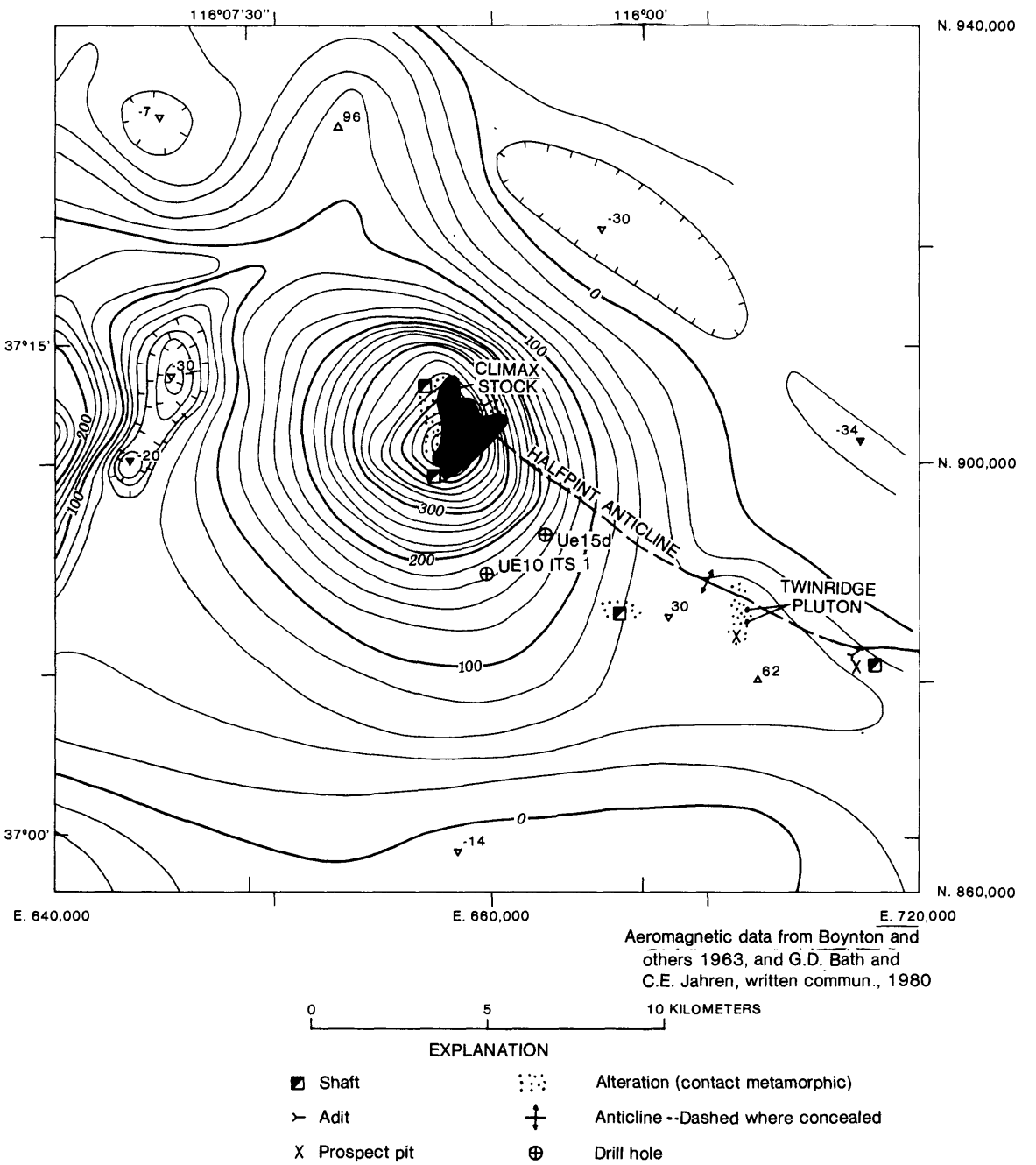


Figure 5.--Aeromagnetic map from data measured 2.45 km above sea level and contoured at 20 gammas showing relationship of anomalies to Climax stock, Twinridge pluton, Halfpint anticline, alteration patterns, and past mining and mineral exploration operations. Triangles give locations of anomaly maxima and inverted triangles give locations of anomaly minima.

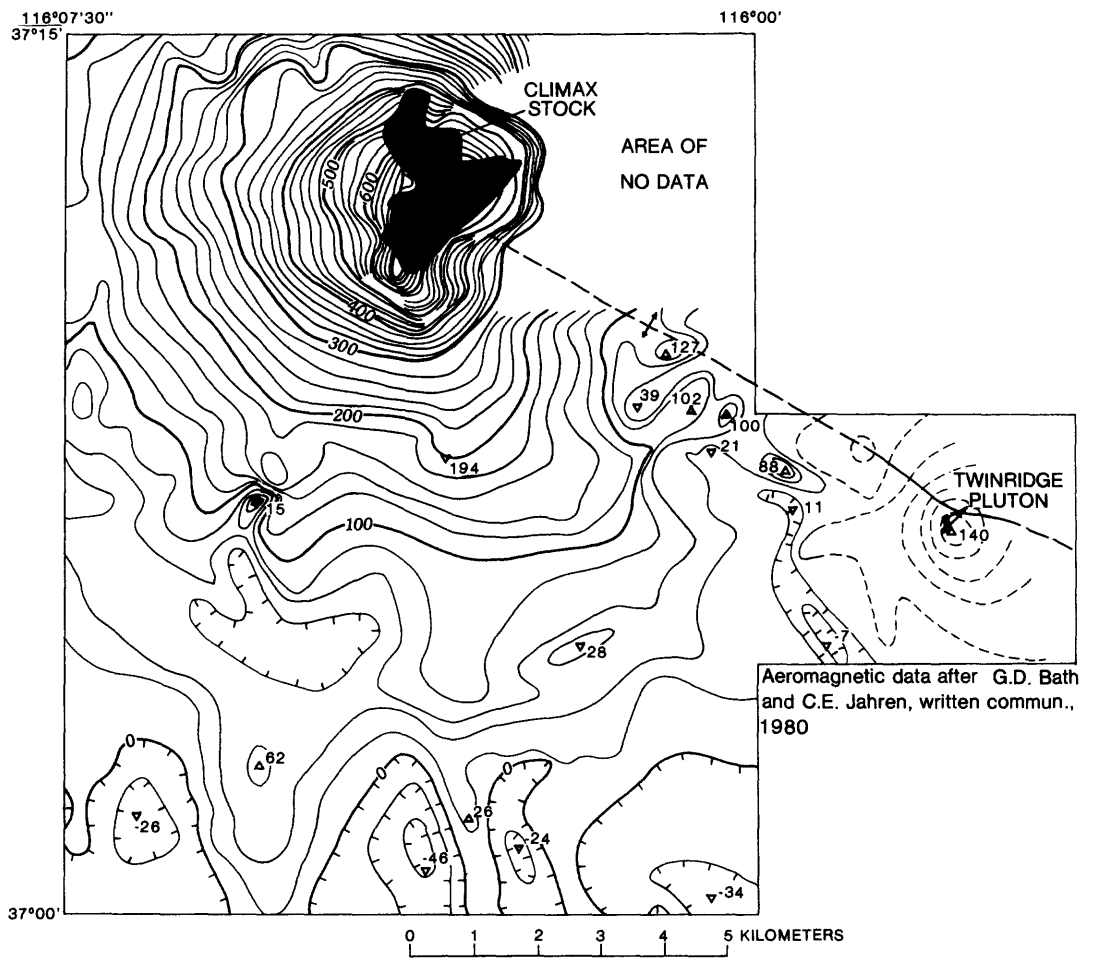


Figure 6.--Aeromagnetic map from data measured 150 m above ground surface showing anomalies over the Climax stock, Twinridge pluton, and highs along the Halfpint anticline. Triangles give locations of anomaly maxima and inverted triangles give location of anomaly minima. Dashed contours where data uncertain. Dashed lines indicate approximate location of axial trace.

A minor eastward-trending high-angle normal fault system has displaced the Precambrian rocks, and could possibly be related to the deformation and folding that occurred during formation of the Halfpint anticline. Small displacements probably occurred along these faults during Tertiary time, as evidenced by minor displacement of Tertiary volcanic rocks.

Mineral Deposits

The mining activity consists mainly of prospect pits in the Twinridge Hill area, and shafts and adits in the vicinity of the Rainstorm, Michigan Boy, and Climax Mine area (pl. 1), all part of the Oak Spring Mining District. Several prospect pits occur in the southern part of the Twinridge Hills (fig. 2), approximately 600 m south of the Twinridge pluton outcrops. The pits are along tactite beds that formed from metamorphism of silty limestone beds of the Rainstorm Member. Bull quartz veins as much as 15 cm thick are also present near the pits.

The Rainstorm Mine is located approximately 4 km southeast of the Twinridge pluton (pl. 1), where workings include a 67-m shaft, a 46-m adit, and several prospect pits in the general area of the mine (Cornwall, 1972). The workings are in the Rainstorm Member where the ore consisted of lead, silver, and gold (Kral, 1951).

The Michigan Boy Mine is located approximately 4 km due west of the Twinridge pluton (pl. 1). Numerous prospect pits and several shafts are present in the Wood Canyon Formation where siltstones and calcareous siltstones have been metamorphosed to hornfels. The ore consisted of an argentiferous galena deposit along a vein 20-61 cm wide (Cornwall, 1972), with malachite present in dump samples.

The Climax Mine is located approximately 10 km northwest of the Twinridge pluton (pl. 1). The ore deposits consisted of tungsten and molybdenite in tactite that formed from contact metamorphism of silty limestones.

The mineral occurrences, altered areas, prospect pits, shafts, and other mining activity appear to occur along or parallel to the axial trace of the Halfpint anticline (fig. 5), but only at Twinridge Hill and at Climax is crystalline rock exposed. However, cuttings from near the bottom of a drill hole (UE10ITS#1), located 1.5 km southeast of the Climax stock (pl. 1), show granitic material and Paleozoic rock fragments (W. J. Carr, written commun., 1980). The total depth of the drill hole is 698 m, with granitic fragments occurring in the cuttings at about 683 m. Minerals present include: garnet, epidote, calcite, pyrite, and trace amounts of chalcopyrite(?) and molybdenite(?). The mineral assemblage is that of a tactite. The cuttings suggest two interpretations: (1) the granitic and tactite material could possibly be paleocolluvium deposit derived from the Climax stock area; or (2) the material could be in place, thereby suggesting the existence of a dike or sill of granitic composition that has intruded Paleozoic rocks, altering them to tactite. Another drill hole, UE15d, located approximately 0.5 km north of UE10ITS#1 (fig. 5), was drilled to 1,828 m. It penetrated the Stirling Quartzite and the Johnnie Formation, and bottomed in a dolomite similar to the Noonday Dolomite of southern Death Valley (H. Barnes, written commun., 1962; F. M. Byers, Jr., written commun., 1980) without intersecting a granitic body. However, the rocks are characterized by the presence of pyrite, which is disseminated and in fractures.

SUMMARY OF EVIDENCE FOR LARGE CRYSTALLINE BODY AT DEPTH

The Twinridge pluton is probably a cupola of a large subjacent crystalline body. The Climax stock is a larger extension of the same crystalline body, but the stock has been uplifted to a higher level by the Yucca-Boundary fault system (pl. 1), and deeply eroded, thus exposing more of the stock than at Twinridge. Factors that suggest the probability that the Climax stock and Twinridge outcrops coalesce at depth to form a continuous crystalline body are as follows: (1) approximate coincidence of the northwest-trending Halfpint anticline with exposures of the Twinridge pluton and the Climax stock; (2) similar mineral composition of the two exposures; (3) presence of bedding-plane faults at the base of the Stirling Quartzite suggesting gravity sliding off the Halfpint anticline with the occurrence of the Stirling Quartzite, paralleling and dipping away from the axial trace of the anticline; (4) the southeastward elongation and continuity of the large aeromagnetic anomaly and the occurrence of aeromagnetic highs, essentially paralleling the axial trace of the Halfpint anticline; and (5) the distribution of alteration, prospect pits, adits, and shafts along or parallel to the axial trace of the Halfpint anticline, suggesting intrusive-related mineralization along this structure.

CONCLUSIONS

Specific geologic criteria for screening of potential sites for storage of nuclear waste at the NTS are not available. This study presents an attempt to evaluate the Twinridge pluton based on existing criteria. The Twinridge pluton should not be considered for further study as a potential nuclear waste repository for the following reasons: (1) the area lies within one of the most highly faulted zones at the NTS; (2) numerous Quaternary faults displace alluvium that can be traced into bedrock, immediately northeast of Twinridge pluton exposures; and (3) the probable difficulty involved in characterizing the Twinridge pluton at depth from existing data without extensive drilling and additional geophysical surveys.

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