TERTIARY GEOLOGY OF THE SOUTHERN PORTION OF THE EUREKA QUADRANGLE, JUAB AND UTAH COUNTIES, UTAH

by

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ABSTRACT

The Tertiary rocks of the southern portion of the Eureka quadrangle were mapped in order to resolve several questions concerning the volcanic stratigraphy and location of vents, calderas, and productive intrusions in the East Tintic Mountains. A vent related to the Latite Ridge Latite ash flow eruptions and biotite latite lava flows and lahars was found near Gold Bond Spring. The vent appears to be located along an east-west fault zone and caldera boundary. The caldera may be related to eruption of an older ash flow tuff, but not to the Packard Quartz Latite. No conclusive contacts were found to substantiate recent radiometric ages which indicate that the Packard Quartz Latite is not the oldest volcanic unit in the East Tintic Mountains. The Silver City stock also appears to have been emplaced along this east-west zone of faults and vents.

There is no evidence that the Latite Ridge/biotite latite vent is spatially related to mineralization. In fact, beneath the volcanic cover, it appears to mark a (caldera) boundary between Paleozoic and Precambrian rocks which host ore and volcanic and intrusive rocks which are not suitable hosts; it forms a "wall" to further mining to the south in the Trixie Mine. Mineralization is only spatially related to monzonite intrusions of Silver City stock affinity. No new biotite latite dikes, rich in magmatic sulfides, were found in the vicinity of the vent.

INTRODUCTION

Much of the central and southern East Tintic Mountains has recently been remapped as either part of our work (Keith et al., 1989; Figure 1) or that of J. Hannah and co-workers (1990). However a critical area of volcanic terrane had remained unmapped (as part of these recent efforts) - namely, the southeastern portion of the Eureka Quadrangle which was interpreted by Morris (1975) as the northern concealed boundary of a caldera (Figure 1). This paper reports the findings of our mapping in this vicinity which includes the area adjacent to the Trixie mine.

This area was remapped for several reasons. First, this is the vicinity where Morris (1975; Morris and Lovering, 1979) stated that definitive contacts were present to substantiate his interpretation that most of this portion of the East Tintic Mountains consists of a single sill (Gough Sill). Our previous work on the southern portion of the sill suggests that it actually consists of a series of biotite latite dikes and flows of the same composition. This is also the general vicinity for the caldera boundary which he proposed for eruptions of the Packard Quartz Latite.

Second, the radiometric dating which we have completed on samples from the Tintic Mountain quadrangle to the south, (Keith et al., 1989) indicates that much of the volcanic, intrusive and hydrothermal activity is about 37-38 Ma rather than about 32 Ma as indicated by previous workers. If both ages of volcanism are present in the East Tintic Mountains, then significant changes in the volcanic stratigraphy would need to be made. We inferred that the area to be mapped for this study probably contains the critical fault or stratigraphic contacts between the Latite Ridge Latite, Packard Quartz Latite, and the flows of Sunrise Peak which would be needed to revise the stratigraphy.

Finally, our previous work in the Tintic Mountain quadrangle suggested a close correlation, in time and space, between biotite latite dikes and productive intrusions of Silver City Monzonite lithology. This correlation has important implications concerning what constitutes productive magma or productive intrusions. For example, our work documented the existence of unusually large and abundant magmatic sulfides in vent-facies biotite latite dikes (and lava vitrophyres). Degassing or resorption of the magmatic sulfides after intrusion into a vent or shallow intrusion may provide a higher than normal budget of sulfur and metals for mineralization. In addition, preliminary analytical data suggest that the sulfides may host most (~75%) of the Ag present in the latites. Inasmuch as some of the biotite latite dikes in the Tintic Mountain quadragle are relatively rich (0.02%) in magmatic sulfides, mapping the location of those in the Eureka quadrangle and examining their magmatic sulfide content may be of use in exploration efforts in this area.

RESULTS

Flows of Sunrise Peak

Lindgren and Loughlin (1919) proposed that some of the latite flows adjacent to the Sunrise Peak stock (Tintic Mountain quadrangle) appeared to emmanate from the stock; we concur with their observations (Keith et al., 1989). Consequently, we informally refer to these flows as the flows of Sunrise Peak; they are well exposed in the southern portion of the mapped area (Plate 1). These exposures are mostly extrusive, but there are some small bodies of the intrusive phase. However, it is sometimes difficult to isolate the intrusive phase from dominantly extrusive rocks in the field. The rocks of this unit are commonly altered - especially when in the vicinity of Silver City Monzonite intrusions. The rocks immediately south of the Silver City Monzonite stock exhibit strong argillic alteration and silicification; they have a reddish brown, bluish white, or dazzling white color. Some of the most silicified areas are also brecciated. The flows of Sunrise Peak to the east of the Silver City stock are strongly argillized (losing most relict texture) which often imparts a very similar appearance to that of altered Silver City Monzonite. Consequently, it is also very difficult to distinguish these rocks from Silver City Monzonite in the field.

The flows of Sunrise Peak are generally dark grey to greenish grey, and porphyritic with distinct phenocrysts of plagioclase and biotite apparent in hand sample. The phenocrysts consist of plagioclase, biotite, and augite. The plagioclase is seriate ranging from 1 to 6 mm in length, but most are larger than 5 mm. Plagioclase phenocrysts commonly occur as aggregates, forming a glomeroporphyritic texture, which is in marked contrast to the occurrence of plagioclase in other latite units. The plagioclase is commonly altered in part to epidote, but near the contact of Silver City monzonite plagioclase is replaced mostly by clay. Biotite phenocrysts are smaller in size than plagioclase phenocrysts and are the second most abundant phenocrystic phase. They are resorbed, producing embayed or ragged shape, and are substantially oxidized and rimmed by magnetite. In addition, most of the biotite is altered to chlorite and lesser epidote. Clinopyroxene (diopside or augite) phenocrysts are far less abundant than biotite phenocrysts, but their amount varies from sample to sample. Clinopyroxene phenocrysts are subhedral to anhedral, and are often altered to chlorite or epidote. The groundmass consists of plagioclase microlites, clinopyroxene, Fe-Ti oxides, and in some samples quartz.

Packard Quartz Latite

The Packard Quartz Latite is exposed only in the nothern portion of the mapped area (i.e. near the Trixie mine) and at the eastern edge of Latite Ridge (Plate 1). However, this volcanic unit covers most area of the East

Tintic mining district north of the mapped area. Near the Trixie mine, the Packard Quartz Latite directly overlies the Paleozoic sedimentary rocks and underlies the mafic flow unit which in turn underlie the Latite Ridge Latite. Near the nothern border of the East Tintic district, the Packard Quartz Latite is overlain by Laguna Springs Volcanic Group. Therefore, it is certain that the Packard Quartz Latite is older than the Latite Ridge Latite and mafic flows (Figure 2). However, its stratigraphic position relative to the flows of Sunrise Peak is uncertain, because the Packard Quartz Latite crops out only in the area to the north of the mapped area and has no exposed contact with the flows of Sunrise Peak (Plate 1). Its limited distribution only to the north of the mapped area and its unique chemical composition compared to other volcanic units in the area (69.9 wt % SiO_2; Morris and Lovering, 1979) may suggest that the Packard Quartz Latite vented from a seperate, more northerly source, relative to the other latitic units mapped in this study. Packard Quartz Latite is easily distinguished from other latite units in the field because of conspicuous quartz phenocrysts.

Mafic Flows

Mafic flows (~55% SiO_2; Kim, 1988) are exposed as a thin stratigraphic horizon near the Trixie mine, and also crop out in a large area north of the Dry Herd Canyon (Plate 1). Near the Trixie mine the mafic flow unit directly overlies the Packard Quartz Latite and underlies an epiclastic sedimentary horizon which in turn underlies the Latite Ridge Latite. Mafic flows of similar appearance are also present in the Tintic Mountain quadrangle where they overlie carbonate-bearing lacustrine sediments (not shown in Figure 2) and the flows of Sunrise Peak. We infer that these mafic flows occupy the same stratigraphic position as those in the Eureka quadrangle. Therefore, the mafic flows are certainly older than Latite Ridge Latite and probably younger than the flows of Sunrise Peak (Figure 2). In addition, a few east-trending mafic dikes are present east of Silver Pass which intrude the flows of Sunrise Peak (Plate 1). These fine-grained dark dikes are not clearly correlative with the mafic flows, but potentially may be the same age and composition.

Morris and Lovering (1979) refered to these flows as the "flow member of Copperopolis Latite" and estimated that the exposed part of the flows near Dry Herd Canyon is at least 400 feet thick. However, we prefer to informally designate these flows as the "mafic flows" instead of the flow member of Copperopolis Latite, because the stratigraphic position of the Copperopolis Latite, as defined by Morris and Lovering (1979) does not agree with the stratigraphic sequence determined from our mapping (Figure 2).

The mafic flows are generally black, very dense, and have an aphanitic groundmass with pyroxene and plagioclase phenocrysts. The capping flow of the mafic flows north of the Dry Herd Canyon is often vesicular. In thin section, the mafic flows consist of about 31% phenocrysts and 69% groundmass (Table 1). Phenocrysts are up to 3 mm in length, but most of them are smaller than 2 mm. The phenocrysts consist of about 62% plagioclase, 25% clinopyroxene 6% orthopyroxene, and 7% Fe-Ti oxides. However, the capping flow of the sequence (on the eastern side of the mapped area) has lesser amounts pyroxene and Fe-Ti oxides. The plagioclase phenocrysts vary in size from 0.2 to 2 mm. The larger phenocrysts have resorbed or corroded cores. The clinopyroxene grains are pale green and anhedral. Many of them are also resorbed. Larger clinopyroxene phenocrysts commonly contain numerous large titanomagnetite grains. Orthopyroxene phenocrysts exhibit green to pale red pleochroism and are often anhedral and resorbed. Fe-Ti oxides are also resorbed. The groundmass consists of light to dark brown glass, feldspar microlites, and traces of pyroxene and oxides.

Latite Ridge Latite and Epiclastic and Lacustrine Sediments

Morris and Lovering (1979) report that the Latite Ridge Latite consists of an airfall tuff member and an upper welded tuff member. However, in the mapped area, the Latite Ridge Latite occurs only as a welded ash flow tuff. It overlies epiclastic sediments which consist of well stratified volcaniclastic sediments which contain little or no pumice. The clasts are generally derived from the immediately underlying unit which, in this area, is usually the mafic flow unit, the flows of Sunrise Peak, or the Packard Quartz Latite (Figure 1). This general sedimentary horizon in the southern portion of the mapped area and in the Tintic Mountain quadrangle (Keith et al., 1989) contains either epiclastic sediments or fresh-water carbonate lacustrine sediments. The thickness of these sedimentary rocks generally does not exceed 10 meters. In the Tintic Mountain quadrangle (Keith et al. 1989; Hannah and MacBeth, 1990) a thicker lacustrine sedimentary horizon is exposed beneath the flows of Sunrise Peak (Figure 2).

The Latite Ridge Latite welded tuff is readily recognized in the field because of its characteristic brownish red color and eutaxitic texture; however, the tuff is argillized and/or silicified over wide areas. Where strongly argillized, the tuff is generally pale pinkish brown to white and little or no relict texture remains. A thin basal vitrophyre is present in some places near the base of the tuff. Two horizons of basal vitrophyre with different crystal contents are present at the base of the unit at a locality south of Willow Spring (Plate 1).

The welded tuff probably consists of several different cooling units which are represented by different crystal contents, i.e. crystal-poor unit, crystal-rich unit, and mixed unit. However, the lack of consistent lateral continuity makes it difficult to map each unit seperately in the field. The mixed lithology is sometimes present above the welded tuff and occurs as welded tuff with large blocks of crystal-rich tuff, crystal-poor tuff, and dark scoriaceous material which suggests mixing of crystal-rich magma and crystal-poor magma during eruption. A small area made up of auto breccia (welded tuff which contains large, up to 1.5 m in diameter, rotated blocks of welded tuff) may indicate a vent or an edge of the caldera which erupted the Latite Ridge Latite ash-flow tuff. This lithology occurs along a high-angle fault (or vent) contact at two localities in the mapped area and is refered to as vent facies Latite Ridge Latite (Figure 2; Plate 1).

The basal vitrophyre of the Latite Ridge Latite welded tuff can be divided into two lithologies on the basis of crystal contents, i.e. crystal-rich and crystal-poor vitrophyre. Crystal-rich vitrophyre is composed of approximately 14% phenocrysts, 5% lithic fragments, and 81% glassy groundmass. Crystal-poor vitrophyre is composed of approximately 6% phenocrysts, 2% lithic fragments, and 92% glassy groundmass (Table 1). The phenocrysts of crystal-rich vitrophyres consist of about 75% plagioclase, 17% biotite, 4% clinopyroxene, 4% Fe-Ti oxide, and a trace of magmatic pyrrhotite (Table 1). The phenocrysts of crystal-poor vitrophyre consist of about 58% plagioclase, 19% biotite, 8% clinopyroxene, and 11% Fe-Ti oxide. One sample of crystal-poor vitrophyre contains a greenish yellow amphibole which might have been formed from pyroxene. Most of the phenocrysts (except for oxides) are fragmental or resorbed, but they are fresh and unaltered. Lithic fragments consist of lava flows of intermediate composition, and are on the average 5-6 mm in diameter, but range up to 20 mm. The groundmass of the vitrophyre is composed of weakly to moderately welded glass shards and pumice fragments. In one sample the glass shows perlitic texture. The crystal-rich vitrophyre has larger phenocrysts and lithic fragments than crystal-poor vitrophyre.

Biotite Latite Flows, Lahars, and Intrusions

The biotite latite flows form the youngest volcanic unit in the East Tintic Mountains to the south of the East Tintic mining district and they cover the largest portion of the mapped area. The biotite latite flows consist of lava flows, lahars, a vent-filling complex which consists of both intrusions and flows. The vent which it fills is that of the Latite Ridge Latite.

Biotite latite dikes also occur along the same trends and in the same vicinity as monzonite porphyry of Silver City stock affinity. This is most noticeable in the Tintic Mountain quadrangle (Keith et al. 1989) and to a lesser extent in the southern portion of the area mapped for this study (Plate 1).

Lava flows of the unit outcrop in small area near Silver Pass, overlying the Latite Ridge Latite, and in large area east and north of the Diamond Divide, overlying the flows of Sunrise Peak (Plate 1). The lava flows range from 300 to 1000 feet in thickness and form prominent cliffs locally. Lava flows are generally dark grey to dark bluish grey, dense, and porphyritic with distinct phenocrysts of plagioclase and biotite in hand sample. They are commonly free from alteration. However, part of the flows near Silver Pass are argillically altered and silicified probably because of their proximity to the productive Silver City monzonite stock. The lava flows near Silver Pass were originally mapped as the Silver City monzonite by Morris (1964). The biotite latite lava flows are similar in appearance to the underlying flows of Sunrise Peak and distinguished from them in the field by the smaller and lesser plagioclase phenocrysts and lack of alteration in the former. The lava flows contain some thin vitrophyre horizons, which suggest the presence of multiple flows.

The vent-filling intrusion is present near Gold Bond Spring and exhibits either fault or intrusive contacts with the vent facies Latite Ridge Latite (Plate 1). The intrusion seems to fill the vent or a small collapsed graben related to the eruption of the Latite Ridge Latite. The rocks of the intrusion have essentially the same texture and mineralogy as those of lava flows, but they are very compact and blocky and show a different weathering pattern. The biotite latite flow lahars are composed of unconsolidated and unstratified cobbles and rubble of biotite latite composition.

In thin section, the rocks of the biotite latite flows are composed of approximately 30% phenocrysts and 70% groundmass (Table 1). The phenocrysts include about 60% plagioclase, 16% clinopyroxene, 7% biotite, 6% hornblende, 3% orthopyroxene, and 7% Fe-Ti oxides. Orthopyroxene and hornblende phenocrysts are not always present. The phenocrysts range from 0.3 to 5 mm in length, but most of them are 2 to 3 mm, and smaller than those of the flows of Sunrise Peak. Clinopyroxene phenocrysts are colorless to pale green and enhedral to subhedral. They commonly have many magnetite inclusions. Some of clinopyroxene phenocrysts are altered to chlorite. Biotite phenocrysts are also commonly resorbeed. In a few samples biotite is altered to chlorite. Hornblende phenocrysts are subhedral to anhedral, have a pleochroism from yellow to yellowish brown, and typically exhibit magnetite rims. The groundmass is made up of glass (often perlitic), plagioclase microlites, oxide grains, and a few pyroxene microgranules.

Monzonite Porphyry of the Silver City Stock and Associated Intrusions

The Silver City Monzonite stock is the largest intrusive body in the East Tintic Mountains, and its main portion crops out in the Tintic district south of Mammoth (Plate 1). It intrudes the flows of Sunrise Peak on the east and southeast, Paleozoic carbonates on the north, and the Swansea Quartz monzonite on the west (Plate 1). The monzonite stock contains many xenoliths of Paleozoic quartzite and limestone. Quartzite xenoliths are scattered widely throughout the stock, but limestone xenoliths are concentrated near the contact of monzonite and limestone. The monzonite stock is intruded by small dikes of quartz-feldspar porphyry and also cut by many veins that have produced ore.

The Silver City stock monzonite is generally pinkish grey or brownish grey in color. The texture of the monzonite is dominantly medium-grained equigranular, but slightly porphyritic in many places. Related satellitic dikes and plugs are always porphyritic. The grain size of the monzonite is generally 3 mm or smaller in length, but rarely up to 5 mm. The monzonite is composed of plagioclase, alkali feldspar, augite, uralitic hornblende, quartz, biotite, and accessory minerals in decreasing order of abundance. Plagioclase, augite, and hornblende constitute phenocrystic phases, and alkali feldspar, quartz, or biotite form a groundmass in porphyritic rocks. Plagioclase is the dominant phase in the monzonite and constitutes about 30% of all the crystals. Crystals average 3 mm in length. In hand specimen, plagioclase is dark grey in fresh rocks, but is white in altered rocks. In strongly altered rocks, plagioclase is largely replaced with clay, sericite, or epidote. Alkali feldspar is always anhedral, forms much of the matrix between plagioclase and mafic minerals, and constitutes about 30% of the monzonite. Alkali feldspar is easily identified in thin sections, because it is uniformly dusty with clay, which contrasts with quartz and fresh plagioclase. Alkali feldspar (or included Fe oxide) imparts a pink color to the matrix. Clinopyroxene is colorless to pale green and subhedral to anhedral. Much of the clinopyroxene is wholly or partly altered to uralitic hornblende. The ratio of clinopyroxene to uralitic hornblende depends on the degree of alteration, ie. the less altered a rock, the less uralitic hornblende. In fresh or weakly altered rocks, clinopyroxene commonly contains many magnetite inclusions. Clinopyroxene is also altered to chlorite and very minor epidote in very altered rocks. In handspecimen, clinopyroxene, uralitic hornblende, and magnetite commonly form dark greenish mafic clots about 3 mm in diameter. All of the hornblende is secondary, fibrous, green uralite formed by the deuteric alteration of primary pyroxenes. Quartz is generally present as anhedral grains associated with alkali feldspar in the matrix, forming micrographic intergrowths in places. However, resorbed, highly embayed phenocrystic quartz is also present in some rocks. Biotite occurs as scattered, flaky, anhedral grains commonly smaller than 1 mm in length. Biotite generally forms about 5% of the monzonite, but it is absent or a very minor phase in some samples. In addition, biotite is partly or completely replaced by chlorite in altered rocks. Accessory minerals include apatite and sphene.

Other Units

A few other lithologies which are included in Figure 2 are not significant aspects of this study and more complete descriptions can be found elsewhere. For example, the Sunrise Peak Monzonite Porphyry, the tuff member of the Copperopolis latite and the overlying lacustrine sediments occur along the southern edge of the Eureka quadrangle, but not in the area mapped for this study. However, they are mapped and described in Keith et al. (1989) and Hannah and MacBeth (1990). Morris and Lovering (1979) have studied the distribution and composition of the Packard Quartz Latite; in addition, a more complete investigation of this unit is in progress by J. Hannah.

DISCUSSION

Several lines of evidence suggest that the vent for the Latite Ridge Latite ash flow eruptions was near Gold Bond Spring about 1 km south of the Trixie Shaft (Plate 1 and Figure 3). For example, the large blocks of Latite Ridge Latite welded tuff which are chaotically reincorporated in welded tuff of the same composition are compelling evidence for collapse (into the vent) at the end of an eruptive cycle. An outcrop of this type of material is located near Gold Bond Spring (Plate 1, Figure 3). This outcrop is stratigraphically below the nearest outcrop of Latite Ridge Latite which may also indicate an origin due to collapse into a vent.

This material is bordered on two sides by biotite latite of intrusive character; the contacts with the biotite latite are shown as fault contacts in Plate 1 (Figure 3), although intrusive contacts may be just as appropriate. The biotite latite is interpreted to have filled the vent shortly after eruption of the Latite Ridge Latite. Underground mining in Paleozoic and Precambrian rocks which was directed to the south-southeast from the Trixie shaft (Figure 3) encountered intrusive or volcanic rock at depth, where the Latite Ridge Latite/biotite latite vent complex is located on the surface (Glenn Mellor, personal communication).

On the south side of the biotite latite vent complex, a steeply-dipping wedge of Latite Ridge Latite is also present (Figure 3). It overlies the flows of Sunrise Peak to the south, but it appears to have been "cut-off" by the biotite latite vent facies unit on the north. The Latite Ridge Latite immediately south of the vent is 200 to 300 meters higher in elevation than the Latite Ridge Latite in the vent; this difference may be due to collapse after eruption. However, some of this difference in elevation may be due to later faulting.

Immediately west of the biotite latite vent complex, the Latite Ridge Latite consists of over 150 meters of densely welded tuff; this unusual thickness may be due to subsidence of a graben or small "caldera" adjacent to the vent (Figure 3).

We previously proposed that both the flows of Sunrise Peak and the lacustrine sediments could be filling a caldera created by eruption of the Copperopolis Latite tuff member (Keith et al., 1989). Immediately south of the mapped area, the flows of Sunrise Peak are often both overlaid and underlaid by lacustrine sediments. The trend of the Sioux Ajax fault zone marks the approximate northern limit of the flows of Sunrise Peak and possibly the northern limit of the caldera as well. Consequently, the vents for the Latite Ridge Latite and biotite latite might very well be nested along an older caldera boundary as shown in Figure 3. For example, evidence of east-west faults controlling eruption is found along the north side of the biotite latite vent complex and the adjacent Latite Ridge vent facies rocks (Figure 3).

However, there is no evidence that this caldera is related to the eruption of the Packard Quartz Latite as proposed by Morris and Lovering (1979). Where we have examined the Packard Quartz Latite, it appears to be a series of flows rather than welded ash flow tuffs. In addition, the flows of Sunrise Peak and other units to the south which fill the caldera are older than the apparent age of the Packard. Our previously determined $^{40}Ar/^{39}Ar$ age for the Sunrise Peak Monzonite is 35.5 Ma (Keith et al., 1989) in contast to 32.8 Ma for the Packard Quartz Latite (Morris and Lovering, 1979).

The Silver City stock also appears to have been emplaced along this east-west zone of faults and vents (Figure 3). Intrusion of the Silver City stock may have caused some resurgence or doming of the caldera. For example, Morris and Lovering (1979) documented almost 500 meters of dip slip movement, with the north side down, along the combined strands of the Sioux Ajax fault zone (all in Paleozoic rocks). These events may be unrelated; however, the importance of the east-west fault zone for localizing intrusions and vents is apparent.

The distribution of Tertiary sedimentary rocks, mafic flows, and ash flow tuffs in the southern Eureka quadrangle and the Tintic Mountain quadrangle is often correlative with paleo valleys or depressions. The east-west fault zone contains epiclastic fluvial sediments and mafic flows which pinch out to the north and south (Plate 1). These units are overlaid by the Latite Ridge Latite welded ash flow tuff; this ash flow may have followed paleo valleys to the southern end of the East Tintic Mountains where it is also present (Hannah and MacBeth, 1990). However, it apparently is not found at many localitites in the northern end of the Tintic Mountain quadrangle where it may have been excluded by paleo topographic highs.

Although intrusive biotite latite fills the apparent vent of the Latite Ridge Latite, there is no evidence of spatially related alteration or mineralization. The biotite latite is relatively fresh and unaltered; adjacent volcanic host rocks only show evidence of alteration when an intrusion of Silver City lithology is also present.

Despite the fact that the Latite Ridge Latite/biotite latite vent is apparently barren, the parental magmas may have been comagmatic with the Silver City monzonite. For example, the Latite Ridge Latite and biotite latite are both younger than the flows of Sunrise Peak (35.3 $\pm$ 0.1 Ma) and older than the Silver City stock (33.6 $\pm$ 0.2 Ma; Keith et al., 1989). This window for their age is permissive evidence for a comagmatic origin with the Silver City magma. If this is the case, then "productive" and "barren" magmas would have been comagmatic. Such a scenario has been documented before with many porphyry Cu and porphyry Mo systems which have barren and productive intrusive phases.

Conclusive evidence as to why the Latite Ridge/biotite latite vent is barren of spatially related alteration or mineralization is not available. However, as previously noted the biotite latite dikes in the Tintic Mountain quadrangle which have closely related alteration, show evidence of abundant magmatic sulfides. The Latite Ridge Latite was clearly saturated with sulfides, but they are much smaller and less abundant (by approximately two orders of magnitude). The vent-filling biotite latite also shows no evidence of abundant magmatic sulfides.

Regardless of how abundant magmatic sulfides may be in any magma, the largest proportion of sulfur will be present as volatile species. Calculation of the speciation and fugacities of the sulfurous gases for the parental magmas of the Latite Ridge Latite and associated biotite latite cannot be done without good estimates of the magmatic temperatures and oxygen fugacities (in progress). However, Keith et al. (1989) calculated that the biotite latite (of the Tintic Mountain quadrangle) which was rich in magmatic sulfides may have had relatively high fugacities of sulfurous gases. In addition, the magmatic sulfides may contain most of the Cu and Ag present in the magma. We speculate that the magmatic sulfides, and associated metals, may have become slightly enriched in some magmas by crystal settling.

In conclusion, there is no evidence that the Latite Ridge/biotite latite vent is spatially related to mineralization. In fact, it appears to mark the boundary of a larger caldera and forms a "wall" to further mining to the south in the Trixie Mine. Mineralization is only spatially related to monzonite intrusions of Silver City stock affinity. No new biotite latite dikes, rich in magmatic sulfides, were found in the vicinity of the vent.

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FIGURE CAPTIONS

Figure 1. Index map and simplified geologic map of the East Tintic Mountains (compiled from Morris, 1975; Morris and Morgensen, 1978; Keith et al., 1989). Replacement and vein ore deposits occur in the area surrounded by the dashed line. The eastern lobe of this area comprises the East Tintic mining district; the remainder comprises the Tintic district. Ore-related monzonite intrusions are shown as solid black; all other Tertiary intrusions and volcanic rocks in the East Tintic Mountains are shown in white; the brick pattern represents Precambrian and Paleozoic sedimentary rocks; Quaternary valley-fill sediments are shown as stipple. The immediate vicinity of the sub-economic Cu-Mo deposit is covered by alluvium or mapped by others (Hannah and Macbeth, 1990). The area enclosed by the trail of circles contains nested calderas and abundant intrusions (Keith et al., 1989). The area mapped for this study is outlined by the solid black line.

Figure 2. Tertiary stratigraphy of the southern Eureka quadrangle (to accompany Plate 1).

Figure 3. Schematic geologic map of vent area. The solid black lines represent the approximate locations of faults as shown in Plate 1. The trail of circles illustrate the best estimate of the possible location of a caldera boundary (related to eruption of the tuff member of the Copperopolis Latite).

Table 1. Point counting modal analysis

	Tmf	Tlrt1	Tlrt2	Tblf
Plag	19.4	10.2	3.6	18.9
Biot		2.3	1.2	2.3
horn				2.0
Cpx	7.9	0.5	0.5	5.0
Opx	1.6			0.9
Magn	2.2	0.5	0.7	2.2
Lith		5.2	2.2	
Grms	69.0	81.3	91.6	68.7
t.p.	2261	3830	3805	2496

Remarks: All numbers (except for t.p.) are volume %.
Magn = Fe-Ti oxide, Lith = lithic fragments
Grms = groundmass, t.p. = total points,
Tmf = mafic flows, Tlrt1 = crystal-rich Latite Ridge Latite vitrophyre, Tlrt2 = crystal-poor Latite Ridge Latite vitrophyre
Tblf = Biotite latite flows

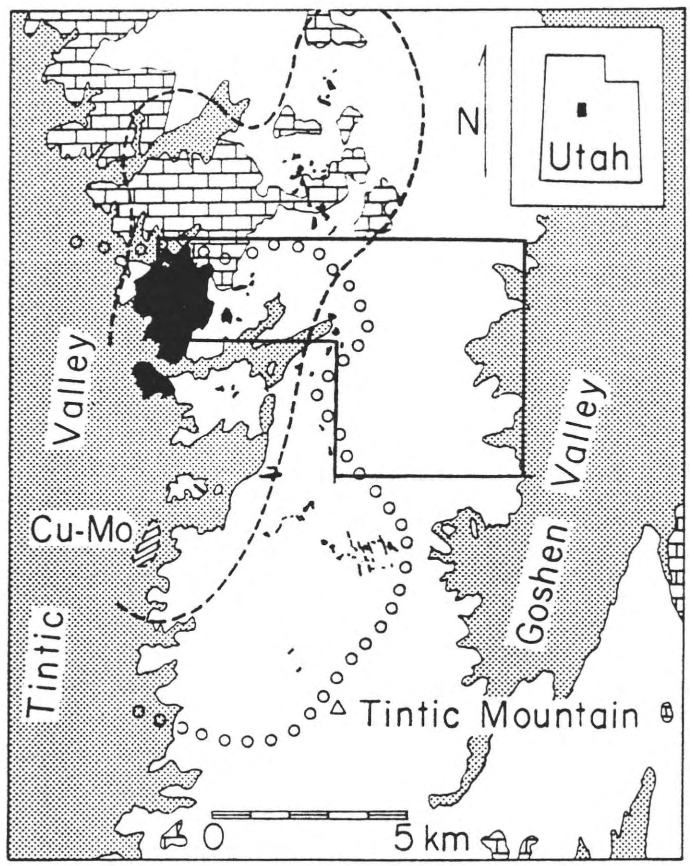

N
Utah
Valley
Tintic
Cu-Mo
Goshen
Valley
Tintic Mountain
0
5 km

Figure 1

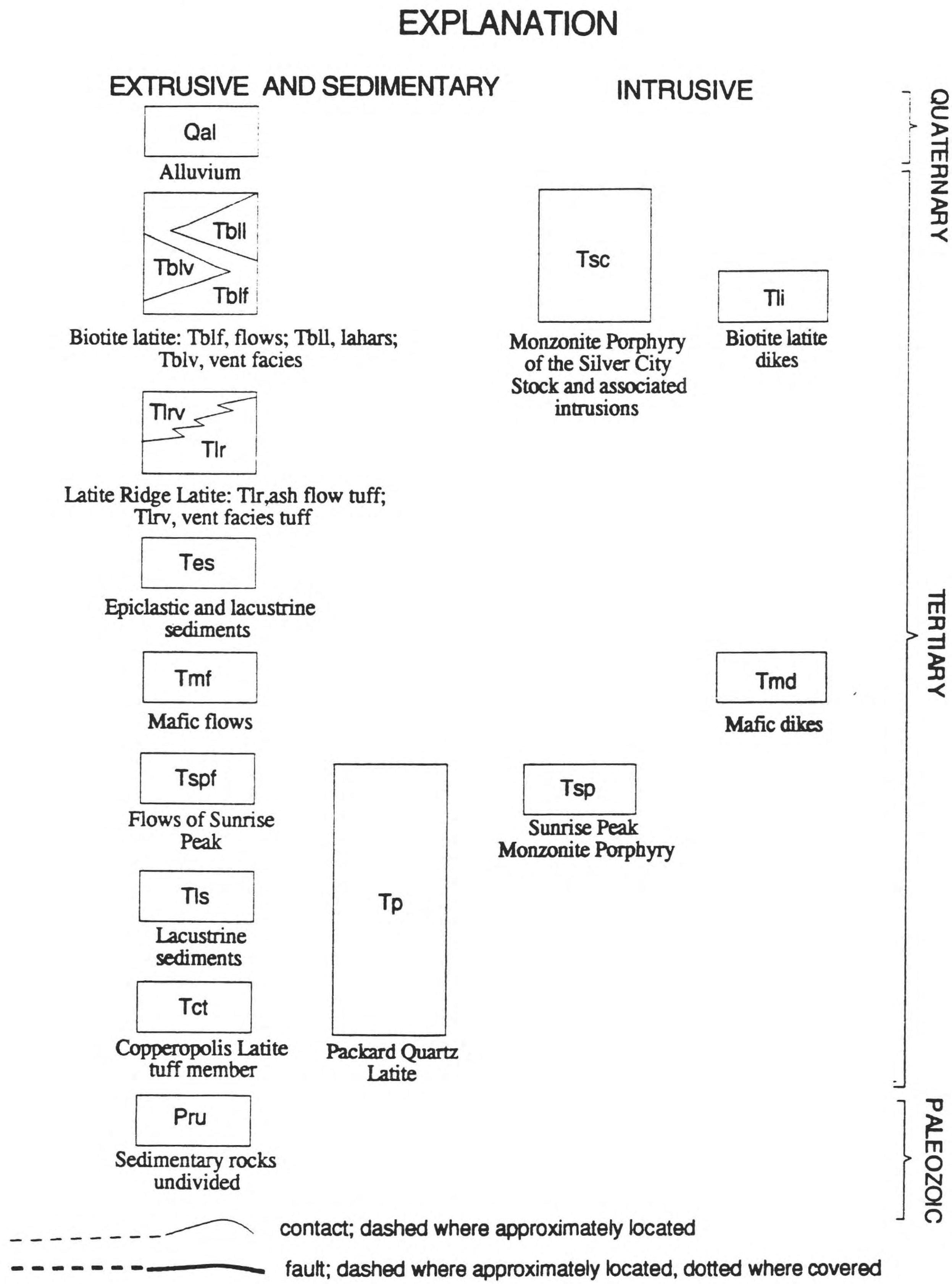


Figure 2. Tertiary stratigraphy of the southern Eureka quadrangle.

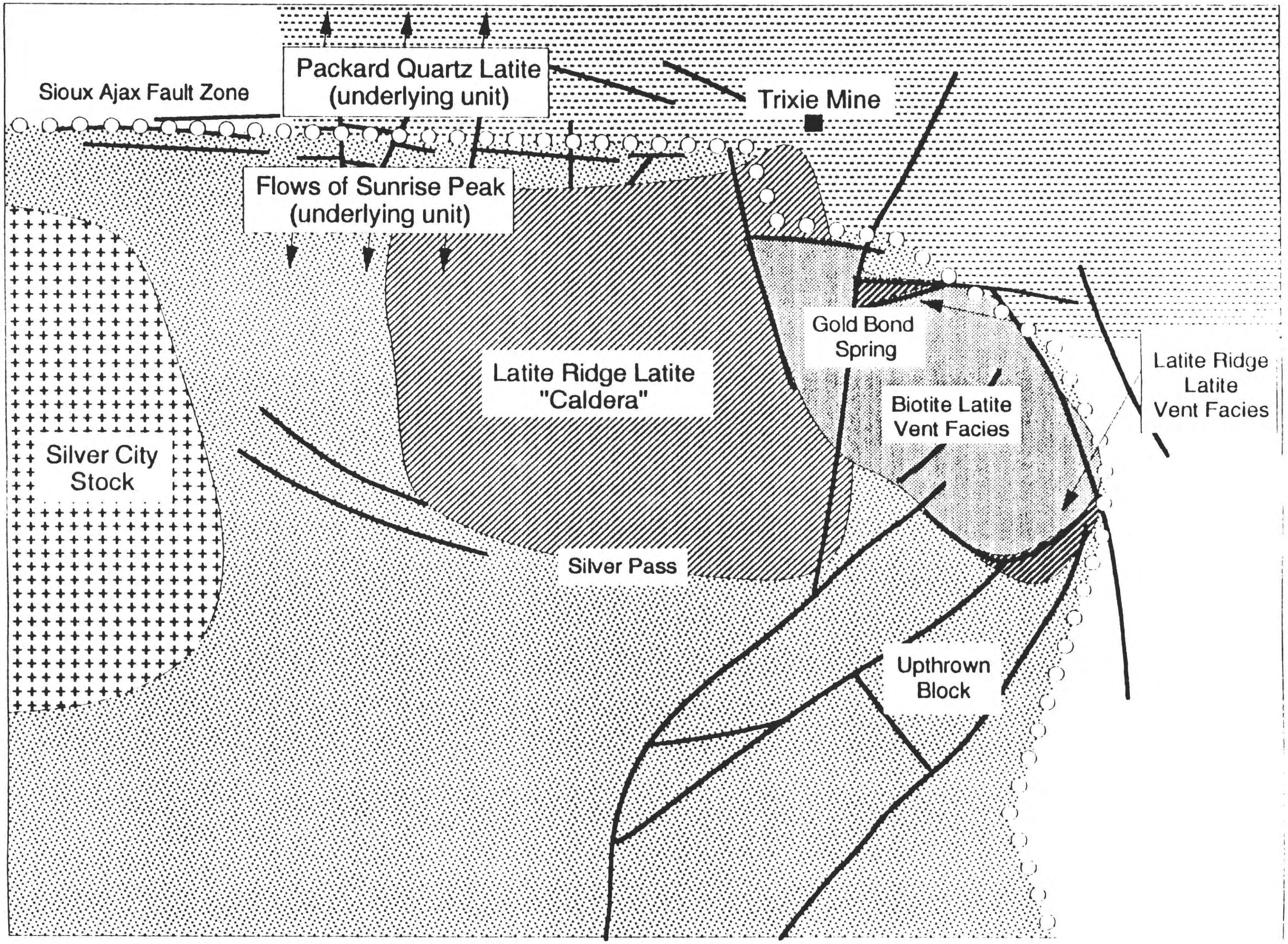
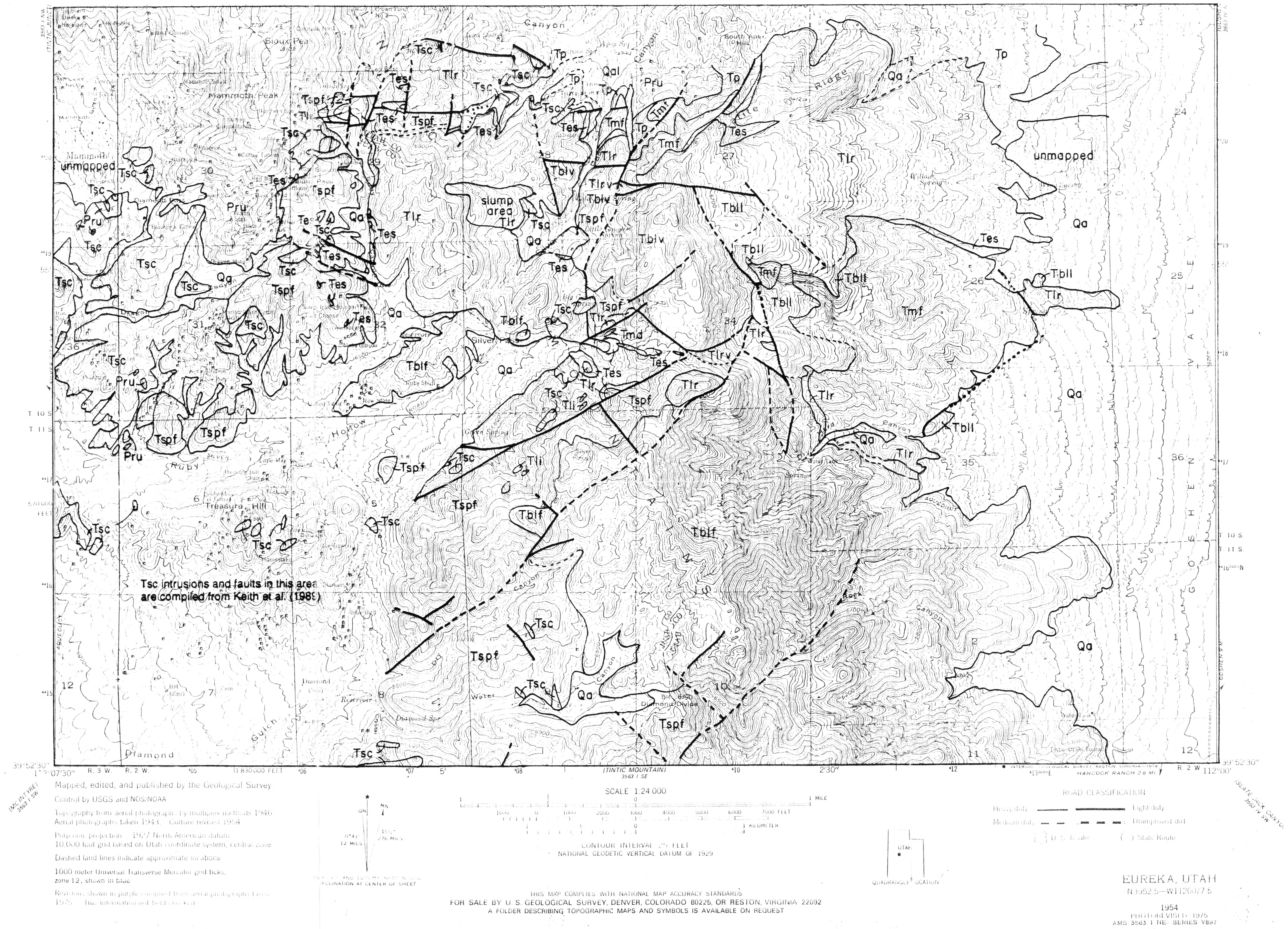


Figure 3. Schematic geologic map of vent areas.



TERTIARY GEOLOGY OF THE SOUTHERN PORTION OF THE EUREKA QUADRANGLE, JUAB AND UTAH COUNTIES, UTAH

by

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EXPLANATION

EXTRUSIVE AND SEDIMENTARY

QUATERNARY

- Qal — Alluvium

TERTIARY

- Tbll, Tblv, Tblf — Biotite latite: Tblf, flows; Tbll, lahars; Tblv, vent facies
- Tlrv, Tlr — Latite Ridge Latite: Tlr, ash flow tuff; Tlrv, vent facies tuff
- Tmf — Mafic flows
- Tes — Epiclastic and lacustrine sediments
- Tspf — Flows of sunrise peak
- Tls — Lacustrine sediments
- Tct — Copperopolis latite tuff member
- Tp — Packard quartz latite

PALEOZOIC

- Pru — Sedimentary rocks undivided

INTRUSIVE

- Tsc — Monzonite Porphyry of the Silver City Stock and associated intrusions
- Tli — Biotite latite dikes
- Tmd — Mafic dikes
- Tsp — Sunrise Peak monzonite porphyry
- Tsq — Swansea quartz monzonite

contact; dashed where approximately located

fault; dashed where approximately located, dotted where covered